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ORIGINAL ARTICLE

A senior liveability index for European cities

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Abstract

The demographic challenge of the ageing population in European countries needs to be assessed in terms of sustainability and effectiveness of public policies improving the quality of life of the elderly. The European Commission has monitored the quality of life in European cities since 2004 through a survey on citizens' perception of their liveability. Given that the assessment of life quality embeds a multitude of positive and negative aspects, we develop a composite indicator that we call the senior liveability index (SLI) to rank the performance of cities, monitor the rank changes over time and explore possible reasons.

KEYWORDS
composite indicator, European cities, quality of life, the elderly

JEL CLASSIFICATION
I31, R10

1 | INTRODUCTION

Two significant demographic shifts, rapid ageing and urbanisation, are currently affecting the population worldwide, resulting in a growing number of older people living in urban environments (WHO, 2015). The expected increase in the number of people aged 60 and older from 1 billion in 2019 to 2.1 billion in 2050 highlights the importance of the ageing phenomenon (Keating, 2022). In Europe, the share of people aged 65 years and above is estimated to reach 30% by 2070, up from about 20% today (OECD/EC-JRC, 2021). This phenomenon is affecting the direction of policies aiming at the enhancement of seniors' wellbeing and assurance of an active and healthy ageing. To this concern, the provision of services and the demand for infrastructures is challenging urban planners and local policy makers about the usage of public and private spaces (Ruth & Franklin, 2014). Cities are centres of economic development fostering opportunities of education, innovation and work, concentrating economic activity and attracting people (Eurostat, 2019). However, they embody drawbacks as well, such as high levels of social exclusion, income inequality and a number of troubles ranging from safety, pollution and traffic congestion. Thus, the concept of liveability in cities has attracted the attention of geographers and urban planners as a key planning target (Stephens et al., 2019), who need to detect reasons behind the inequalities that distinguish citizens who enjoy a comfortable lifestyle from others facing considerable challenges, both within and across cities. Given the relevance of the ageing phenomenon within the urban context and it being a multiple and complex matter, we develop a composite indicator (CI) called the senior liveability index (SLI). It summarises several indicators of the suitability of European cities. Senior inhabitants require a number of favourable living conditions supporting their physical, mental and social changes that occur during biological ageing. Such requirements may be deficient in urban environments, which currently are not perfectly designed to be residencies for a sizable population of elderly people (WHO, 2015). However, as the Council of Europe Development Bank (CEB) puts it, "given that the majority of essential services for older people are dispensed at the local level, the way local authorities in particular adapt to demographic changes will be one of the key determinants of quality of life for older people and of the well-being of the wider community" (CEB, 2014: 9). Certainly, local governments are responsible for increasing the opportunities of wellbeing by creating adequate and affordable infrastructure and providing services for the senior population.

Adopting a CI metric has proved to be very useful as a straightforward measure to summarise the information contained in a wide set of variables into a single figure (see e.g., Kelley & Simmons, 2015; Montalto et al., 2019; Nardo et al., 2005). In addition, the World Health Organization suggests that empirical frameworks and indicators are instrumental in providing a shared understanding by policy makers about which assets should be leveraged and which goals must be accomplished towards achieving a liveable environment for the elderly (WHO, 2015). Monitoring and evaluating changes over time are essential to implementing an age-friendly city, as numbers inform local policy makers precisely about the city's performance and, therefore, may stimulate prompt action. In fact, the European Commission has surveyed the citizens of Europe's capital cities and other major cities since 2004 about the quality of life they have or perceive to have in the cities where they live. The answers to the questions in each wave of the survey deliver useful insights of the urban environment. On the basis of microdata from these surveys, our SLI index ranks and compares the performance of cities over time. Furthermore, the yearly rankings in our opinion may help decision makers revise and question their conduct and their effort towards improving standards of living and allocating resources. In this respect, the results in our analysis are drivers of change (see also Kelley & Simmons, 2015).

The paper is structured as follows: section 2 examines the issue of urban liveability in the European context according to the existing literature and provides the setting for variable selection; section 3 describes the data and the necessary methodological steps to develop the SLI; section 4 presents the results via graphs and other graphical configurations and compares the ranking over time; and section 5 concludes and discusses some policy implications.

2 | URBAN LIVEABILITY IN EUROPE: BACKGROUND

Owing to the interdisciplinarity and multidimensionality of its characteristics, the definition of liveability has no universally shared interpretation (Van Kamp et al., 2003). Urban planners conceive urban liveability as an equitable interaction of economic, social, cultural, land-use and environmental development in cities (Asgarzadeh et al., 2012; Flores et al., 1998). A liveable city is characterised by two mutually non-exclusive elements: the first accounts for the characteristics and attributes of the population, shaping the demand for services supplied by the city. The appraisal of liveability occurs through the lens of the needs and wants of those who live in cities (Midgley & Livermore, 1998; Waste, 1998). The second element is the city's environment, represented by the infrastructures and the ecosystem that provide goods and services, naturally impacting the level of suitability of the city.

Next, metropolitan or urban areas per se condition many human features, such as health and wellbeing, as well as environmental factors such as the socioeconomic status of neighbourhoods and the access to services and transportation. The issue of urban environmental quality relates to the concepts of liveability and quality of life, whose importance is central in research programmes, policy making and urban development (Van Kamp et al., 2003). The preconditions for a liveable city include the possession of satisfactory requisites of accommodation and configuration of land usage that allow citizens to meet their needs and enhance development in the long run (Chen et al., 2016; Mesimaki et al., 2017). This proposition is of utmost importance for the elderly, who are particularly vulnerable to changes in neighbourhood safety (Yen et al., 2009), at greater risk of loneliness and isolation (D'Hombres et al., 2018) and subject to daily life activities impairments (Mlinac & Feng, 2016).

Figure 1 shows the percentage of cities (for each European country) with a share of elderly people going from less than 14% (dark green bar) to more than 20% (red bar) in 2004. Only the cities with more than 100,000 inhabitants are considered. It is evident that the "eldest" cities are located in Italy, Germany, Spain, Portugal and France, which show a significant percentage of cities whose residents with an age of more than 65 years are more than 20% (especially in Italy). On the contrary, the youngest cities of Europe are located in Eastern Europe and Ireland (in the latter and in Slovakia all main cities have less than 14% share of elder residents). More recently, OECD population statistics in metropolitan areas, shown in Figure 2, highlight that in 2019 the dependency ratio of over 65 years on the population of 15–64 years is greater than 30% in cities like Rome, Athens, Lisbon and Oviedo. On the contrary, Turkish cities display the lowest values of the dependency ratio, together with Dublin, London and Oslo.

Overall, the total number of people aged 65 years and above in EU-27 increased up to 10.45% from 2014 to 2022, shifting from almost 32 million to more than 35 million. Such figures underline the significance of addressing policies to create the best living environment because of the magnitude of the ageing phenomenon. In this respect, in 2007 WHO published a Global Age-Friendly Cities guide that we use as a frame of reference in the choice of the variables and their following allocation to each pillar of the SLI, as described in the next section. The guide provides a

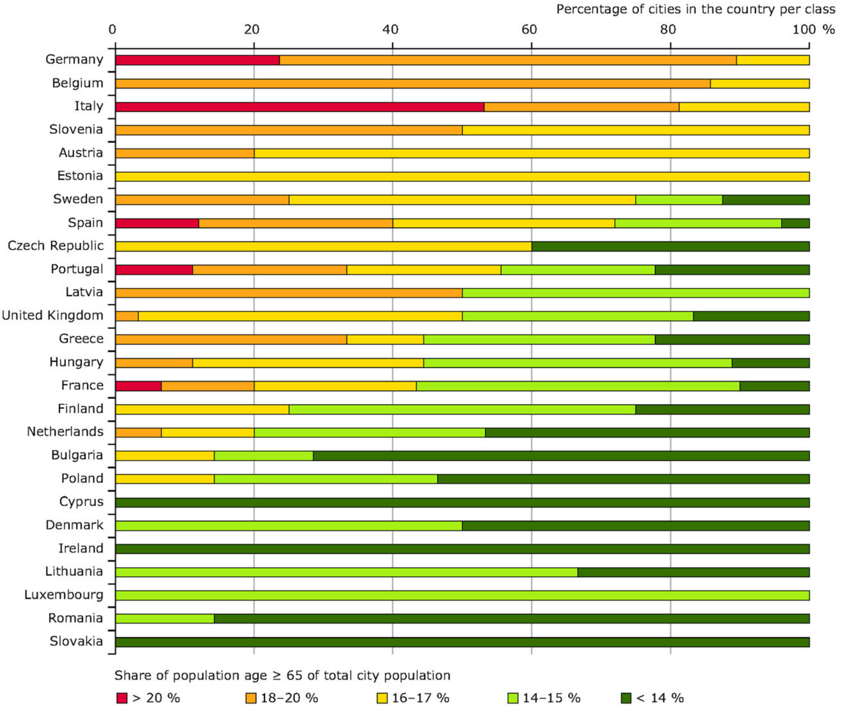

FIGURE 1 Percentage of cities in European countries showing a share of population aged 65 and over going from less than 14% (dark green) to more than 20% (red) in 2004. For example, about 50% of Italian cities have more than 20% of their residents with an age above 65 years. *Source*: Eurostat, Urban Audit database, 2004

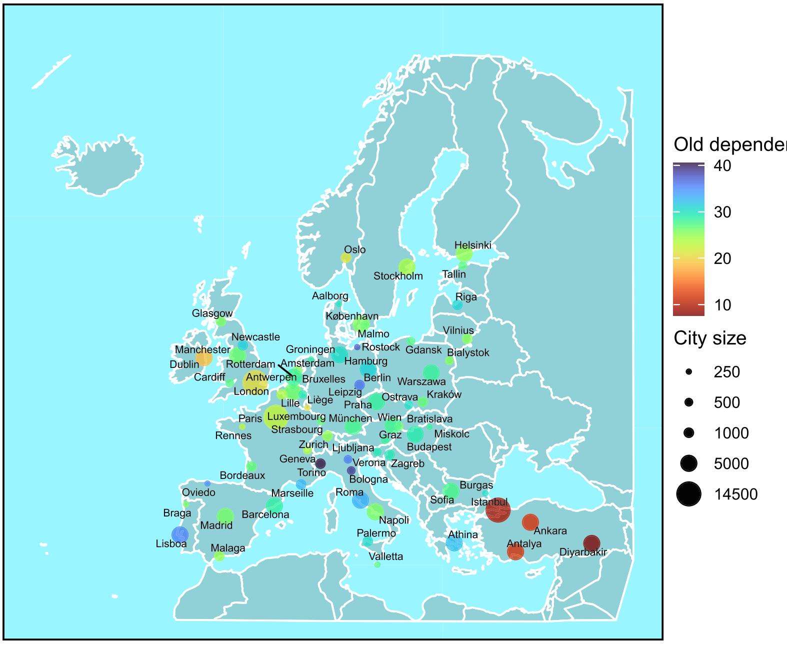

FIGURE 2 Old dependency ratio 2019

checklist of action items ranging from supply of services, including health and transportation, to dimensions of the built environment, such as outdoor spaces and buildings, as well as social aspects of participation to compensate for the deficiencies that occur with biological ageing (WHO, 2007).

On the basis of this background, the SLI consists of three pillars, each covering one feature of the urban area, that provide summary indicators of European cities' senior liveability. The first pillar includes features of the physical urban environment, such as public spaces in the city, markets, squares and pedestrian areas, also considered in Rantakokko et al. (2010) to calculate the correlation between the outdoor urban environment and the quality of life of the elderly. Along this line, Klinenberg (2002) attributes the reduction of quality of life of aged people to structural features in the urban environment, such as barriers to physical mobility, slippery pavements, inadequate lighting and deteriorated walkways. Another feature within the same pillar is the quality of the air in the city, since deteriorating environmental quality is a serious threat to human health, and air pollution is considered one important factor contributing to the degradation of liveability in cities (Silva & Mendes, 2011). In fact, the 2012 EEA Report[1] highlights that above 80% of European citizens are exposed to particulate matter (PM) levels above the threshold provided by WHO (2006), which implies a reduction of life expectancy in the range of 8 months to 2 years on average per person. Additionally, the issue of cleanliness of the city, including the absence of waste and dirt on streets and pavements, but also the existence of non-commissioned or worthless graffiti that spoil the surrounding buildings, is likely to impact the perception of liveability and health by influencing people's willingness to spend more time outside and conduct physical activities (Duncan & Mummery, 2005; Kweon et al., 2010).

The second pillar encloses service accessibility and public transport in the city, such as bus, tram or metro. These are connected with safe, attractive and enjoyable environments (Anciaes & Jones, 2020). However, research by Rees et al. (2020) claim that aged people might be less capable of utilising public transportation due to the distance from their neighbourhood, a feeling of unsafety or the inability to reach the destinations they want to go to; thus, transportation options should allow older adults to move around their communities (Lawton, 2015). In addition,

[1]EEA Report No 4/2012, 'Air quality in Europe – 2012 report' http://www.eea.europa.eu/publications/air-quality-in-europe-2012.

Green et al. (2014) highlight that the possibility of having social interaction on public transports is likely to improve the wellbeing of older people. Again, health care services offered by hospitals and doctors are an important factor to be considered, and prevention and control of health problems require the simultaneous incorporation of health, social welfare and urban development projects (Shrivastava et al., 2013). Indeed, a high quality of urban liveability for the elderly heavily depends on the availability of accessible short-distance healthcare services for them (Khalil, 2012; Moroke et al., 2019). A reduced use of health care and uptake of preventive services is often a consequence of spatial barriers within the city (Cvitkovich & Wister, 2001; Hiscock et al., 2008). In addition, the efficiency of administrative services in helping older citizens is relevant as found by a number of empirical studies discussing the quality of local administrative services as an important determinant of liveability (Bérenger & Verdier-Chouchane, 2007) and wellbeing (Charron et al., 2014).

The third pillar concerns the amenities offered by the city; green spaces, such as public parks and gardens, offer a chance to achieve a wide range of benefits (Bedimo-Rung et al., 2005). There are plenty of studies that confirm the previous statement, for example, Tinsley et al. (2002) pinpoint that older people rate the opportunity to have physical activity as the most important advantage of parks, and Wood et al. (2017) claim that individuals living in urban areas with parks improve their own wellbeing with respect to those who do not. Moreover, sports facilities such as sport fields and indoor sport halls are features of the city that affect urban liveability (Mahdzar et al., 2017) because, by providing access to relief from urban stress, they respond to citizens' need for an improved urban living quality (Richard & Stout, 2015). Lastly, within the amenities pillar, cultural facilities such as concert halls, theatres, museums and libraries are included. Culture-based leisure activities play a key role in stimulating social interaction among people in the city (Terzi et al., 2015). The study by Koponen et al. (2022) argues that elderly people who have the possibility of participating in more cultural activities value their quality of life better.

3 | METHODOLOGY AND DATA

The senior liveability index provides a summary assessment of European cities as far as their liveability, and informs broad strategic decisions for the city policy makers. In this paper, we set up our indicator using R 4.2.0 (R Core Team, 2022), and the recently developed COINr package (Becker et al., 2022) for construction and analysis of composite indicators. The latter includes commands for a step-by-step construction of a composite indicator, allowing also for normalisation, weighting, aggregation and the consequent analysis and comparison among multiple configurations. Our indicator is based on a four-step approach illustrated in Figure 3 that will be described in the following part of the section.

The first step consists of the selection of the sub-indicators to construct our single main indicator. We build the SLI on the basis of the availability of microdata collected from the Perception Survey on the Quality of Life in European Cities for the years 2009, 2012, 2015 and 2019. The surveys are designed to be representative of the population of the selected cities. The first three waves (2009 to 2015) collect 500 complete individual interviews for each city and the last wave (2019) collects 700. The sample is stratified by age, sex and education. The criteria on the choice of the cities are not explicitly stated in the surveys and/or in the supporting material. However, as a general rule we observe that all capital cities of the selected countries are included (with the exception of Switzerland). Furthermore, for larger countries, medium-sized cities are included too, located in different regions (north, south,

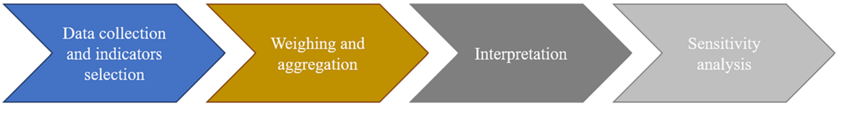

FIGURE 3 The senior liveability index four-step approach.

east or west).[2] In 2009 the survey accounted for 75 European cities, in 2012 and 2015 for 79, and in the last edition (2019) for 83. We then revise the master questionnaires of the different editions to select the relevant questions according to the existing literature, that is, those concerning urban liveability for the elderly, and check their consistency across the four waves of the survey. As presented in Table 1, we end up with nine key variables, three for each pillar (accessibility of services provided in the city, amenities and the features of the urban environment). The response to each question is based on a four-point Likert scale: very satisfied (code 1), rather satisfied (code 2), rather unsatisfied (code 3), not at all satisfied (code 4), as well as do not know/no answer (code 9). For uniformity among indicators, we combine response categories with code 1 and code 2 to calculate the percentage of elderly citizens who answer that they are either very or rather satisfied in their city at each observable year. The indicators within each pillar and their descriptive statistics, based on the responses of very or rather satisfied with each aspect of citizens aged 65 and over are in Table 1.

Table 1 presents important disparities in the perception of urban features on behalf of elderly citizens. The average share of satisfied people confers some information about the perceived importance of the issue. 'Quality of the air' and 'cleanliness of the city' have the lowest scores among the variables describing urban liveability, both on average and in comparison to other issues in the same year. This means that fewer people are fully satisfied with those two parameters, although they show a high standard deviation, especially in 2009, right in the middle of the economic crisis. On the other hand, 'public transport', 'green spaces' and 'cultural facilities' have the highest average values.

In general, the average share that most of the variables take goes from about 0.2 to 0.9, meaning that at least 20% of the respondents show a good level of satisfaction, except for a few cases in which the average share is less than 10%, highlighting the fact that dissatisfaction is massive for certain issues in certain cities of Europe (e.g., cleanliness of the city).

To evaluate the reliability (or consistency) of our variables, that is, how much the selected items can be grouped together in the same dimension, we use Cronbach's alpha test.[3] In our case the Cronbach's alpha is equal to 0.902 for 2009, 0.864 for 2012, and 0.897 and 0.926 for the last 2 years, respectively. This means that our variables have relatively high internal consistency for all the years considered.

The second step consists of a weighting and aggregation strategy at two levels, that is, pillars and variables within each pillar, where typically the variables are combined in a weighted average to give the resulting value of the composite indicator.

We do not have an a priori preference on the weighing and aggregating strategy, and therefore we test three options:

- equal weighting and arithmetic mean;
- principal component weighting and arithmetic mean;
- equal weighting and geometric mean;
- principal component weighting and geometric mean;

The weighted arithmetic mean is the most straightforward and widely used approach to aggregation as, in principle, it is easy to interpret. Denoting the indicator variables, within each pillar P_j, with $x_i \in \{x_1, x_2, x_3\}$, a weighted arithmetic mean is calculated as:

[2]A recent inquiry by the authors to the DG Regio economic analysts explained that the cities were chosen in 2004 to reflect capital cities (apart from Switzerland) and medium-sized cities for larger countries, and the list of cities are observed over the years to keep track of any changes. Moreover, there are available EU funds for national statistics institutions to encourage the extension of the survey to other cities within the country.

[3]Cronbach's alpha is a measure of internal consistency and reliability. It is defined as the ratio of the total covariance in the 'test' to the total variance in the 'test'. By 'test' we mean the set of indicators constituting each pillar of the composite indicator. It can be written as follows: $\alpha = kk - 11 - i = 1kYi^2X^2$, where k is the number of items, X^2 the total variance in the 'test', Yi^2 the total covariance in the 'test', and i the sample. Cronbach's alpha ranges from 0 to 1. If all indicators are entirely independent from one another (i.e., they are not correlated or share no covariance) Cronbach's alpha equals 0. If all of the items have high covariances, then Cronbach's alpha will approach 1.

$$P_j = \frac{1}{\sum_{i=1}^{3} w_i} \sum_{i=1}^{3} x_i w_i \quad \forall P_j, j = 1,2,3 \tag{1}$$

TABLE 1 Descriptive statistics of the share of very/rather satisfied respondents.

Pillar	Variable description	Year	Min	Mean	Std.dev	Max
Accessibility to services	Public transport in the city (e.g., bus, tram or metro)	2009	0.224	0.827	0.146	1.000
		2012	0.212	0.732	0.154	0.955
		2015	0.210	0.748	0.159	1.000
		2019	0.258	0.805	0.143	0.990
	Health care services offered by hospitals and doctors	2009	0.443	0.796	0.152	0.986
		2012	0.239	0.745	0.193	1.000
		2015	0.365	0.737	0.168	0.991
		2019	0.427	0.747	0.163	0.966
	Administrative services of the city, help you efficiently	2009	0.226	0.684	0.172	1.000
		2012	0.212	0.549	0.144	0.797
		2015	0.178	0.547	0.127	0.797
		2019	0.197	0.636	0.151	0.863
Amenities	Sport facilities (e.g., indoor sports hall)	2009	0.250	0.761	0.178	0.981
		2012	0.204	0.541	0.156	0.830
		2015	0.133	0.540	0.143	0.765
		2019	0.307	0.818	0.127	0.985
	Cultural facilities (e.g., theatres, museums, libraries)	2009	0.400	0.868	0.144	1.000
		2012	0.333	0.744	0.146	0.946
		2015	0.348	0.742	0.136	0.966
		2019	0.483	0.856	0.108	0.987
	Green spaces (e.g., parks and gardens)	2009	0.326	0.810	0.152	1.000
		2012	0.271	0.795	0.152	1.000
		2015	0.213	0.794	0.160	0.981
		2019	0.250	0.801	0.157	0.980
Features of the urban environment	Public spaces of the city (e.g., squares, pedestrian areas)	2009	0.250	0.801	0.163	1.000
		2012	0.333	0.757	0.131	0.933
		2015	0.358	0.760	0.134	0.910
		2019	0.373	0.796	0.137	0.941
	Quality of the air	2009	0.000	0.361	0.210	0.792
		2012	0.158	0.644	0.194	0.928
		2015	0.279	0.672	0.176	0.955
		2019	0.217	0.668	0.182	0.926
	Cleanliness of the city	2009	0.000	0.595	0.226	1.000
		2012	0.177	0.577	0.175	0.952
		2015	0.051	0.615	0.184	0.935
		2019	0.056	0.622	0.183	0.948

where w_i are the weights corresponding to each x_i and P_j is the index of the pillar. Equal weights (equal to 1) are then assigned to the highest hierarchical dimension, that is, the pillars, which are aggregated into an arithmetic mean to compose the SLI.

Arithmetic mean is an additive aggregation method that sums up the values of sub-indicators to form an index. This aggregation function has the advantage of being simple and easily interpretable, but it is criticised for the compensation between sub-indicators that are not substitutable for each other. In fact, it compensates bad performance in one aspect with good performance in another. As an example, it is employed for the aggregation of 36 normalised variables into the quality of life index for Italian provinces by the Italian economic newspaper *Il Sole 24 Ore* (Lun et al., 2006).

The geometric mean aggregation provides minor compensability for sub-indices with lower values, assuming a multiplicative, rather than additive, relationship of the variables (Greco et al., 2019).

The weighting strategy reflects the 'explicit importance' attached to each variable in a composite index, affecting the ranking of the units under research (Greco et al., 2019). Endogenous weights, resulting from a data-driven approach, can reflect the importance of the different dimensions in the composite measure of liveability (OECD, 2008), letting the data speak for themselves.[4]

Equal weighting, according to OECD (2008), is a common scheme in CI development as the assignment of the same influence to all the variables accounted for. This weighting technique is employed as a baseline for the construction of the OECD Better Life Index (OECD, 2013) and for the computation of the final score of the Human Development Index (United Nations Development Programme, 2014). In addition, when several dimensions are selected to give a comprehensive picture of a concept related to the quality of life, such as city liveability, equal weighting is a straightforward method to synthesise information from the sub-indices (Tkach & Gigliarano, 2022).

Weights based on a PCA are those that account for the most variation in the initial data. Under this method, collinear sub-indicators are linearly combined using PCA into new units called 'components', able to incorporate as much of the shared data as possible and explaining most of the variability. Because consecutive components are independent of one another, one can be sure that the extracted factors are effectively measuring different dimensions. As customary, weights are obtained from normalized squared loadings (implying the portion of variance of each component explained by each variable). We used the highest loading per variable weighted according to the relative contribution of the respective component to the explanation of the overall variance. This weighting elicitation scheme was employed by the European Commission for the EU Regional Social Progress Index (European Commission My Region, My Europe, 2017).

The third step consists of interpretation of results and the last in the sensitivity or uncertainty analysis used to verify that the rankings obtained through the synthesis are not biased by the decisions during CI's construction process. It focuses on how uncertainty in the input factors propagates through the structure of the composite indicator and affects the values of the composite indicator. Assuming a certain degree of uncertainty surrounding all weight values, a random 'noise' is applied to the weights, at both pillar and individual index levels. With this approach, for each replication of the composite indicator, a random value is added to each weight, of the form:

$$w'_i = w_i + \epsilon_i, \epsilon_i \sim U[-\phi w_i, \phi w_i] \tag{2}$$

where w_i is a weight, ϵ_i is the added noise, and ϕ is a 'noise factor'. This means that if we set $\phi = 0.25$, it would let w_i vary between ±25% of its nominal value, following a uniform distribution. Appendix B reports the synthesising process related to the definition of the weighting system and the graphical results.

[4]Another option regarding the choice of weights would be relying on the judgment of experts. However, unfortunately, we have not found any expert judgment related to the specific context (people older than 65 in cities). It appears that no expert has been consulted to give an assessment of the importance of each indicator, as the Budget Allocation method would require (OECD, 2008). Carrying an expert survey, on the other hand, is out of our possibilities as it would require funding that we actually do not have.

4 | RESULTS AND DISCUSSION

A first preliminary step of our analysis is to check for differences that could rise from different aggregating and/or weighting schemes. In Table 2, it turns out that correlation among the four different ways we use to compute SLIs is almost 1 for all the years. This means that our indicator does not vary substantially with the weights and aggregating schemes, providing additional strength to our analysis. In the rest of the analysis, we rely on the SLI calculated with unit weights and geometric mean, as it is straightforward to interpret.

A general overview for each year of the correlation among the equal weighting SLIs, our benchmark weighting scheme, is in Table 3. We observe a strong positive link in the relationship between the indices, with the highest occurring between 2012 and 2015 and between 2015 and 2019. This highlights a high degree of persistence in the

TABLE 2 Correlation matrix between SLIs based on different weights and aggregating schemes.

2019	Unit weights, geom. mean	Unit weights, arith. mean	PCA weights, geom. mean	PCA weights, arith. mean
Unit weights, geometric mean	1.00000	0.99873	0.99858	0.99995
Unit weights, arithmetic mean	0.99873	1.00000	0.99995	0.99877
PCA weights, geometric mean	0.99858	0.99995	1.00000	0.99872
PCA weights, arithmetic mean	0.99995	0.99877	0.99872	1.00000
2015	**Unit weights, geom. mean**	**Unit weights, arith. mean**	**PCA weights, geom. mean**	**PCA weights, arith. mean**
Unit weights, geometric mean	1.00000	0.99803	0.99778	0.99993
Unit weights, arithmetic mean	0.99803	1.00000	0.99992	0.99810
PCA weights, geometric mean	0.99778	0.99992	1.00000	0.99799
PCA weights, arithmetic mean	0.99993	0.99810	0.99799	1.00000
2012	**Unit weights, geom. mean**	**Unit weights, arith. mean**	**PCA weights, geom. mean**	**PCA weights, arith. mean**
Unit weights, geometric mean	1.00000	0.99692	0.99664	0.99949
Unit weights, arithmetic mean	0.99692	1.00000	0.99953	0.99622
PCA weights, geometric mean	0.99664	0.99953	1.00000	0.99691
PCA weights, arithmetic mean	0.99949	0.99622	0.99691	1.00000
2009	**Unit weights, geom. mean**	**Unit weights, arith. mean**	**PCA weights, geom. mean**	**PCA weights, arith. mean**
Unit weights, geometric mean	1.00000	0.98222	0.98324	0.99997
Unit weights, arithmetic mean	0.98222	1.00000	0.99995	0.98146
PCA weights, geometric mean	0.98324	0.99995	1.00000	0.98254
PCA weights, arithmetic mean	0.99997	0.98146	0.98254	1.00000

TABLE 3 Correlation matrix between yearly SLIs.

	SLI 2009	SLI 2012	SLI 2015	SLI 2019
SLI 2009	1.000			
SLI 2012	0.873	1.000		
SLI 2015	0.851	0.939	1.000	
SLI 2019	0.835	0.876	0.942	1.000

position of the cities in the ranking, which takes into account their relative position within their geographical area of reference.

After performing the correlation analysis, Figures 4–7 map the SLI for the selected years emphasising city size. The colour of the city's bubble corresponds to the magnitude of the indicator, where blue means a higher rank, red/orange indicates a lower position, and yellow/green signals intermediate ranking. Units range from 0 to 100, where 0 is the minimum value of the SLI representing unsuitability of the city and 100 is considered the maximum suitability level. The map also emphasises the city's number of citizens, represented by the size of the bubble, from 250,000 inhabitants to more than 14 million. Overall, smaller cities with up to 500,000 inhabitants, such as Aalborg, Rennes, Oviedo and Oulu, had a better ranking than larger ones, meaning that the elderly are more satisfied when living in narrowed conurbations with respect to large scale metropolitan areas. This finding is consistent with studies proving that happiness or subjective wellbeing are often higher in smaller cities than in larger ones (Burger et al., 2020). Indeed, the calculated correlation between the city size and the SLI scores is negative and approaches the value of −0.24 for 2009, −0.21 for 2012, −0.29 for 2015 and −0.26 for 2019. This means that there is a weakish inverse relation between living in a big city and assessing it as liveable. The differences in terms of liveability scores in the sample of cites are also related to their status of capital or not. Our calculations confirm a higher mean score for non-capital cities, 0.77 for both 2009 and 2019 and 0.71 for both 2012 and 2015, while the average SLI for capital cities is 0.68 for 2009, 0.64 for 2012, 0.66 for 2015 and 0.71 for 2019. The standard deviation is lower for non-capital cities, at around 0.10, while it reaches 0.12 for capital cities, highlighting slightly greater variability in general perception. Furthermore, Figure 4 displays a clear north–south gradient, where the ranking of European cities decreases as we approach Southern Europe, mostly in Greece, Cyprus and Italy.

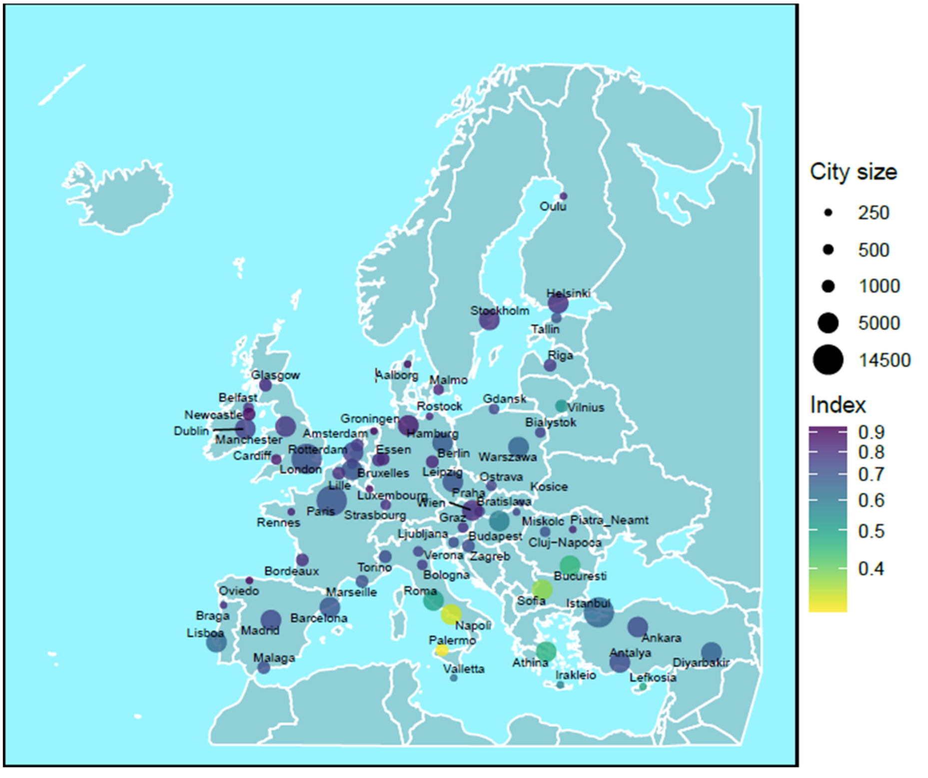

FIGURE 4 Map of SLI 2009 according to the population of the city.

Figure 5 reports SLI rankings in 2012, where the performance of Southern European cities has worsened, probably due to the biting economic crisis, which hit Southern European countries the most. However, some heterogeneity among them emerges; Spanish and Turkish cities are better positioned than Southern Italian cities such as Palermo and Naples. Thus, we highlight interesting differences within the regional cluster as well. Even within the same country, there are north–south variations, which are particularly relevant in Italy, Romania, Portugal and France. On the contrary, the liveability assessment for the majority of Northern and Western European urban areas were subject to fewer variations, especially for Great Britain, Denmark and Germany.

By looking at Figure 6, we can state that Southern European capital cities score worse with respect to other cities within the same country surveyed in 2015. This happens particularly in Lisbon, Athens and Istanbul. On the contrary, this variation is less noticeable for Northern and Western European urban areas, whose rankings are more homogeneous. Moreover, there is still a detectable trend regarding the higher liveability of smaller cities in comparison with metropolises.

Figure 7 shows the SLI rankings for the last year of our investigation. There it is possible to detect a general trend in the graph according to which of the greatest number of Southern European cities lie at the end of the index spectrum, meaning that they perform worse with respect to Northern European cities.

Given the variability assessment within the SLI performance for cities throughout Europe, we grouped cities according to their geographical location into Western, Eastern, Northern and Southern[5] European countries to detect broad regional patterns of the liveability assessment by elderly city inhabitants. The rankings reported in the Figures 8–11 are increasing in 2009 scores, where cities plotted on the horizontal axis are ordered from worst to best performing. We adopted this approach to detect whether improvements or deterioration have happened over the years when cities' relative position in the chart remained unchanged from the 2009 chart.

Looking at the trends for Western European cities in 2009 and 2012, in Figure 8 we observe a general worsening of general satisfaction in most of the cities, especially relevant in Marseille, which reports a decrease of more than 10 points, followed by Groningen, Rennes, Leipzig and Hamburg. In 2009, there is a narrow range of variability among Western European cities, as 12 out of 22 of them had a score greater than 80 points. Starting from a decrease in the scores recorded by every city in the sample in 2012, the progression towards 2015 scores is characterised by a gradual recovery from the bad score in the previous recordings, and after that, in 2019, cities obtained a better position and regained a few points. Moreover, the gap between the first city (Zurich) and the last one (Marseille) for the year 2012 is around 15 points, highlighting a huge gap in the performance of two cities belonging to the same regional area. However, this interval has progressively increased up to 27 in 2019. The cities that maintain an approximately constant placement over the years are Bordeaux, Paris and Dortmund. As far as this group of cities, the descriptive statistics available in Table A1 highlight that the amenities pillar has the lowest mean in all periods, while the remaining pillars are better aligned to the average SLI. We also observe greater deviation from the mean for the amenities pillar in all four time periods, while the other two dimensions of accessibility to services and features of the urban environment display a lower standard deviation.

Figure 9 reports the ranking of Eastern European cities. The best performer in the benchmark year is Piatra Neamt, which reports a SLI score of 86, whose distance from the last city, Sofia, is equal to 56 points. However, the majority of other urban areas present a score around or greater than 70, since 11 out of 17 cities score more than 70. In 2012, only 4 out of 17 cities scored more than 70, while in 2019 there were 14 cities above that threshold. The progression of city ranking has varied over time and, indeed, some of them went from a bad position to gradual recovery, like Sofia.

[5]Cities belonging to Western Europe are: Bruxelles, Liège, Marseille, Berlin, Paris, Rotterdam, Amsterdam, Graz, Wien, Antwerpen, Essen, Lille, Strasbourg, Rennes, Rostock, Bordeaux, Leipzig, Dortmund, München, Hamburg, Luxembourg, Groningen, Geneva and Zurich. Eastern European cities include: Bialystok, Bratislava, Brugas, Bucureşti, Budapest, Cluj-Napoca, Gdansk, Kosice, Kraków, Ljubljana, Miskolc, Ostrava, Piatra-Neamt, Praha, Sofia, Warszawa, Zagreb, Tirana, Skopje, Podgorica and Belgrade. Northern European cities are: Vilnius, Tallinn, London, Riga, Dublin, København, Helsinki, Manchester, Glasgow, Stockholm, Belfast, Oulu, Cardiff, Malmo, Newcastle, Aalborg, Oslo and Reykjavík. Finally, cities in Southern Europe include: Naples, Palermo, Athens, Rome, Lefkosia, Irakleio, Istanbul, Turin, Lisbon, Antalya, Diyarbakir, Valletta, Ankara, Barcelona, Madrid, Verona, Bologna, Malaga, Braga and Oviedo.

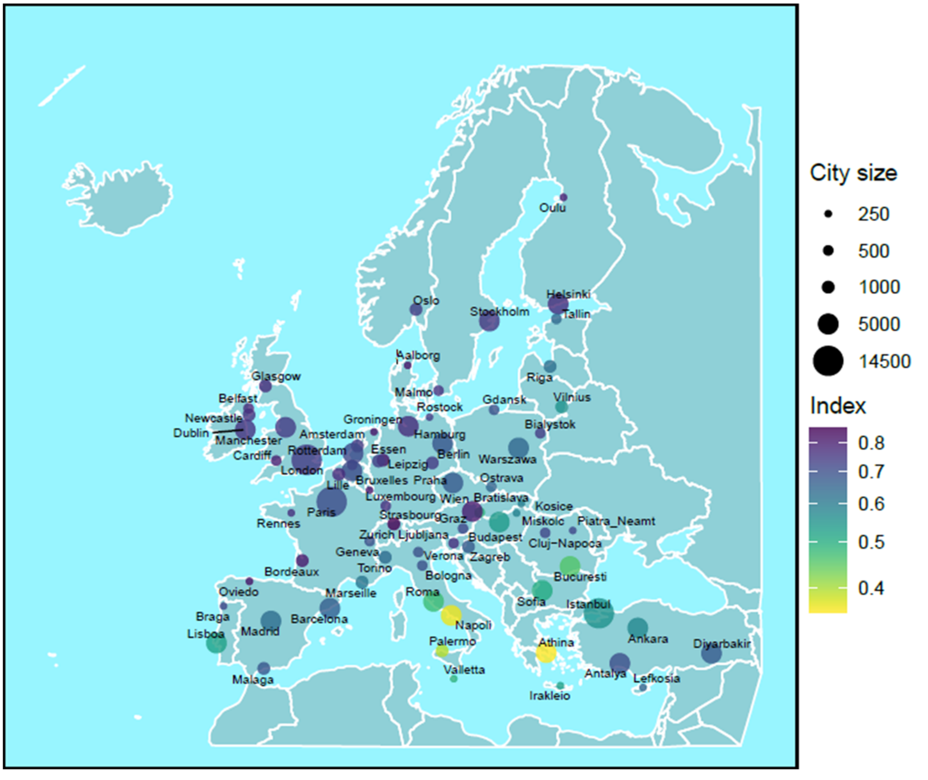

FIGURE 5 Map of SLI 2012 according to the population of the city.

Although the majority of Eastern European cities experienced a general downward trend in 2012 and 2015, when we analyse the average of Eastern Europe, there is a slight increase in these figures from 2009 (68) to 2019 (70). The most noticeable example is represented by the city of Sofia, whose 2009 SLI was lower than 40 and steadily increased up to 65. The cities of Belgrade, Podgorica, Skopje and Tirana were included in the survey on the quality of life only in 2019, and their score ranges from 45 to more than 65, which is far lower than average in Eastern European cities for the same year, which approaches 70. The descriptive statistics, available in Table A1 for this group of cities, highlight a wide range between the minimum and maximum values in 2009 for amenities, which go from 8 to more than 80 points. Finally, the amenities pillar has the lowest average value in all examined periods.

Figure 10 reports the SLI scores obtained by Northern European cities. For the first year of observation the top three are Aalborg, Newcastle and Cardiff, whereas Vilnius, Tallinn and London are at the bottom of the ranking, even if all cities score above 70 with the exception of Vilnius. The range between the two tails of the distribution stands at 39 points in 2009 and gradually reduces to 14 in 2019. An interesting trend is observed for urban areas with a wide difference between 2009 and 2019, namely that Vilnius, Tallinn, London, Dublin and København appear on the left part of Figure 10. They were able to outperform in 2019 and achieve a better placement. Cities that display the greatest variability in this area are in the Baltic countries. However, Riga recorded a drop in its score from 2009 to 2015, but recovered in 2019, while Tallinn and Vilnius showed an improvement from a low ranking in 2009 and surpassed Riga in 2019. By looking at the descriptive statistics in Table A1 for Northern European cities, the maximum value for each pillar in each year is greater than or equal to 80 and the higher deviations from the mean are again recorded for amenities and accessibility to services.

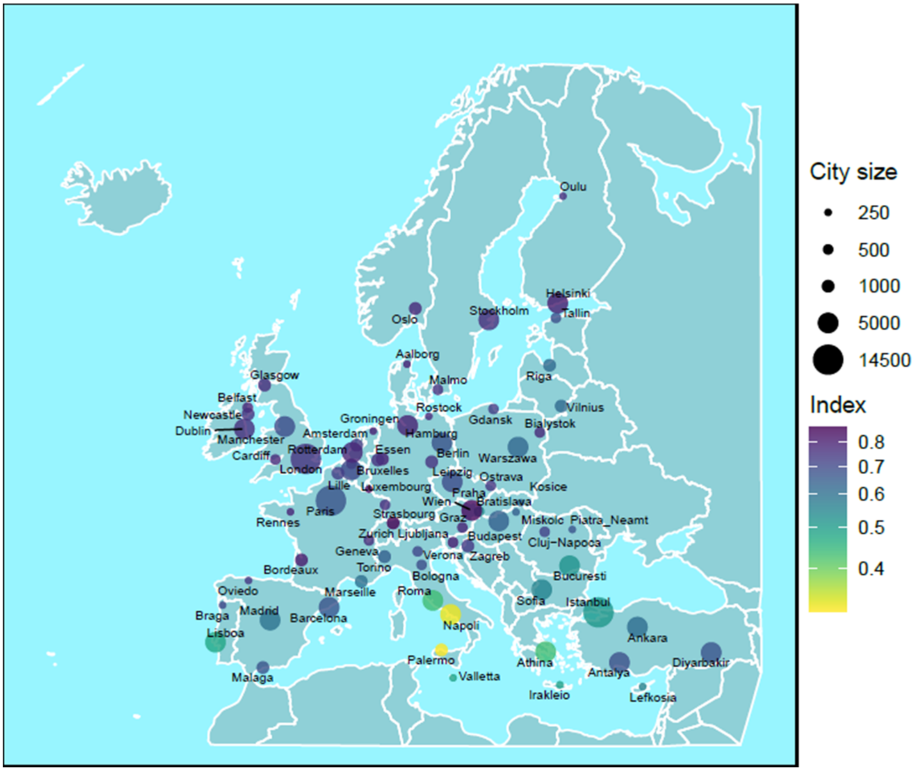

FIGURE 6 Map of SLI 2015 according to the population of the city.

The ranking of Southern European cities, shown in Figure 11, displays a great variability among urban areas belonging to the same country in 2009. In fact, the Spanish city of Oviedo obtains a score of 92, followed by Malaga, Madrid and Barcelona (about 75). Italian cities obtain very different scores as well, from the best city (Bologna) to the worst (Palermo). The cities that report the lowest variation through the 10-year period are Antalya and Barcelona. The city of Diyarbakir is another interesting exception, obtaining the same place for the years 2009, 2012 and 2015, but losing more than 10 points in 2019. The descriptive statistics for the group of Southern European cities, shown in Table A1, record a higher deviation from the mean with respect to the other three city groups in every pillar. Minimum values are particularly low for the accessibility to services and amenities pillars, especially in 2009, 2012 and 2015. In general, the average SLI had decreased in every regional macro-area from 2009 to 2012, and this downturn in the trend may be associated with the fact that Europe was heavily affected by the global financial and economic crisis. This depreciation in liveability, driven by the crisis in the Eurozone, was particularly remarkable in Greece, where austerity measures and consequent protests reduced the senior liveability index, but also in Italian and Spanish cities such as Madrid, Oviedo and Verona (Figure 11). However, for most conurbations included in the study, the overall ranking of 2019 has gradually recovered and almost reached pre-crisis levels.

Furthermore, we assess the weight of each pillar on the SLI by plotting them with a bar graph, represented in Figure 12.[6]

[6]The scale does not correspond to the SLI as the latter is rescaled between 0 and 100. However, the rank position in Figure 12 corresponds exactly to the SLI.

FIGURE 7 Map of SLI 2019 according to the population of the city.

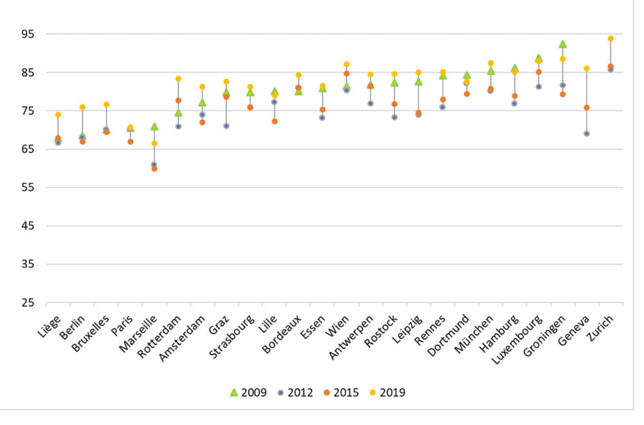

FIGURE 8 SLI rankings of Western European cities using equal weighting over time.

Figure 12 shows that the variability in the composition of the SLI is mostly affected by the accessibility to services pillar while, on the contrary, the dimension concerning amenities displays less variability between the low- and high-ranking cities. Overall, this trend lasts for the whole period under investigation.

Finally, we perform the uncertainty analysis, whose results are reported in Appendix B to account for the effects of uncertainty in the input factors and its impact on the values of the composite indicator. As mentioned in the

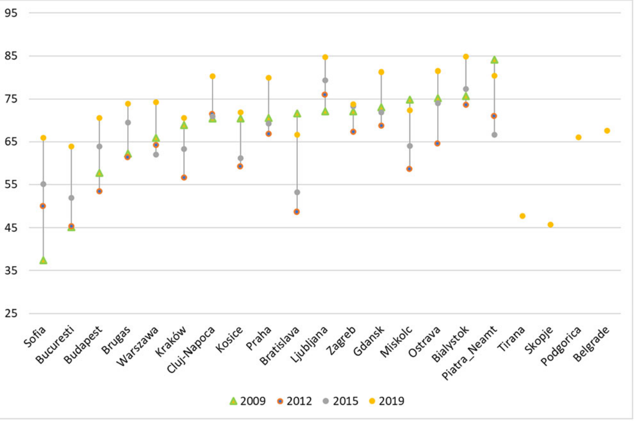

FIGURE 9 SLI rankings of Eastern European cities using equal weighting.

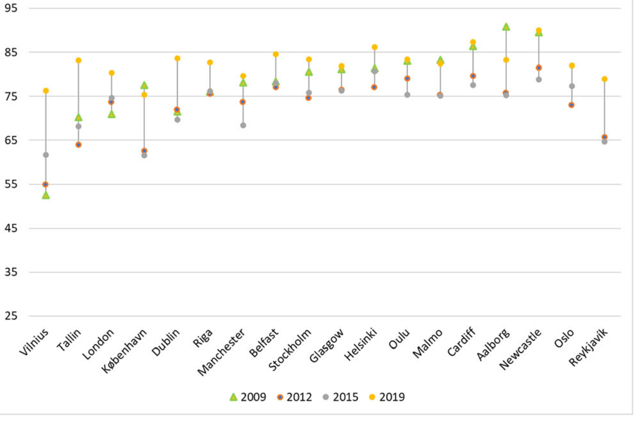

FIGURE 10 SLI rankings of Northern European cities, using equal weighting.

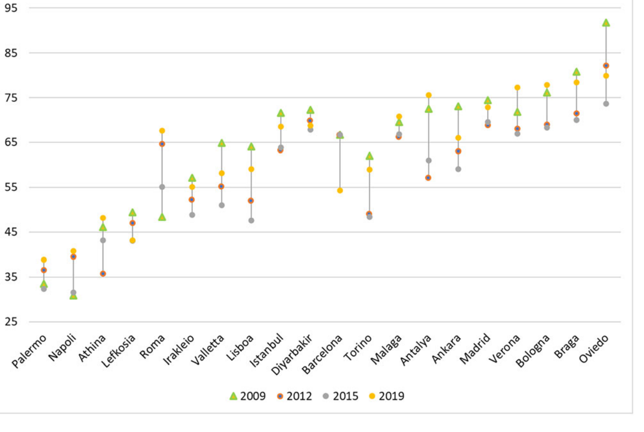

FIGURE 11 SLI rankings of Southern European cities, using equal weighting.

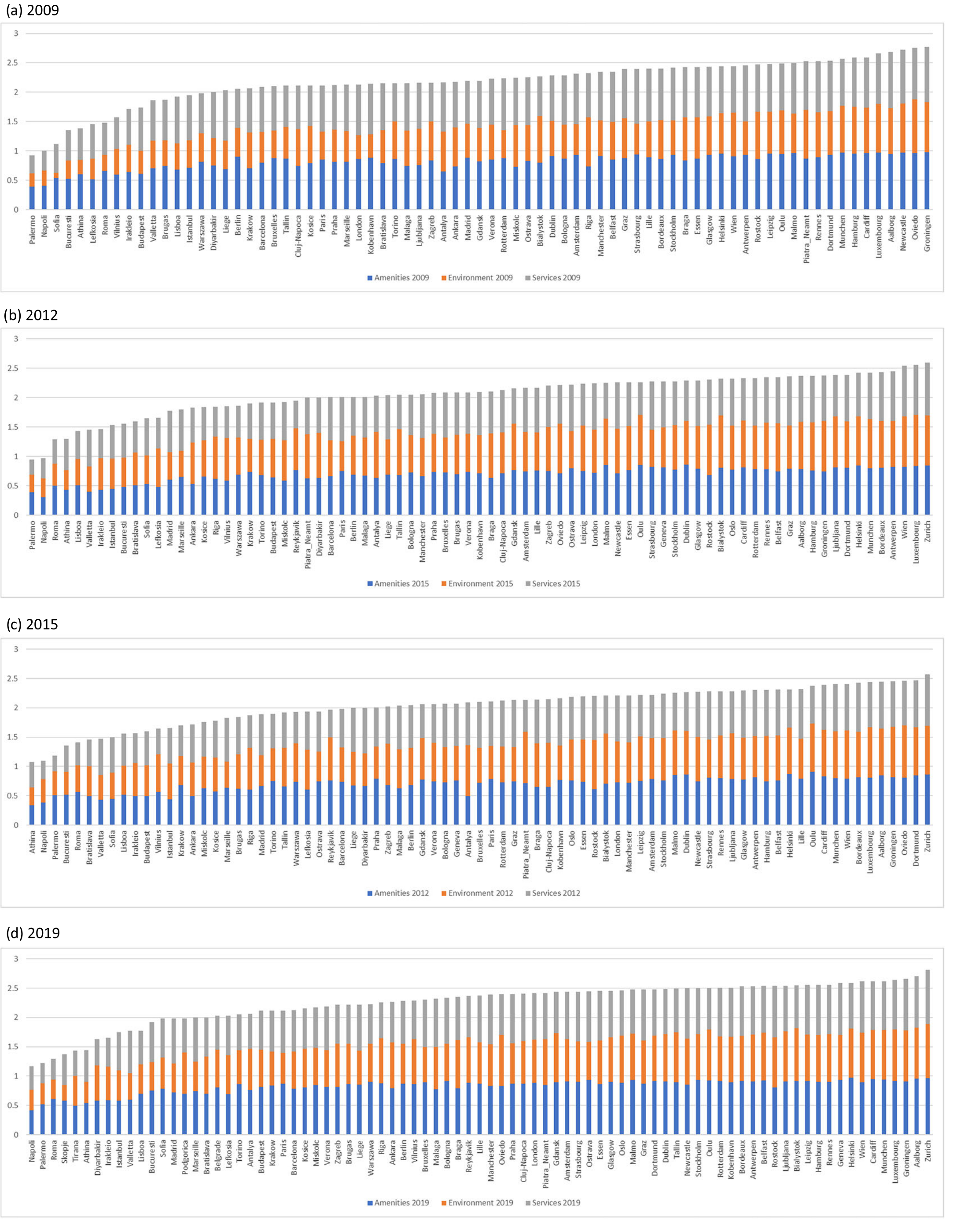

FIGURE 12 SLI components over time and cities.

previous section, we introduced a ±25% noise in the weighting scheme. Figures B1–B4 display the corresponding 5th and 95th percentiles (bars) of the distribution of the SLI per city, while the points indicate the original value of the SLI. From this analysis we can conclude that, for the best and the worst cities, the original SLI value does not change its distribution when we introduce uncertainty. This implies that the original SLI provides a trustworthy picture of urban liveability for the elderly that is generally not biased.

5 | CONCLUSIONS AND POLICY IMPLICATIONS

The proposed urban liveability assessment metric and the methodology adopted is going to enable city governments to devise appropriate policies and take proper actions to improve liveability from a quantitative perspective. The indicator may be used at the national, state and local levels to compare the liveability of cities, and effort is required to translate the informative message of an index into planned decision making. The SLI intersects many policy domains and allows city policy makers to base their interventions on comparative and substantive assessments of urban liveability. The SLI presented in this paper in particular offers a tool for measuring and evaluating the potential of certain cities for older people. It covers not only the subjective appraisal of the features of the city, such as cleanliness and air quality, but also opportunities for spending time enjoying the outdoor environment and receiving services delivered by local public administrations, whose importance is essential for ensuring active and healthy ageing. Moreover, it captures how EU cities differ with respect to the individual variables as the complexity of cities forces the analysis of pathways to health and wellbeing that are influenced by environmental factors. In addition, liveability and age-friendliness of urban environments is a complex, dynamic and multi-dimensional concept which is also highly context dependent. The results show an evident disparity between Northern and Southern European cities, which require interventions in terms of cohesion policies to boost the liveability potential of those lagging behind. The relevance of the institutional framework for the development of liveable cities is further validated by a correlation of 0.70 between the 2019 SLI and the 2017 Regional Quality of Government (QoG) Index developed by Charron et al. (2014). Moreover, a deeper analysis confirms that all three pillars of the QoG Index, namely quality, impartiality and corruption, positively correlate to our composite indicator, with values around 0.70. This indicates that welfare policies are better developed in regions whose government quality is higher. A closer interpretation of the results suggests that accessibility to and provision of services is lacking in Northern European cities to some extent, but mostly in Southern European cities, lowering the overall assessment of liveability by elderly people. As a matter of fact, this population group requires adequate support to age in place, especially for what concerns transportation, health care and help from local administration. For example, local governments may implement an individual-based transport service to hospitals or medical centres based on vouchers or discounts with the city's taxi services. Furthermore, the contribution of liveability to social cohesion matters in the creation of cleaner, greener and more culturally active neighbourhoods. Promoting the use of electric public transport, lowering the price of transport passes or reinforcing the use of public electric cars or bicycles goes in that direction. The enhancement of the quality of life of a community of citizens can occur through social and environmental progress, in which the achievement of basic needs is necessary but not sufficient and must be complemented by conditions to fulfil everyone's full potential. In this vein, there is a correlation equal to 0.58 of SLI 2019 with the 2020 EU Social Progress Index (EC, 2020), a measure of societal development and quality of life at the regional level. Future developments of the SLI include the next waves of the Perception Survey on the Quality of Life in European Cities to add more information regarding the dynamics of liveability standards and suitability for the elderly, especially with the COVID-19 pandemic.

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APPENDIX A

TABLE A1 Descriptive statistics for the SLI and its axes by geographical area.

	SLI				Accessibility to services				Amenities				Features of the urban environment			
	2009	2012	2015	2019	2009	2012	2015	2019	2009	2012	2015	2019	2009	2012	2015	2019
Mean	72	68	68	75	81	69	69	83	77	73	68	73	59	66	68	70
Min	31	36	32	39	39	34	30	42	31	34	26	34	8	31	30	27
Max	92	86	87	94	98	91	86	97	95	93	90	93	91	89	89	92
Std. dev	13	11	11	12	14	13	13	12	13	13	12	13	17	13	14	14
Western Europe																
Mean	80	75	76	82	90	77	77	89	84	83	78	83	65	71	73	75
Min	69	61	60	67	82	61	65	74	66	72	65	72	47	44	45	50
Max	92	86	87	94	98	87	84	97	95	93	90	93	85	86	86	92
Std. dev	6	6	6	6	4	6	5	5	7	5	6	5	13	11	12	11
Southern Europe																
Mean	64	59	57	63	71	58	56	69	69	62	58	62	51	58	57	58
Min	31	36	32	39	39	34	30	42	31	34	26	34	23	31	30	34
Max	92	82	74	80	96	81	73	92	88	82	73	82	91	89	85	86
Std. dev	15	13	13	13	15	14	13	13	16	15	13	15	18	15	17	16
Northern Europe																
Mean	79	73	74	83	89	77	75	91	82	77	70	77	65	74	76	80
Min	52	55	62	75	59	56	59	83	54	61	51	61	40	64	65	72
Max	91	81	81	90	97	91	86	97	95	88	80	88	84	82	85	87
Std. dev	9	7	6	4	10	10	8	4	10	7	10	7	13	5	5	5
Eastern Europe																
Mean	67	63	66	72	75	65	67	81	71	68	64	68	56	62	68	66
Min	37	45	52	46	52	45	48	49	50	43	53	43	8	39	49	27
Max	84	76	79	85	87	79	82	94	82	86	79	86	83	88	89	90
Std. dev	12	9	8	11	10	11	11	11	10	10	7	10	19	14	11	14

APPENDIX B

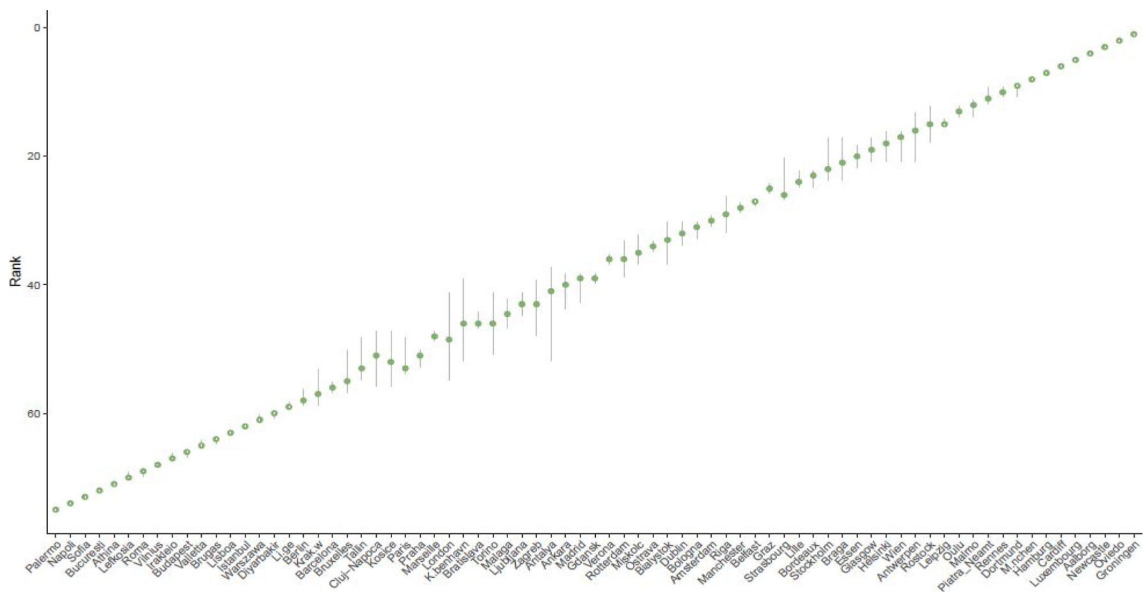

FIGURE B1 Results of uncertainty analysis for 2009 SLI rankings.

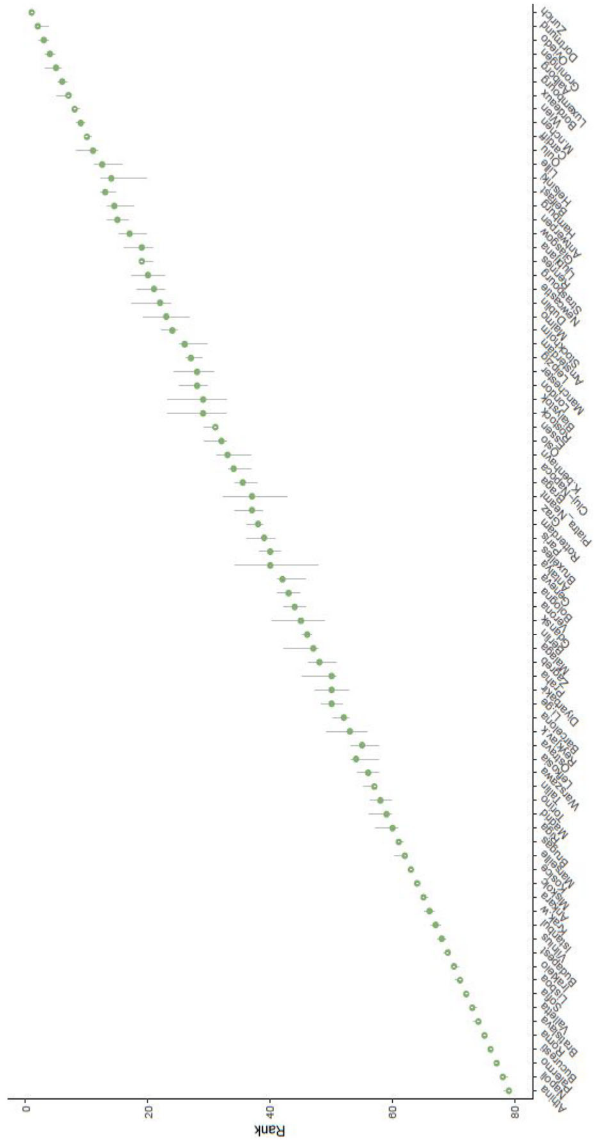

FIGURE B2 Results of uncertainty analysis for 2012 SLI rankings.

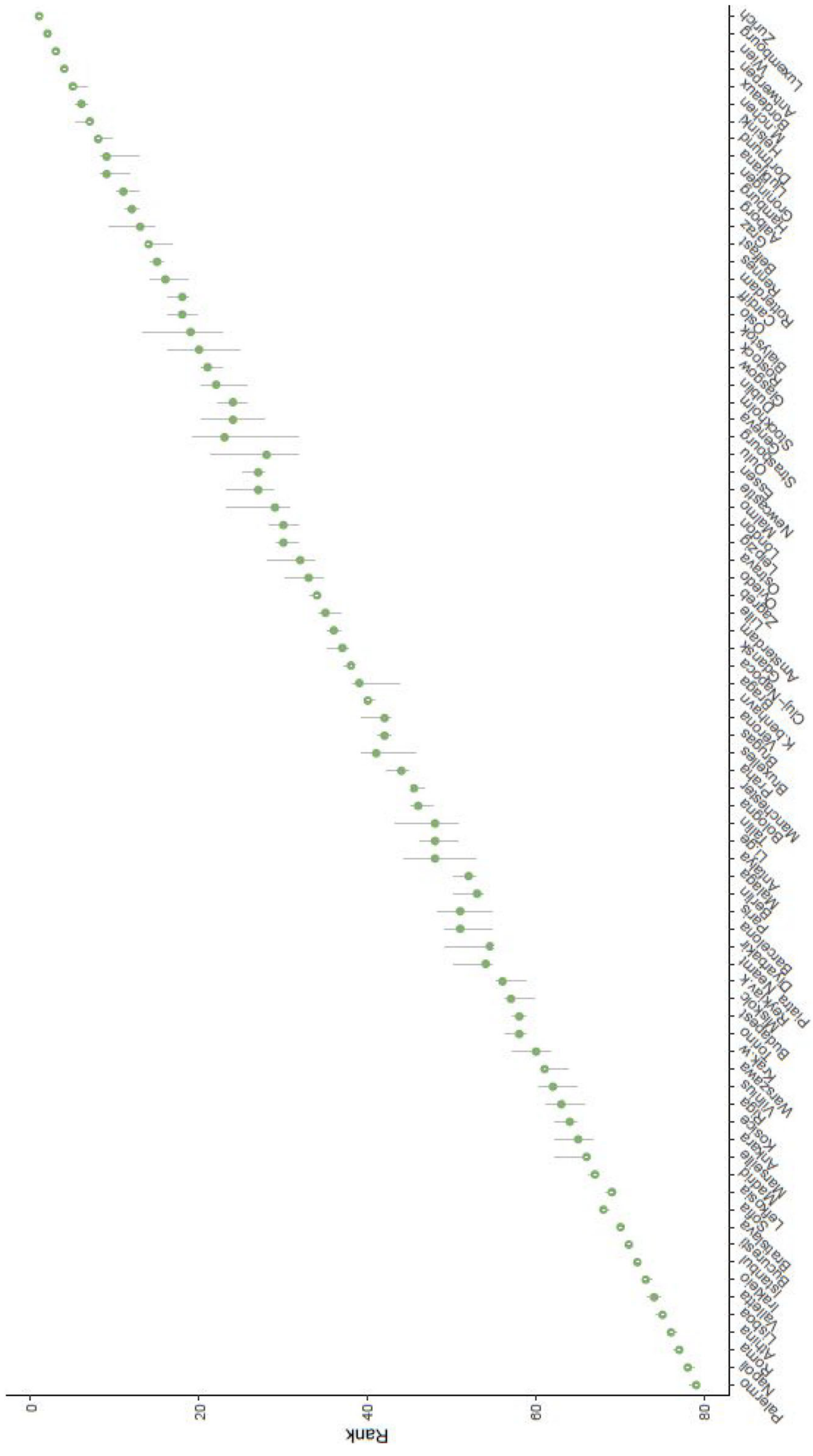

FIGURE B3 Results of uncertainty analysis for 2015 SLI rankings.

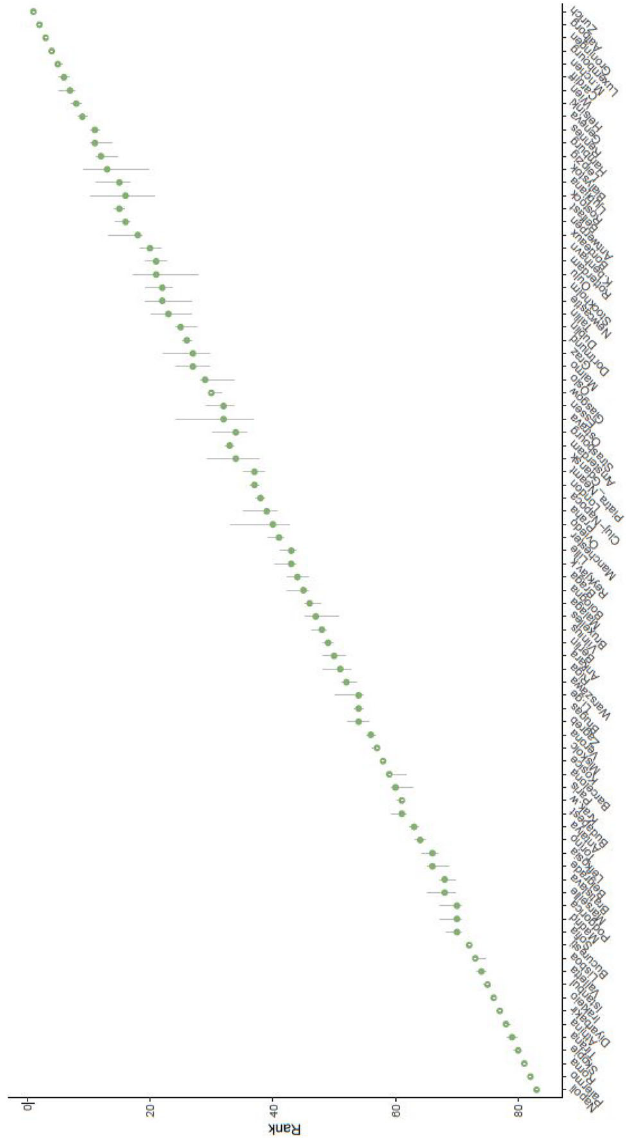

FIGURE B4 Results of uncertainty analysis for 2019 SLI rankings.

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Resumen. El reto demográfico del envejecimiento de la población en los países europeos debe evaluarse en términos de sostenibilidad y eficacia de las políticas públicas para mejorar la calidad de vida de las personas mayores. La Comisión Europea realiza desde 2004 un seguimiento de la calidad de vida en las ciudades europeas mediante una encuesta sobre la percepción que tienen los ciudadanos de su habitabilidad. Dado que la evaluación de la calidad de vida engloba multitud de aspectos positivos y negativos, se ha desarrollado un indicador compuesto denominado como índice de habitabilidad de las personas mayores (SLI, por sus siglas en inglés) para clasificar los resultados de las ciudades, hacer un seguimiento de los cambios de clasificación a lo largo del tiempo y explorar las posibles razones.

抄録: ヨーロッパ諸国における人口高齢化という人口統計学的課題は、高齢者の生活の質を改善するための公共政策の持続可能性と有効性の観点から評価される必要がある。欧州委員会は2004年以降、暮らしやすさに関する市民の意識調査を通じて、欧州の各都市における生活の質を観察してきた。生活の質の評価には様々な肯定的側面と否定的側面が含まれていることを考慮して、本稿では、高齢者の居住性指数(senior liveability index:SLI)と名付けた複合指標を作成し、各都市のパフォーマンスをランク付けし、そのランクの経時的な変化を観察し、その変化の理由を探索する。