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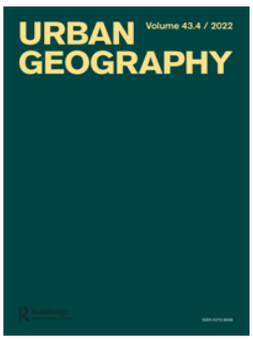

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City-regional demographic composition and the fortunes of regional second cities

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ABSTRACT

This paper asks whether meaningful differentiations between small and medium-sized cities – "regional second cities" – can be constructed based on their demographic composition, and how these cities differ among each other and from core cities. We investigate 64 regional second cities in eight British city-regions, based on the demographic groups developed from the 2011 census and mapped by the BODMAS/Datashine project. First, we conduct a cluster analysis to extract demography-based city typologies. Second, we look for regularities within and contrasts between clusters to test whether these typologies are meaningful. Third, we compare population diversity and the representation of specific demographic groups in second cities and core cities. The results confirm that it is possible to meaningfully differentiate among cities based on demographic profile, reveal systematic differences between core and second cities across the UK, identify challenges in specific second city types and discuss their positionality and engagement in city-regional dynamics.

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Demographic composition; city-regions; second-tier cities; small and medium-sized cities; population diversity

1. Introduction

City-regions, large systems of proximate urban centers linked to each other and to a shared hinterland, are increasingly experiencing processes of functional, economic, institutional and spatial interdependence. However, the small and medium-sized cities that constitute city-regions alongside large core cities – conceptualized here as regional second cities – are often dismissed as an indistinct backdrop to a core city that captures the attention of scholars and policymakers (Servillo et al., 2017). Across Europe, the city-region narrative has expanded on the success story of large cities as places of innovation, growth, dynamism and international competitiveness. This tendency, that some label as "metrophilia" (Waite & Morgan, 2019), removes the spotlight from regional second cities. This is quite an oversight, not only because Europe is weaved around a diverse landscape of medium-sized cities and towns with unique historical trajectories, but also because these cities are often the weakest link in city-regional networks that claim to pursue joint strategies.

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The economic geography literature has been concerned with how city-regional integration can extend the benefits of urban agglomeration beyond the main cities. From an economic perspective, there is the expectation of "borrowed size" processes, through which positive effects of agglomeration are equalized across cities despite differences in size and centrality. Smaller cities can thus exhibit some features typical of larger cities, such as hosting top-level amenities, increasing economic productivity, or achieving higher population growth rates (Alonso, 1973; Meijers & Burger, 2017). From a governance perspective, there is the assumption that adhering to the city-regional network enables just and balanced growth in *all* cities (Beel & Jones, 2021; Haughton et al., 2016).

However, city-regional dynamics generate uneven socioeconomic effects and development prospects across places. The persistence of intra-regional imbalances beyond what can be explained by size differences signals the presence of "agglomeration shadows" (Burger et al., 2015), by which smaller cities are emptied out of population, jobs and amenities due to the polarizing effect of a dominant core. At the same time, the preference for competitive over distributive models of territorial development and deal-making as the interaction mechanism among unequal partners, emerging from the agglomeration economics rationale and the reduction of collective responsibility by the state (O'Brien & Pike, 2015), exacerbates intra-regional inequalities (Beel & Jones, 2021) and constrains regional cooperation (Cardoso, 2016). This creates a generally unfavorable context for regional second cities.

Acknowledging that regional second cities are places with distinctive features and challenges worthy of attention, rather than just "collapsing into the mass of the city-region" (Pendras & Williams, 2021, p. 1), helps us identify their specific role and position in larger networks, and formulate better policy options for city-regional development. This requires the definition of criteria of differentiation between, and a systematic categorization of, regional second cities. Earlier literature has achieved that according to relative size and centrality (Volgmann & Rusche, 2020), networking abilities (Sýkora & Mulíček, 2017), functional specialization, economic dynamics (Hamdouch et al., 2017; Meili & Mayer, 2017), and capacity for agency to occupy a preferred position in regional networks (Kaufmann & Meili, 2019). That research allowed the definition of some distinctive second city types and roles in city-regions.

This paper proposes a new way to differentiate between these uneven collections of cities by analysing the demographic composition of regional second cities. This is relevant not only to trace their overall profile, but also to assess their liveability, attractiveness for people and firms, and fortunes in the competitive arena of city-regions. Indeed, alongside the *quantitative* dimensions of population size and change, used to assess both "vibrant" and "shrinking" second cities (Smith, 2017), the *qualitative* dimension of population composition matters for urban economies and policy development, particularly the levels of population diversity (Arribas-Bel et al., 2013; Rodríguez-Pose & Berlepsch, 2019; Syrett & Sepulveda, 2010), and the representation of specific socioeconomic groups (Dembski et al., 2017). But these have been relatively understudied aspects of demography as a factor of urban differentiation, when compared to size, growth and decline (Franklin, 2020).

Therefore, by combining the arguments that regional second cities need new frameworks of differentiation and categorization, and that demographic composition is an unexplored but relevant factor to understand their role in city-regional dynamics, two

questions are asked. First, can we meaningfully differentiate between these cities based on their population composition? In other words, does an analysis of the mix and balance of different demographic groups return a clear set of regional second city profiles and are they meaningful enough to be reflected in other distinctive and relevant features? And second, how do regional second cities differ demographically from each other and from core cities, and in what way might these characteristics matter for their role and prospects in city-regions?

Both questions are explored by analysing the distinctive demographic profiles of 64 regional second cities and their respective core cities in eight British city-regions. The research relies on the detailed mapping of the spatial distribution of population "supergroups" in the United Kingdom, based on clusters of demographic characteristics extracted from the 2011 Census (BODMAS/Datashine, 2014). This dataset allows a multilevel assessment of demographic features, as the supergroups are built according to several socioeconomic indicators, including age, education, housing types, ethnicity, and others. The UK is a topical case not only due to the availability of this data, but also because its regions are being spatially and institutionally rearranged by the emergence of combined authorities with extensive powers and resources, which have been criticized as examples of intra-regional imbalance and non-inclusive growth (Beel & Jones, 2021).

We first review current research on regional second cities to discuss why population composition is relevant to characterize them, namely when considering the demographic and socioeconomic imbalances in British city-regions. Then the methodology is introduced, based on a geodemographic analysis of the spatial distribution of census-based population groups in eight city-regions. The empirical part is divided into three parts. First, a cluster analysis is conducted to return a number of typologies of regional second cities with similar population profiles. Second, the similarities and differences between these typologies are elaborated in order to build differentiated portraits and discuss how much they reveal about the cities. Third, second cities are compared to each other and to core cities, based on the two aspects of population composition considered most significant – diversity and the representation of specific groups. The conclusion examines the implications of different second city profiles for their development and position in city-regional dynamics.

2. Population composition as a differentiation factor in regional second cities

Population size and growth are often used as proxies of urban success. Size triggers agglomeration economies, enabling added functional performance, attractiveness to people and firms, and productivity. Growth is a simple and accessible indicator of performance, as it responds to differences in employment or quality of life between places (Turok & Mikhnenko, 2007). However, size also triggers agglomeration diseconomies and growth (and decline) become inadequate indicators for broader socioeconomic dynamics in cases of demographic stability or shrinkage, such as Western Europe (Franklin, 2020). In addition, both size and growth mean very different things for the character and development of places depending on the type and variety of population that contribute to it.

Population composition thus becomes an important feature to characterize cities, differentiate them beyond their size and design their policies, as it has implications for income inequality, residential segregation, institutional cooperation, labor specializations, functional roles, and economic dynamism (Franklin, 2020), all of which help explain the role of cities in city-regions. Indeed, second cities in the same city-region often experience contrasting fortunes along all these dimensions, but knowledge about what drives these discrepancies is still scarce (Meijers & Cardoso, 2021). Taking the population composition lens to differentiate them provides a new angle on comparative research on the topic, which contests certain assumptions about their role in city-regional dynamics and is particularly relevant in light of the unbalanced processes of demographic redistribution in British city-regions, as we now discuss.

2.1. Regional second cities and city-regional complementarity: a demographic lens

The diversity of small and medium-sized cities in multicentric city-regions sparked a large amount of research on their specific features and relational position in broader networks (Meili & Mayer, 2017; Pendras & Williams, 2021). Many approaches attempt typological characterizations, rather than analysing cities case-by-case. Alongside differentiations by population size and change (but *not* composition, as noted), regional second cities have been classified by economic profile – residential, productive, mixed (Hamdouch et al., 2017), spatial structure – autonomous, networked, agglomerated (Sýkora & Mulíček, 2017), service specialization – tourism, retail, job centers (Malý, 2016), and functional orientation, as in the typologies developed by the SMST project in Switzerland – from "alpine tourism" to "high-tech" towns (Kaufmann & Meili, 2019; Meili & Mayer, 2017).

A common thread in these studies is that regional second cities tend to specialize in certain economic-functional roles that together complement the overall city-regional system, in contrast with the more encompassing profile of core cities. Although different cities are likely to have different trajectories to choose from and depend on larger economic dynamics and policy decisions, the literature on borrowed size does argue that they can afford specialization because the functions and activities they lack are available in other cities nearby and housing and labor markets operate at larger scales (Meijers & Burger, 2017). The integrated city-region thus captures a broader range of functions and assets, which it can exploit efficiently to trigger agglomeration benefits. However, even if specialized city profiles become assets from economic or functional perspectives, the "specialization towards complementarity" logic may not hold for demographic factors. Population composition contrasts can reveal a different picture of second city typologies and relations in city-regions.

Population diversity illustrates this point: a diverse population mix in which different groups are represented in a balanced way can bring socioeconomic benefits and matters to the reputation and liveability of places. A heterogeneous mix coexisting in close proximity, in terms of age, ethnicity, education, job sector, socioeconomic profile and lifestyle, has been a hallmark of "cityness" for centuries (Arribas-Bel et al., 2013; Storper & Venables, 2004). Capturing the "urban buzz" enabled by diversity has become part of urban planning agendas aiming to realize the so-called "diversity dividend" (Syrett & Sepulveda,

2010), as studies show positive and long-lasting links with economic and non-economic gains. These include a larger variety of available skills, markets for goods and services, social networks and opportunities for innovation, and even more open-minded political preferences (Gimpel et al., 2003; Ottaviano & Peri, 2006; Quigley, 1998; Rodríguez-Pose & Berlepsch, 2019).

However, an individual city might not gain from such a city-regional demographic arrangement if its "specialized" contribution is a very homogeneous local configuration. First, the benefits listed above are scale-dependent and have little weight on local development if diversity is achieved only at the city-region level. Gordon and Monastiriotis (2006) show that British city-regions that are diverse overall form large "patches" of socioeconomic homogeneity, due to the many opportunities for residential choice enabling household self-selection into similar clusters. If these homogeneous patches are larger than the channels through which social interaction operates (catchment areas of urban functions, daily mobility flows), diversity becomes invisible in daily life and its effects on localities may be inhibited.

Second, in many cases these homogeneity patches composing the city-region represent deprivation clusters caused by the displacement of lower income groups from the core to other smaller nearby cities (Bailey & Minton, 2018). This typically leads to one of the imbalances noted in critiques of British city-regional dynamics: the overrepresentation of deprived groups in regional second cities (Dembski et al., 2017). As a result, regional second cities can simultaneously become less diverse, losing access to its potential benefits, and more burdened with poverty concentrations, facing additional challenges for local development.

Therefore, population composition contrasts between cities in a city-region do not respond to the specialization-complementarity logic used in functional and economic frameworks to model intra-regional relations and inform policy decisions. The overall benefits of pooling together specialized and complementary cities in a city-region can obscure local winners and losers, especially in competitive systems where collective responsibility and redistribution have little weight, as in British city-regions. In an asymmetrical playing field, relative equalization across cities may be considered preferable to city-regional complementarity and regional second cities may therefore strive for encompassing local economies of their own, competing to attract people, investments and amenities (Cox & Longlands, 2016). For local policymakers, borrowed size abilities become more about accessing resources from the larger system to mitigate weaker local development factors than chipping in with their specializations to complement other cities and benefit the city-region.

2.2. Population redistribution trends in British city-regions

Four implications can be derived from the discussion so far:

- Enabling a diverse and balanced population composition to trigger socioeconomic benefits is generally a desirable policy goal, and has indeed become a "new guiding principle" (Fainstein, 2005, p. 3) for urban policymakers.
- The spatial reach of demographic effects turns the ambition of attracting such a mix a *local* rather than a city-regional aim, which means that demographic contrasts

between cities must exist and may reflect how they approach that aim within the city-region.
- The diversity ambition is generally coupled with attracting wealthier and educated groups and avoiding deprivation, meaning that cities compete for similar and narrower population profiles, which tend to be available to only a handful of places.
- That ambition triggers, and clashes with, the parallel trend of concentrated deprivation shaped by city-regional demographic redistribution, suggesting that population profiles of regional second cities reveal the winners and losers of that competition.

These issues are exacerbated by the imbalanced and competitive nature of British city-regional strategies. It was noted early in the process of institutionalization of city-regions as combined authorities that furthering the agglomeration economics narrative of size and density as triggers of development promotes further detachment between core cities and the regional hinterland. O'Brien and Pike (2015) point out the rationale of competitiveness behind the City Deals model as a tool of strategy-making and the withdrawal of the state as a mechanism of mediation and redistribution. Cox and Longlands (2016) criticize the dominant "big city narrative" in city-regional planning and its consequences of further benefiting the winners and overlooking struggling smaller cities. Waite and Morgan (2019) and Beel and Jones (2021) ask whether city-regional models can promote inclusive growth, as their reliance on city-centric narratives of development results in uneven policy and fiscal conditions, encourages intra-regional rivalries and imposes competitiveness on partners with unequal levels of power to advance local agendas.

Several authors converge in the argument that such city-regional visions neglect pre-existing geographies, namely imbalances emerging from earlier phenomena such as the displacement of lower income groups from the core city to other cities in the regional hinterland, known as the suburbanization of poverty (Bailey & Minton, 2018). This has been happening partly as a result of the so-called "urban renaissance" undergone by cities in the late 1990s, supported by national policies to that effect (Rae, 2013). Through these policies encouraging the return to cities, mixed and cosmopolitan centers became appealing again for younger and educated societal groups with greater purchasing power (Cheshire, 2006; Davidson & Lees, 2005). However, this trend has been mostly limited to the core cities of each city-region – London, Manchester, Bristol. Smaller neighboring cities were unable to compete to attract similar inflows and their growth was fueled by poorer population groups willing to commute and displaced by the increase in housing and living costs in the main cities, which cascaded into several development barriers (Dembski et al., 2017). A diverse demography in the city-region is a poor consolation for the cities in question, even if they experience net population growth and keep functional links to the core (Swinney et al., 2018) – they still face an agglomeration shadow expressed by their role as receivers of core–periphery displacements. Once again, the benefits of hosting a diverse and balanced population mix become available only to some places, typically core cities. City-regional visions ignoring these geographies and assuming a level playing field overlook these negative interactions.

In conclusion, population composition is an important and unexplored lens of differentiation between cities in general, and particularly important for the case of regional

second cities assumed to play specialized and complementary roles but facing unbalanced and competitive city-regional dynamics. An analysis of population composition can tell us something about what types of urban demography are shaped by the constraints of city-regions, what roles different cities play in larger population redistribution processes, and how they navigate the tensions between local priorities and city-regional integration.

3. Methodology

The analysis of population composition in cities in UK city-regions focuses on the construction of distinctive typologies through a cluster analysis, their characterization and associations with other features relevant for urban development, and finally on the comparison of population diversity and representation of different groups, checking for consistent distinctions among regional second cities and between them and core cities in various city-regional settings.

The study relies on the mapping of demographic data taken from the UK Census 2011, made available by DataShine, a platform developed by James Cheshire and Oliver O'Brien (UCL) as part of the ESRC BODMAS project, which ran at UCL between 2013 and 2015. It connects indicators from the 2011 Census with open geographical data, allowing the visualization of demographic indicators plotted over a user-friendly map that can be displayed and manipulated in web browsers (O'Brien & Cheshire, 2016; http://oac.datashine.org.uk).

The data used come from DataShine OAC, a geodemographic classification of eight prevalent socioeconomic "supergroups" of population, developed and mapped by Chris Gale (UCL) in partnership with the Office for National Statistics (ONS). The method clusters the results of statistical indicators according to key characteristics common to the population in each group (ONS, 2016). This is now called the 2011 Area Classification for Output Areas and covers a variety of socioeconomic indicators available at the smallest possible scale (Output Area, avg. pop. 309). An initial list of 167 elementary census variables were transformed to avoid skew and reduce outliers, and then standardized to ensure compatibility. This allowed building datasets from which 60 final variables were derived, on demographic structure, household composition, housing, socioeconomic features and employment. Finally, k-means cluster analysis was applied, with numerous outputs and permutations tested to create the final hierarchy. The identification of the optimal cluster number led to a classification of three hierarchical tiers of eight Supergroups, 26 Groups and 76 Subgroups. Here we use only the top tier for the sake of synthesis and to produce meaningful contrasts between places.

More details about the method to construct these groups, including the exact list of variables and the allocation of socioeconomic typologies to statistical subsections can be found in the ONS Methodology Note (ONS, 2015a). ONS materials also include pen portraits and radial plots describing the distinctive characteristics of each supergroup, shown in Table 1. This is an informal summary of the strict outputs produced by the clustering algorithm, aimed at making the classification accessible and relevant for end users (ONS, 2015b). Note that Supergroup 1, called "Rural Residents', was

Table 1. Summary of characteristics of Supergroups 2–8. See more details in ONS, 2016 (archived). Comparisons (e.g. "lower" or "higher") are made with the UK as a whole. Cells where no feature is given mean that the group is not clearly distinctive in that particular variable.

SUPERGROUP	AGE	TENURE	HOUSING TYPE	EDUCATION	JOBS	POPUL. DENSITY	TRANSPORT MODE	IMMIGRATION ETHNIC MIX
SG2 Cosmopolitans	*younger*	*private rent*	*flats*	*higher*	*high-end services*	*higher*	*public*	*higher*
SG3 Ethnicity Central	*younger*	*private rent*	*flats*	–	*services*	*higher*	*public*	*higher*
SG4 Multicultural Metropolitans	–	*social + private rent*	*terraced*	*mid-lower*	*low-end services + admin.*	*higher*	*public*	*higher*
SG5 Urbanites	–	*private rent*	*flats + terraced*	*average*	*services + public sector*	*average*	–	*mid-higher*
SG6 Suburbanites	*older*	*buy*	*detached*	*higher*	*services + public sector*	*lower*	*private*	*lower*
SG7 Constrained City Dwellers	*older*	*social rent*	*flats*	*lower*	–	*higher*	*private*	*lower*
SG8 Hard-pressed living	–	*social rent*	*terraced*	*lower*	*industrial + retail*	*lower*	–	*lower*

practically inexistent in the city-regions and was removed from the analysis. We refer hereon to seven supergroups, labeled SG2 to SG8.

While the census-derived data is based on non-geographical variables, geographic groupings emerge from the mapping through spatial autocorrelation, linking specific groups to locations and allowing insights on the spatial distribution of population. Note that spatial allocations are based on the prevalent supergroup in each statistical unit, which does not mean that other groups cannot co-exist in the same locations. Classifications are an average across the local area, rather than for individual households, which is a convenient simplification of the variations within places (Gale, 2014). But this is mitigated by the fact that the spatial allocations occur at the smallest existing statistical units, Output Areas, originally designed to be as socially homogenous as possible (ONS, 2016). Significant deviations from the prevalent supergroup are therefore not expected, and the allocations are considered robust.

The raw data identifying the supergroup attributed to each Output Area was downloaded from the ONS website. Allocated Output Areas were then aggregated into Lower Super Output Areas and then into Wards, as defined for the 2011 Census. Finally, Urban Areas were manually defined – based on ward boundaries but rarely coincident with local authority boundaries – to achieve an adequate approximation of the morphology of the 72 cities in the analysis (eight core cities and 64 regional second cities). The selection of cities and towns in each city-region covers the main urban areas. A broad population interval was adopted, ranging from 41,495 (Kirkby) to 336,261 (Coventry), to capture a wide variety of second cities. In some situations, areas that have merged together morphologically are taken as one – see e.g. Clevedon-Portishead.

The result is a distribution of supergroups (SGs) in each city measured by the number of Output Areas (OA) in which they prevail. To exemplify, the city of Bath has 300 OAs, ranging from 3 OAs in SG3 (1%) to 118 in SG5 (39%). Greater London has 26,521 OAs, ranging from 281 (1%) in SG7 to 9,996 in SG3 (38%). This forms the basis for all the subsequent analyses, explained in detail in the relevant sections. The city-regions selected for the study all feature an important core city – London, Birmingham, Manchester, Liverpool, Leeds, Sheffield, Bristol and Newcastle – and are experiencing integration processes which involve their second cities, either functionally or institutionally. In some cases, such as Warrington, cities are between two city-regions and participate in the life of both: some ad-hoc decisions were made about where to include them, but this is not seen as affecting the results. Table 2 shows the eight city-regions and their constituent cities, together with the 2016 population (ONS).

4. Results

The paper now focuses on four sets of results addressing the questions formulated earlier. First, a cluster analysis groups 64 regional second cities according to their demographic profile based on the relative distribution of population among the seven supergroups. This serves to generate different typologies and identify their similarities and differences. The typologies are then associated with other socioeconomically relevant urban characteristics, to assess the value of the results returned by the analysis and check whether population composition is a meaningful way to differentiate between second cities.

Table 2. Cities in the analysis and respective populations (for simplicity, the designation of each city-region – e.g. West Midlands – has been replaced by the name of the core city; populations based on adding the ONS 2016 estimates of relevant ward populations).

London	Manchester	Liverpool	Birmingham	Newcastle	Sheffield	Leeds	Bristol
8,778,500	541,263	484,578	1,124,569	274,721	538,361	571,505	454,213
Medway	Bolton	Warrington	Coventry	Sunderland	Rotherham	Bradford	Bath
242,902	*162,019*	*172,671*	*336,261*	*175,595*	*103,518*	*322,296*	*94,462*
Reading	Oldham	Birkenhead	West Bromwich	Gateshead	Doncaster	Huddersfield	Weston
234,190	*160,583*	*151,361*	*322,712*	*96,380*	*102,261*	*157,519*	*82,333*
Luton	Salford	Widnes-Runcorn	Dudley-Stourbridge	South Shields	Mansfield	York	Clevedon-Portishead
216,791	*159,029*	*120,498*	*317,634*	*83,204*	*91,511*	*155,695*	*47,664*
Aldershot	Sale-Altrincham	Bootle-Crosby	Wolverhampton	Blyth-Cramlington	Barnsley	Dewsbury-Batley	Yate
190,213	*124,247*	*110,165*	*256,621*	*56,230*	*89,552*	*137,763*	*42,587*
Slough	Stockport	St Helens	Telford	Washington	Chesterfield	Wakefield	–
147,181	*116,853*	*104,125*	*135,344*	*55,021*	*66,993*	*94,213*	
Crawley	Rochdale	Southport	Solihull	Wallsend	Worksop	Halifax	–
111,375	*110,270*	*91,786*	*101,401*	*52,613*	*45,127*	*80,363*	
Basildon	Wigan	Chester	Walsall	Durham	–	Harrogate	–
108,746	*103,541*	*81,534*	*92,729*	*51,474*		*75,058*	
Chelmsford	Ashton-u.-Lyme	Wallasey	Nuneaton	–	–	Keighley	–
104,019	*71,506*	*61,133*	*82,973*			*51,604*	
Watford	Bury	Kirkby	Redditch	–	–	–	–
96,773	*57,879*	*41,495*	*78,963*				
Maidstone	–	–	Tamworth	–	–	–	–
93,893			*76,955*				
High Wycombe	–	–	–	–	–	–	–
80,959							

Then, we compare population diversity in core cities and regional second cities, focusing on the socioeconomic and geographical features associated with different levels of diversity, and observe the prevalence of specific population groups in certain types of cities. We check the regularity of these findings against the cluster belonging developed earlier and discuss important differences between regional second cities as well as city-regions.

4.1. Clustering second city typologies

We expect that regional second cities can be grouped into clusters based on distinctive population profiles, and that these clusters share similarities within and differences between them in other potentially relevant indicators besides population. The clusters are generated by a k-means cluster analysis, a method that separates a dataset into groups, in which observations in the same group are as similar as possible and in different groups as dissimilar as possible. The variables considered are the proportions of Output Areas in each supergroup, meaning that the clusters are formed out a matrix of 64 rows corresponding to the second cities in the dataset and seven columns corresponding to the relative shares of SG2 to SG8. The analysis was performed in R. Subsequent tests were done to determine the optimal number of clusters: algorithms for the Elbow method (based on the total within-cluster sum of squares) and Gap Statistic method (based on the deviation of within-cluster dispersion from a reference distribution) both returned an optimal result of three clusters. Note that while some sources discuss whether to perform an ANOVA test to show that the clusters differ statistically significantly, most specialists argue that that is exactly what the k-means cluster method does through other means – the clusters are constructed to differ as much from each other as possible. Therefore, further significance tests are omitted from the analysis. Only for the purposes of the visualization in Figure 1, the algorithm performs principal component analysis (PCA) to plot the results on two main axes. This step occurs after, and independently of, the cluster analysis, meaning that the PCA transformation does not affect its results.

The differentiation is indeed meaningful: three groups of regional second cities emerge, with some proximity at the edges but no overlaps and some similarities and contrasts stand out. A first observation shows that Group 1 (n = 19) gathers many historic and university cities, such as York, Chester, Durham, Solihull and Bath. Group 2 (n = 17) is quite dispersed around the mean but the common feature of these cities seems to be size – the cluster includes the largest second cities, such as Bolton, Bradford, Coventry and Reading. Group 3 is the largest (n = 28) but has the lowest dispersion. It cannot claim size or history as distinctive features and renders a more indistinct variety of new towns and former industrial cities facing economic transition. Geographically, it includes only one city from the South (Basildon) and many Northern cities, a reflection on second city typologies of the famed North–South divide in Britain.

4.2. Common factors distinguishing the clusters

The clusters above emerge only from the demographic distribution across supergroups. We now investigate whether other relevant characteristics, namely those that appear in

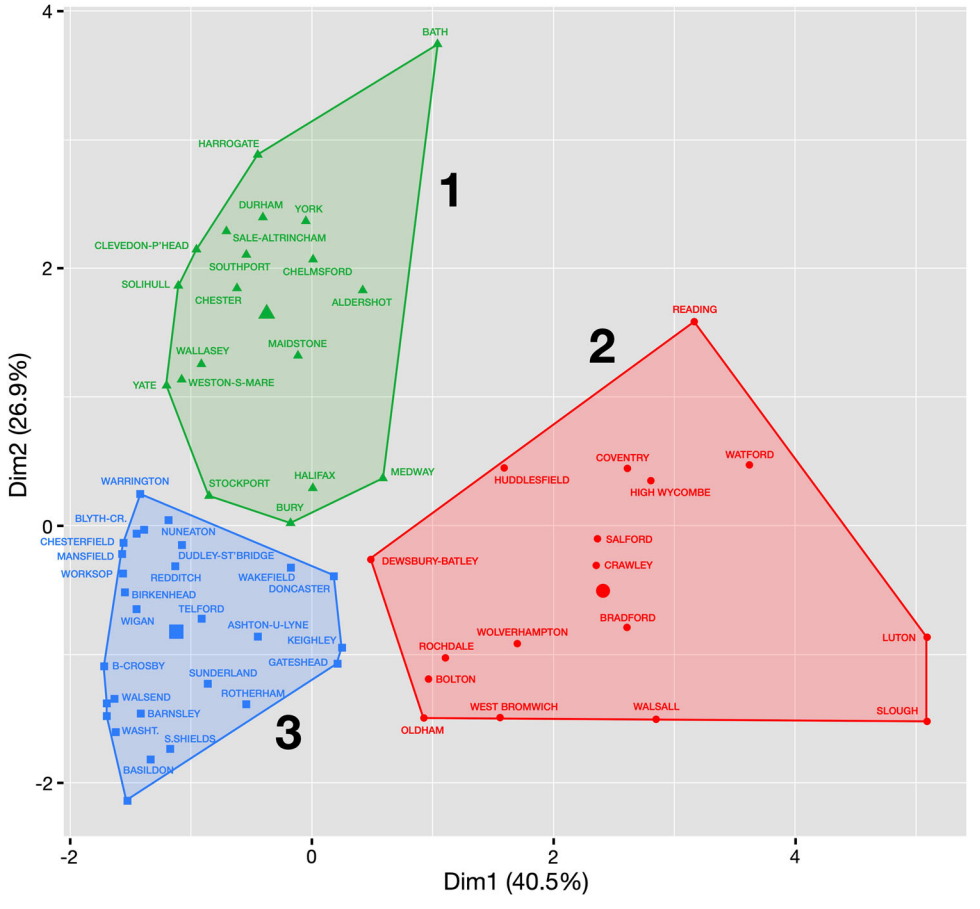

Figure 1. Cluster plot K-means cluster analysis, 3 clusters, PCA for visualization purposes.

the literature as related to demography, are also distinctive for each cluster. If that is the case, then the differentiation of regional second cities by population profile is not only scientifically sound but also relevant for research and policy. Given the relatively small sample and the likelihood that several other factors besides population influence the characteristics covered below, we expect the statistical robustness of the analysis to be quite suggestive but not fully conclusive. But that does not reduce the interest of finding similarities within and differences between clusters. Therefore, rather than conducting regressions, boxplots are used to compare the variation of each indicator for each cluster, providing a visualization of the contrasts between second city types. The analysis integrates the following indicators:

1. Urban amenities index weighted to population, adapted from the pan-European index of metropolitan functions in six major domains (institutional, economic, scientific, transport, cultural and sports), compiled by the BBSR institute (BBSR, 2011). This dataset includes standardized values for all European cities according to the presence of functions like government and firm headquarters, universities, research centers, airports, stations, stadiums, museums, musical venues, and others. Since this analysis

focuses on functions typically present in larger cities, we compensate this bias by adding an indicator applicable to every city size, namely a "Health and Leisure" index proxied by a single value derived from distance to leisure and health services and amount of green space per resident (compiled by the Consumer Data Research Centre (CDCR); see the list of indicators in Daras et al., 2017). This index is added as a seventh indicator to the six BBSR domains. The indicators, all with equal weight, are then normalized into a single index.

2. The level of population diversity, classifying each city according to a "diversity ranking" using the Herfindahl-Hirschmann (HH) index. This index is commonly used to measure primacy of firms in a market, giving more weight to larger actors to account for potential monopolies. It is equivalent to the Simpson diversity index in ecology, used to measure the degree of concentration versus diversity when individuals of a population are classified into groups (Simpson, 1949). Since the logic here is essentially the same, applying the index to the supergroup distribution provides a simple but accurate indicator of population diversity in cities. Note that the HH-index does not fully account for spatial spread, and high diversity at one scale may mask homogeneity at other scales. However, the index is applied to individual cities, allowing comparisons and providing a satisfactory overview of diversity at that scale. It is inevitable that some homogeneity at sub-city levels remains unseen, but that does not affect how the problem is framed: people identify with cities and move freely across them, and we argue that this is the scale at which population diversity is mainly perceived and produces its effects.
3. The self-reported life satisfaction in cities, an index ranging from 1 to 10 measured by the 2015 Annual Population Survey Personal Wellbeing Dataset (ONS; mean values by local authority, meaning that some cities in the sample have the same index).
4. Population growth between 2001 and 2011 to proxy urban attractiveness (ONS data).

From an intuitive assessment of the cities contained in the three clusters, we hypothesize that historic and university cities in Group 1 are likely to have more urban amenities than average for their size, higher population diversity, and high levels of attractiveness and satisfaction. By contrast, cities in the less distinctive Group 3 (many of which have experienced economic downturn and lie in less privileged regions) may have below average amenities and be generally less attractive and diverse. Group 2 cities may have additional advantages in the indicators more sensitive to size. Figure 2 shows the results.

The boxplots confirm that cities in Group 1 have indeed the highest urban functions index of the three groups, and the observations are also more concentrated, suggesting a consistent functional performance across all cities. This is the case even if their median population, the main predictor of urban functions presence (Burger et al., 2015), is smaller than Group 2 and roughly the same as Group 3, which scores lower. York, Chester and Harrogate top this rank mainly due to their scores in Health & Leisure and Cultural functions.

Group 1 cities also tend to be more demographically diverse (i.e. have a lower HH-index) than the other two groups, suggesting greater proximity to diversity levels usually seen in core cities. Nevertheless, the contrasts in median and quartile values are less pronounced than in the case of urban functions. From the literature associating

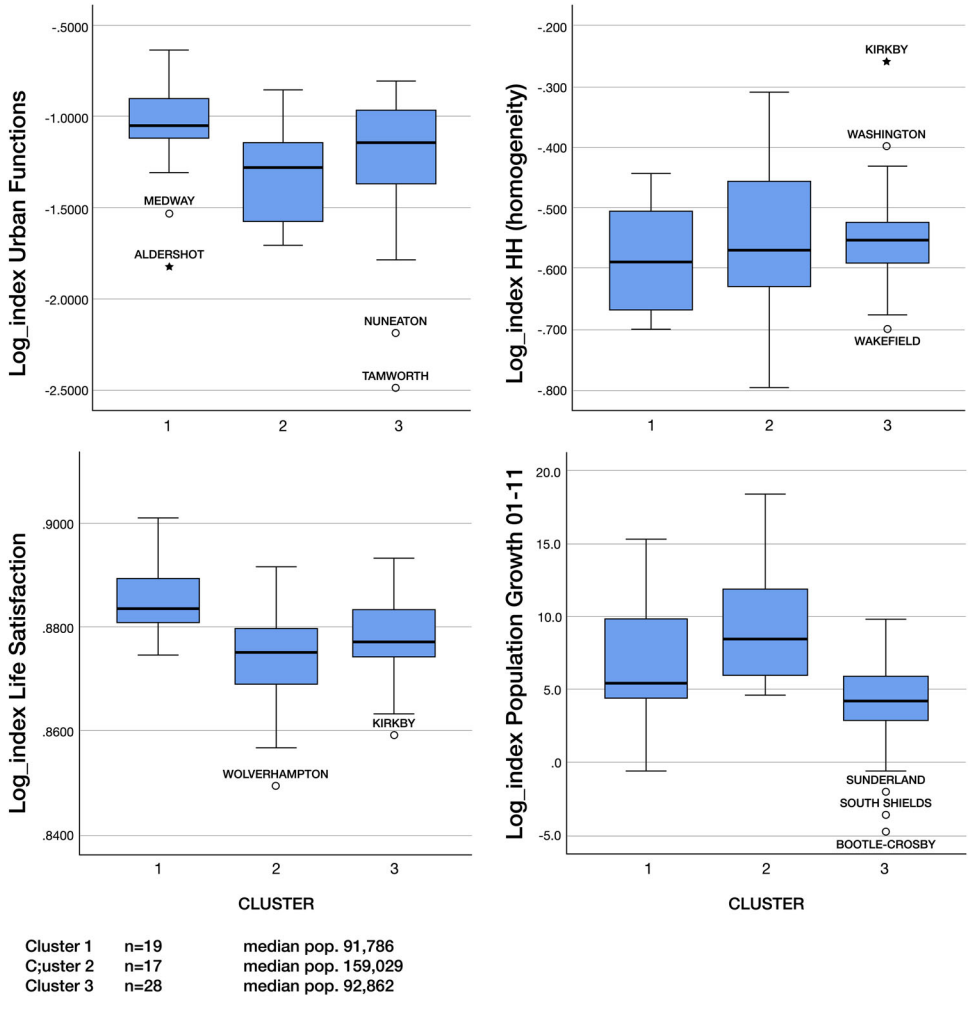

Figure 2. Boxplots of differences between clusters (1, 2 and 3). From top, (a) urban functions by population, (b) HH-index of diversity, (c) life satisfaction, (d) population growth 2001–2011.

city size and population diversity, the larger cities in Group 2 were expected to be the most diverse. However, that is not the case and this group is very dispersed, due to contrasting cities stretching the results towards both ends of the spectrum. This variety may signal the role of city-regional dynamics in diversity levels in individual cities, overriding the usual effects of size.

Self-reported life satisfaction is markedly higher in Group 1 and lowest in Group 2. The fact that amenity-poor, often struggling cities in Group 3 report greater life satisfaction than more prosperous and dynamic cities in Group 2 suggests that this feature is indeed negatively correlated with size, as found by Lenzi and Peruca (2018) for Western Europe. However, the next boxplot shows that Group 2 cities are also the ones growing faster despite offering less satisfaction, as people pursue economic opportunities and other benefits enabled by size. As expected, cities in Group 3 have the lowest growth rates, including outliers losing population.

4.3. Heterogeneity and homogeneity in core cities and second cities

We can indeed differentiate in a meaningful way between regional second city types based on their population mix, and the analysis returns a clear set of typologies with specific features. The next question is how these cities differ among each other and from core cities. We focus first on population diversity, an indicator which matters for urban economies but has not received as much attention as quantitative measures of size and growth.

In the boxplots above, it is clear that different second city types have different levels of diversity, but the differences in HH-index between the clusters are not as expressive as expected. More substantial differences can be found when comparing population composition in core cities and second cities. Overall, the patterns indicate higher levels of diversity in the former than the latter. Figure 3a shows how core city populations are distributed among supergroups (SGs). Manchester and Birmingham stand out due to the weight of SG4 (called "Multicultural Metropolitans"), which according to the ONS profiles is the closest group to the standardized mean of the UK, except for ethnicity indicators where it exhibits more variety. Therefore, it is unsurprising that it is quite common in large cities. But the other core cities have a balanced distribution across supergroups, with the largest in the range of 20–25%.

Regional second cities present a different picture, as shown in Figure 3b. Prevalent groups here climb to the range of 30–40%, with some groups which are common in core cities almost disappearing. The contrasts become more illustrative when looking at individual cities. 25 s cities host one supergroup well over 40%, with Walsall (SG4 = 58%), Kirkby (SG8 = 71%), Washington (SG8 = 57%) or Slough (SG4 = 93%) reaching extreme levels of single-group dominance, with many groups absent. Figure 3c shows some examples.

To zoom into these findings, Table 3 ranks every city according to the HH-index of diversity described earlier. Scores range from 0 to 1; the lower, the more diverse. Cities with high homogeneity include economically strong, growing cities around London and struggling cities in the North of England and Midlands. These two different types require different explanations for their population profile – looking at the index without due context is insufficient to understand them. In the case of London, it indicates that population redistribution processes are truly regional in scale, so that large patches of homogeneity – larger than individual cities – may indeed take shape in overall heterogeneous city-regions. In the smaller Northern cities, on the other hand, low diversity suggests places which suffered shocks to their economic base, gradually lost cohorts with differentiated skills, age and education to outmigration, eventually received an influx of specific population groups, and now host less demographic variety in tune with a narrower economic base. In line with the differentiation features of the cluster analysis, the ten less diverse cities include five in Group 2 and four in Group 3.

Table 3 also shows that higher diversity levels are indeed in the core cities. Five out of eight occupy the lowest positions in the ranking, alongside Salford, a large and centrally located "second city". The regional second cities that get closest to the core cities are historic cities in Group 1, as predicted: Bury, Halifax, Maidstone, York and the Medway Towns. The reader is directed to the DataShine OAC online viewer for illustrations of

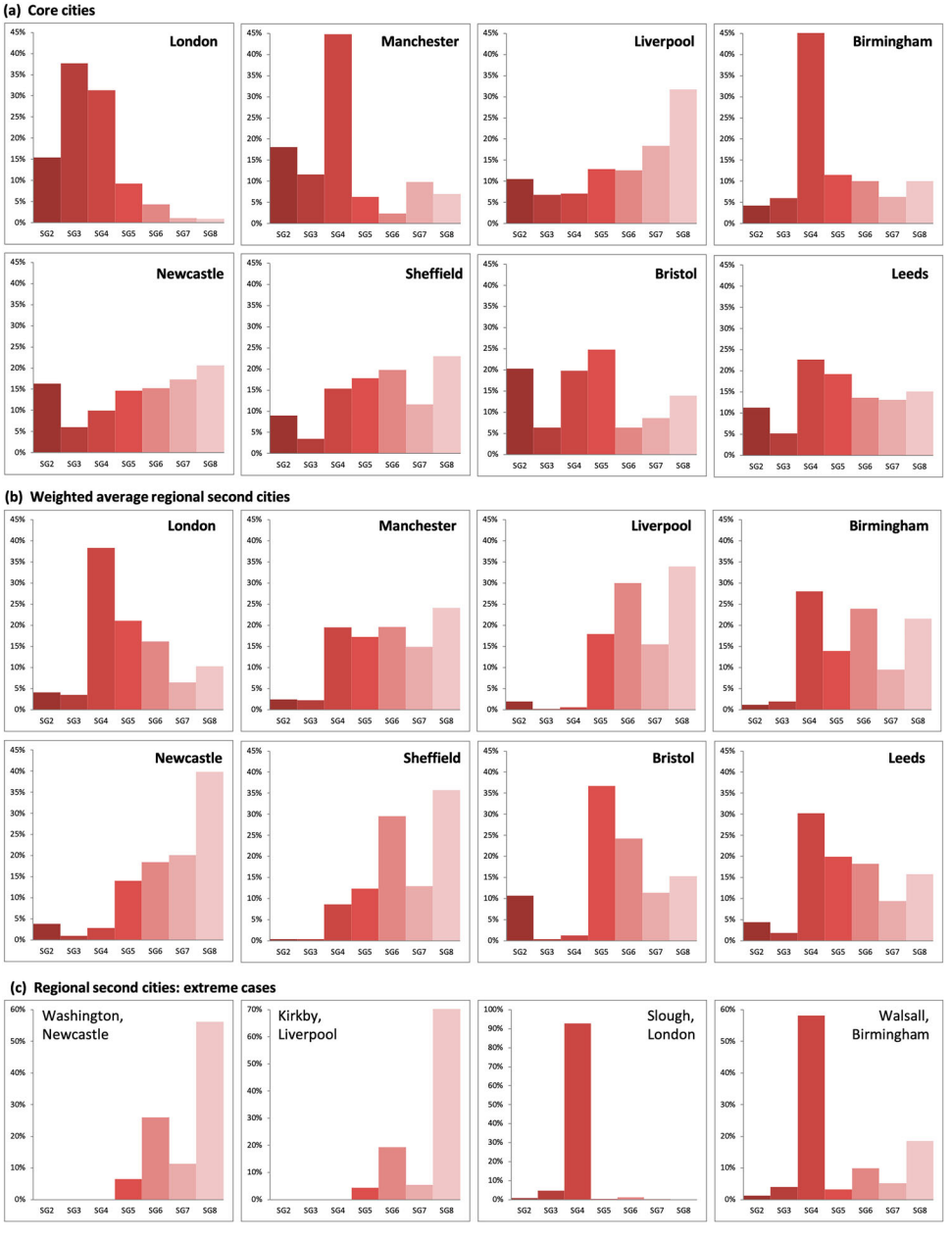

Figure 3. OAC supergroup distribution SG2 to SG8 in (a) core cities; (b) regional second cities, weighed average by city-region; (c) illustrative cases of unbalanced distributions.

how historic cities stand out in this respect, regardless of size and location (compare, for instance, the neighboring cities of Windsor and Slough). If these high levels of diversity otherwise found in core cities are synergistic with higher urban functions performance, life satisfaction and general urban attractiveness, as the cluster analysis suggests, then being a historic city may indeed open an access route towards a better position in the city-region lacking in other cities.

Table 3. Herfindahl-Hirschmann index of heterogeneity in cities (whole UK = 0.17).

#	City	HH-index	Cluster	#	City	HH-index	Cluster
1	SLOUGH	0,860	2	37	DUDLEY-S'BRIDGE	0,270	3
2	KIRKBY	0,550	3	38	CHESTERFIELD	0,268	3
3	LUTON	0,490	2	39	**MANCHESTER**	**0,266**	n/a
4	HIGH WYCOMBE	0,460	2	40	BATH	0,265	1
5	WASHINGTON	0,400	3	41	ALDERSHOT	0,263	1
6	WALSALL	0,390	2	42	BIRKENHEAD	0,261	3
7	ST HELENS	0,370	3	43	HUDDERSFIELD	0,261	1
8	WIDNES-RUNCORN	0,370	3	44	WESTON S MARE	0,258	1
9	SOLIHULL	0,360	1	45	ROTHERHAM	0,253	3
10	CRAWLEY	0,350	2	46	DURHAM	0,247	1
11	WATFORD	0,347	2	47	BOLTON	0,241	2
12	CLEVEDON-P'HEAD	0,347	1	48	DEWSBURY-BATLEY	0,241	2
13	BARNSLEY	0,330	2	49	CHELMSFORD	0,240	1
14	YATE	0,319	1	50	STOCKPORT	0,240	1
15	HARROGATE	0,316	1	51	READING	0,235	2
16	SALE-ALTRINCHAM	0,315	1	52	WOLVERHAMPTON	0,234	2
17	**BIRMINGHAM**	**0,312**	n/a	53	OLDHAM	0,233	2
18	BRADFORD	0,312	2	54	REDDITCH	0,231	3
19	WALLSEND	0,310	3	55	KEIGHLEY	0,227	3
20	WEST BROMWICH	0,310	2	56	ROCHDALE	0,224	2
21	SOUTHPORT	0,309	1	57	CHESTER	0,220	1
22	MANSFIELD	0,300	3	58	GATESHEAD	0,220	3
23	SUNDERLAND	0,300	3	59	DONCASTER	0,219	3
24	TAMWORTH	0,300	3	60	ASHTON-U-LYNE	0,210	3
25	WORKSOP	0,300	3	61	BURY	0,210	1
26	WIGAN	0,294	3	62	HALIFAX	0,210	1
27	SOUTH SHIELDS	0,293	3	63	MAIDSTONE	0,210	1
28	WALLASEY	0,291	1	64	MEDWAY	0,210	1
29	WARRINGTON	0,290	3	65	WAKEFIELD	0,200	3
30	BASILDON	0,280	3	66	YORK	0,200	1
31	BLYTH-CRAMLINGTON	0,280	3	67	**LIVERPOOL**	**0,190**	n/a
32	TELFORD	0,275	3	68	**BRISTOL**	**0,180**	n/a
33	**GREATER LONDON**	**0,274**	n/a	69	**SHEFFIELD**	**0,170**	n/a
34	NUNEATON	0,274	3	70	**LEEDS**	**0,160**	n/a
35	BOOTLE-CROSBY	0,270	3	71	**NEWCASTLE**	**0,160**	n/a
36	COVENTRY	0,270	2	72	SALFORD	0,160	2

LONDON
BIRMINGHAM
LIVERPOOL
BRISTOL
NEWCASTLE
SHEFFIELD
LEEDS
MANCHESTER

4.4. Dominant groups in core cities and second cities

Another important differentiation in demographic composition is whether specific supergroups prevail in different city types. Some clear contrasts are visible in the figures above and Table 4 below. The first is the concentration of younger, more educated and wealthier strata (SG2, "Cosmopolitans"), as well as non-deprived ethnic minority groups (SG3, "Ethnicity Central"), in core cities and their underrepresentation in

second cities. Especially SG2 is likely to be the key group policymakers aim to attract in their quest for diversity. Together, these groups in core cities range from 10% in Birmingham to 58% in London, whereas in second cities they range from 1% in the Sheffield city-region to 11% around Bristol. In the cluster analysis, SG2 + SG3 represent 3.2% in Group 1, 3.4% in Group 2 and 0.5% in Group 3. Historic and university cities do punch above their weight to approach their larger counterparts in Group 2, but both are far from the core city values. These are clearly "big city" populations with a distribution arguably inherited from the "urban renaissance" trends of recent decades.

SG7 ("Constrained City Dwellers") and SG8 ("Hard-pressed Living") are the most deprived population groups, according to the ONS portraits. Their relative presence is always higher than SG2/SG3, but increases in regional second cities. As hypothesized, they are not only less diverse than core cities, but their homogeneity tends to concentrate vulnerable groups in search of affordable housing and amenities. The contrast is visible, to different degrees, in London, Newcastle, Manchester, Sheffield and Birmingham. In Bristol, Leeds and Liverpool, SG7/SG8 have a similar share in the core and across the average of second cities, but Table 4 shows different contrasting underlying patterns. Bristol and Leeds have a comparatively low presence of these groups in the city-region, suggesting the presence of economically strong cities alongside the core, many of which are historic/university cities in Group 1 (Bath, York, Harrogate). The Liverpool region, on the other hand, has a high proportion of SG7/SG8 both in the core and the second cities, which the cluster analysis mostly allocated to Group 3.

Generally, core cities and some second cities in the South have higher proportions of SG2/SG3 (London and Bristol, but also Reading, Luton or Bath) than Northern cities, which host larger shares of SG7/SG8. Second cities in the Newcastle and Liverpool city-regions reach 70% with hardly any presence of SG2/SG3 (e.g. Kirkby, Widnes-Runcorn, South Shields). This contrasting pattern is indicative of the so-called North–South socioeconomic divide in England – the only regional second cities in the North with some representation of SG2/SG3 are university cities like Durham and York. Recall the apparent geographic differentiation of the cluster analysis above, with hardly any city from the South in the struggling, amenity-poor Group 3 and an overrepresentation of Northern cities. While core cities also differ among each other – most notably London – the North–South divide is very visible in the contrasting demographic profiles of their respective second cities.

Table 4. Relative presence of wealthier/more educated groups (SG2/SG3) vs. vulnerable/ more deprived population supergroups (SG7/SG8) in core cities and regional second cities.

SG2 + SG3 groups (relative presence in %)			SG7 + SG8 groups (relative presence in %)		
CORE CITY	*City-region*	AVG. 2ND CITIES	CORE CITY	*City-region*	AVG. 2ND CITIES
53	LONDON	8	2	LONDON	16
26	BRISTOL	11	23	BRISTOL	26
10	BIRMINGHAM	3	16	BIRMINGHAM	31
12	SHEFFIELD	1	35	SHEFFIELD	49
17	LIVERPOOL	2	50	LIVERPOOL	49
30	MANCHESTER	4	17	MANCHESTER	39
16	LEEDS	6	28	LEEDS	27
22	NEWCASTLE	5	38	NEWCASTLE	60

5. The state and futures of regional second cities

Population composition is a relevant way to differentiate and categorize regional second cities, as well as an important indicator of their roles and prospects in city-regions. Indeed, some demographic patterns are more beneficial than others for urban economies and are synergistic with other desirable urban features, but are inaccessible to many cities, especially those facing unbalanced city-regional geographies and competitive territorial development models. The paper attempted a typology of regional second cities based on their demographic profile. Then it showed how the resulting types score differently in other relevant features and explored how second cities differ demographically among each other and from core cities.

The paper dealt with some limitations to reach relevant conclusions. First, a time dimension is lacking to assess changing population profiles. This limits the discussion of the dynamics of inter-city relations, including the mechanisms through which second cities attract and retain certain groups and how these flow among them, making it harder to uncover ongoing segregation processes across the city-region and provide policy recommendations. The CDRC developed another dataset comparing 2001 and 2011 but with a different supergroup classification, making the comparison with the DataShine dataset impossible: another *a priori* grouping of population categories would probably render a different clustering of second cities, and others may have different interpretations of the results based on that data.

Second, the scope of the analysis, comparing 72 cities in eight city-regions, may overlook distinctive population profiles and city-regional imbalances that emerge from local historical legacies and path dependencies. Good examples are the different explanations for the high homogeneity of second cities in the London and Liverpool regions discussed in section 4.3, or the cases in which city-regional demographic dynamics are strong enough to override the association between size, functions and diversity in individual cities, as discussed in section 4.2. Future studies may take some of these patterns and contrasts to conduct detailed case study analysis, thus adding explanatory power to the research.

Two methodological caveats on diversity are worth mentioning. First, the HH-index works for the spatial scale to which we apply it, in this case the urban areas. It does not imply that there is no homogeneity at other scales. However, as explained earlier, we assume to be working with the scale at which population diversity is perceived and matters for localities. Second, the supergroups may include some aspects of diversity as an inherent feature. For instance, Slough is one of the most ethnically diverse cities in the UK despite being dominated by SG4 at 93%, as this is because SG4 is itself characterized by ethnic variety. But Slough does concentrate a population sharing all the other (non-ethnicity) features of SG4 summarized in Table 1. This is a consequence of using multi-variable indicators to approach diversity, understood here as *between*, but not necessarily *within*, supergroups.

The three distinctive clusters emerging from the demographic comparison of regional second cities suggest that size, historic features and, to a smaller extent, location either in the North or South of England are strong differentiators of population profiles. The fact that these demography-based clusters are mirrored by visible differences in other indicators (although statistical robustness is not attempted) strengthens this claim and

makes the suggested approach more relevant. Indeed, levels of diversity, urban functions, population growth and life satisfaction exhibit significant regularities within and contrasts between clusters.

Most regional second cities have relatively low diversity levels, possibly reflecting a narrowing economic base and corresponding demographic variety, the exchange of population flows with other attractive and increasingly diverse (core) cities, or the extensive spatial patches of homogeneity in otherwise heterogeneous city-regions created by large-scale metropolisation processes. Knowing more about how these hypotheses play out would require a comparison in time not offered by this paper. However, the snapshot traced here shows systematic contrasts across the UK, suggesting that, if a diversity dividend exists, it is indeed reserved for core cities and a selection of second cities. The spatial selectivity of the diversity dividend is further revealed by the extent to which low diversity and concentration of deprived groups converge in second cities. There are also indications of a North–South divide in the list of cities and the cluster allocation, but the patterns mainly suggest a transference of former "inner-city" problems of clustered deprivation to the city-regional periphery, reflecting the downside of the "urban renaissance" in British cities noted by Dembski et al. (2017). Regional second cities inherited structural demographic problems that core cities had in the past and very few seem to be not only reaping the benefits of greater population diversity, but also capturing the groups considered most desirable by policymakers. The guise of local demographic homogeneity as a "specialized" contribution towards beneficial city-regional diversity does not hold indeed. Most second cities do not borrow size from a demographic perspective.

If a balanced and diverse population mix is indeed an asset and becomes an ambition of cities, do some cities benefit from being in a networked city-region? Historic and university cities group together in the cluster analysis and are consistently closer to the population profile otherwise found in the core. They also do better than their counterparts in urban functions and life satisfaction indexes, while larger second cities do better in population growth. If there is something like being "the" second city in a city-region – i.e. to profit from city-regional relations to enhance a series of positive dynamics – its winning features are either based on size or historical-cultural features. Knowing more requires analyzing change in time to see whether this trend is consistent. But can it be argued that these cities have an increased capacity to emulate desirable core city features, in this case a demographic profile? And is this capacity related to being part of a city-region? A comparison with other second cities *outside* city-regions is necessary to see if their specific features are indeed related to, and enhanced by, city-regional relations.

What seems clear, in any case, is that many regional second cities face an agglomeration shadow regarding their efforts to extract dividends from a beneficial population mix. These cities may fail to see the advantages of further city-regional cooperation if they do not perceive a fair spread of benefits and do not meet local objectives, even if participating in the broader success of the city-region. This removes the incentive to engage in city-regional dialogues precisely in the cities that would gain the most in reaching out to the city-regional critical mass, in terms of population, functions and economic activity. Such paradoxes stress the spatial unevenness of city-regions and the need to consider their exacerbated divides when assessing the merits of city-regional integration.

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