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The (Metropolitan) City Revisited: Long-term Population Trends and Urbanization Patterns in Europe, 1950-2000

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Abstract

Following distinctive trends toward urbanization and suburbanization, spatially heterogeneous demographic dynamics are increasingly reflective of different development trajectories at both urban and metropolitan scales. A comprehensive investigation of population trends along homogeneous cycles of urban expansion – with identification of the most relevant factors of growth and change – is still lacking for several European cities. On this point, the present study investigates spatio-temporal patterns of urban expansion in 174 metropolitan regions of Europe, comparing population trends in inner cities and suburbs during a relatively long-time interval (1950-2000). A mixed (parametric/ non-parametric) statistical approach was developed with the aim to profile the specific socioeconomic context underlying population growth (or decline). A comparative analysis of population trends in inner cities and suburbs allows identification of similarities and differences in urbanization patterns and processes across Europe and contributes to define metropolitan clusters associated with a specific background context. The empirical results of this analysis give a more complete representation of contextual factors of population growth and decline in European cities, outlining the increased demographic polarization in inner cores and suburbs during the earlier phases of urbanization. Evidence for higher heterogeneity and fragmentation of long-term population trends during the late phases of urbanization brings further insights in the debate over the future development of contemporary cities.

Keywords

Sequential urban growth, inner city, indicators, metropolitan regions

1. Introduction

Metropolitan transformations have resulted in spatial configurations that reflect the intimate relationship between urban form and economic functions (Cross, 1990; Schneider and Woodcock 2008; van Criekingen 2010; Zambon et al. 2017). In advanced economies, large cities have experienced intense socioeconomic transformations since World War II (Champion 2001; Cuberes 2011; Díaz-Palacios-Sisternes et al. 2014; Haase et al. 2016), evolving from mono-centric structures to more scattered models and revealing a dynamic interplay between social forces in inner cores and suburban areas (Duvernoy et al. 2018). With the progressive expansion of metropolitan areas, population expansion has driven urban growth up to the 1980s (Champion 1989; Cross 1990; Hall 1997; Mordridge and Parr 1997). In more recent decades, however, urban expansion was increasingly decoupled from population growth, being instead influenced by economic factors less associated with demographic dynamics (Guérin-Pace 1995; Eaton and Eckstein 1999; Partridge et al. 2009; Haase et al. 2010).

Population growth rates in urban areas was the highest in the 1960s and the 1970s, reflecting the so-called 'baby-boom' in Europe – a period with intense fertility and relatively low mortality in terms of more recent dynamics (Moriconi-Ebrard 2000; Pacione 2003; Billari 2008; Kulu et al. 2009; Lerch 2014). Increasingly complex processes of population redistribution over larger metropolitan regions were observed since the mid-1980s (Antrop 2004; Angel et al. 2011; Bell et al. 2015). Despite a consolidated interest in regional studies, a wide-ranging assessment of population dynamics and the (evolving) demographic structure in metropolitan regions was developed only in specific cases (e.g. Haase et al. 2010; Kabisch and Haase 2011; Kroll and Kabisch 2012).

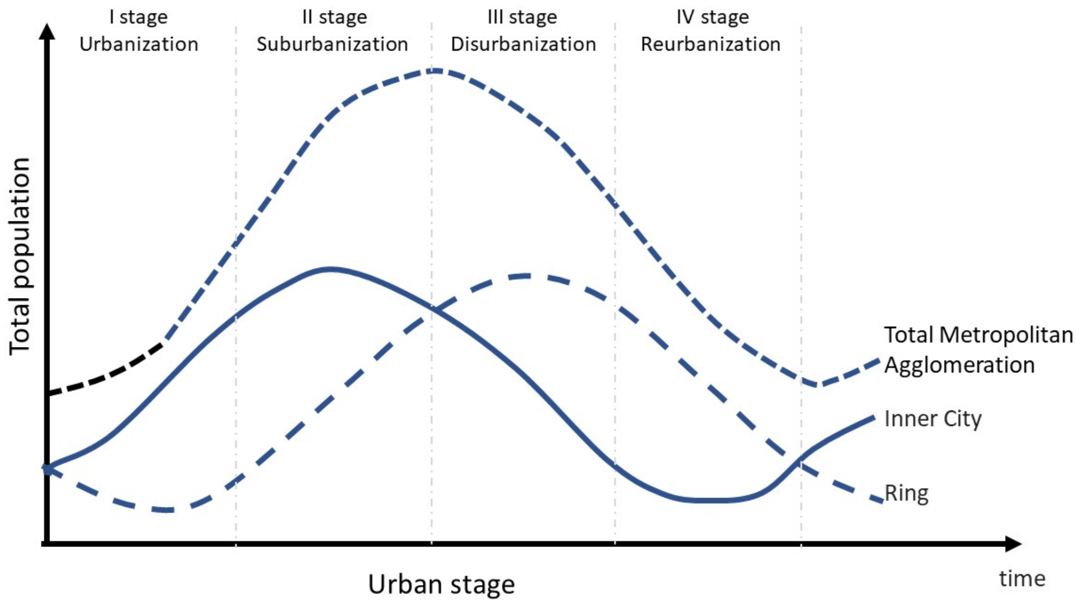
European urban systems have undergone important changes in spatial structures and socioeconomic functions with traditional mono-centric models and polycentric urban configurations diverging markedly (Partridge et al. 2009). At the same time, European cities moved from compact-dense forms toward more dispersed morphologies, with discontinuous settlements expanding into rural countryside (Leontidou 1996; Coccossis et al. 2005; Kasanko et al. 2006; Munafò et al. 2013). Taken as a response to transforming job markets and changes in lifestyles and housing preferences (Storper and Scott 2009), population redistribution across larger metropolitan regions in Europe was influenced by several factors, depending on economic dynamics (Buzar et al. 2007; Martinez-Fernandez et al. 2012; Colantoni et al. 2016) and the latent relationship between form and functions (Nyström 1992). In this regard, the City Life Cycle (CLC) theory predicts short- and long-term transformations in the spatial structure of cities at multiple scales, from local to regional (van den Bergh 1982). A cycle defines a specific time period during which a demographic phase at a given spatial unit arises and declines (Champion 1989, 1992; Cross 1990; Couch et al. 2007). Consequently, the long-term development of metropolitan regions can be assessed investigating population dynamics in inner cities and suburbs. Such analysis contributes to identify sequential urban stages with distinctive form-function relationships (Morelli et al. 2014).

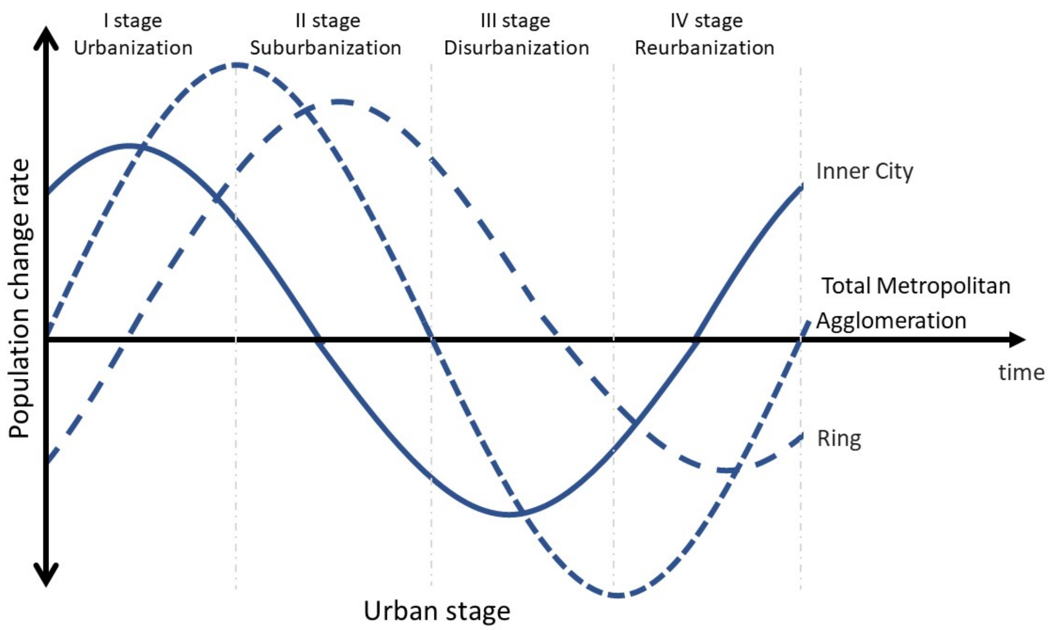
Based on the seminal study by Klaassen *et al.* (1981), the sequential expansion of metropolitan regions has been described according to changes over time in both intensity and spatial direction of population growth (Figure 1, p.148). Demographic dynamics in inner cities/ suburbs have been interpreted as a four-stage process (Champion 1989, 1992; Cross 1990; Cheshire 1995): (i) '*urbanization*', characterized by intense movements of population and economic activities from the suburbs toward inner cities (Le Galès 2002; Zitti et al. 2015; Moriconi-Ebrard 2016); (ii) '*suburbanization*', when population in outer rings grow more rapidly than population in urban cores – mainly due to medium- and high-income households that move to suburbs searching for higher environmental quality and favourable housing conditions (Pacione 2003; Cuadrado-Ciuraneta et al. 2017; Perez et al. 2018); (iii) *'counter-urbanization*', when population loss in urban cores exceeds population gains in suburbs, determining an overall population decline (Martinez-Fernandex et al. 2012; Rink et al. 2012; Gkartzios 2013; Salvati et al. 2013); and (iv) *'re-urbanization*', when inhabitants in central cities start increasing once again, usually to the expense of suburbs, that switch to negative rates of growth (Lever 1993; Leontidou 1995; Rérat 2012; Pili et al. 2017).

Predictions theorized by CLC theory are relatively simplified and linear and seem to be less suitable to represent the inherent complexity of current metropolitan transformations (Morelli et al. 2014). However, despite criticisms to CLC theory (Nyström 1992), this model still constitutes a base to a comprehensive reading of long-term urban dynamics when identifying patterns of change coherent with theoretical predictions (Salvati and Serra 2016). The CLC theory is also relevant when interpreting departures from model's predictions as a signal of the inherent evolution of urban systems toward complexity, fractality, heterogeneity and fragmentation (Brenner and Schmid 2014), with special regard to population dynamics and economic performances (Sato and Yamamoto 2005). In other words, CLC model provides a baseline interpretation of population trends in both earlier and more recent time periods, assuming that demographic dynamics in earlier decades (e.g. immediately after World War II) were more adherent to the model's prediction than those observed in the last decades (Salvati et al. 2013).

Assuming divergence from the general prediction of CLC model as an indicator of the progressive shift of population dynamics toward spatially-heterogeneous and less predictable trends over time (Bocquier and Costa 2015), the use of traditional analysis' domains, such as 'inner city' and 'suburbs', may represent a reference to test divergence in population dynamics towards more complex development paths (Champion 2001). Going beyond demographic issues, this exploratory framework may also contribute to document the progressive abandon of the 'compact city' growth mode – characterized by dense settlements and radio-centric expansion. Such patterns of growth reflect the urbanization wave typical of early stages of CLC. The decline of the 'compact city' model went hand in hand with consolidation of more dispersed forms at urban scale and polycentric structures at metropolitan scale – in part reflected in later stages of CLC.

Figure 1. A graphical representation of the City Life Cycle considering absolute population (up) and total population growth (bottom)





Source: Own elaboration

2. Logical framework

Based on the above-mentioned premises, the present study adopts the empirical framework of CLC theory with the aim to provide a comprehensive outlook of post-war development trajectories in a wide sample of European cities, taking advantage of a comparative analysis of population trends observed between 1950 and 2000 in 'inner cities' and 'suburbs' of 174 metropolitan areas in five macro-regions and 17 countries of Atlantic, Western, Northern, Central and Southern Europe. Although relatively mixed, post-war population dynamics reflected, more or less, rapid transformations that diverged from the dominant trend that was observed in the pre-war decades (Van Den Berg 1982; Zukin 1987; Brenner 2000), resulting in a quite homogeneous cycle that underlies the progressive shift from the 'compact city' paradigm (1950s) to spatial structures more oriented toward polycentrism (1990s). Reflecting homogeneous demographic dynamics as well (Bocquier and Costa 2015), population trends during the study period were mostly regulated by socioeconomic processes underlying the Second Demographic Transition (Wacquant 1992; Kroll and Kabisch 2012; Lerch 2016). These processes led to a slow (and continuous) decline in fertility throughout Europe (apart from some exceptions, such as France: Pison 2011) and a progressive increase in life expectancy at older ages, fuelling population growth, especially in urban and peri-urban areas (Kulu et al. 2009; Lerch 2014; Vitali and Billari 2017).

Since the early 1950s, total fertility rate decreased, reaching its lowest-low values at the beginning of the 1990s and reversing an upward trend since the late 1990s (Billari 2008). Profound changes in patterns and processes of urban expansion were observed in the subsequent decades (2000s and 2010s), probably as a result of accelerated, sequential phases of economic expansion and recession (Kulu and Washbrook 2014). While immigration demonstrated to be an important factor of urban expansion in the last part of the study period (Berry 1988), the most recent decades were characterized by heterogeneous population dynamics (e.g. Kotzamanis et al. 2017) fuelled by international immigration since the early 2000s (Bell et al. 2015). In this regard, cities in Eastern Europe were excluded from the sample because of their peculiar post-war urban cycle, influenced by centralized developmental policies and planning decisions taken by socialist governments (Klaassen et al. 1981; Couch et al. 2007; Kabisch and Haase 2011; Vobecká and Piguet 2012).

Assessing long-term population trends during a (supposedly homogeneous) urban cycle that extends between World War II and the great recession of the 2000s, allows a more comprehensive identification of distinctive trajectories of growth in core and ring areas (Carlucci et al. 2017). More specifically, results of this analysis constitute a knowledge base to understanding complex socioeconomic patterns and processes toward later phases of (i) suburbanization, leading to less polarized metropolitan regions – especially in peripheral Europe – thanks to the inherent decline of inner cities (Salvati and Serra 2016) or (ii) re-urbanization, with the progressive slowdown of suburban growth in the most advanced European regions (Buzar et al. 2007) or, conversely, the emergence of (iii) individual paths of urban expansion less clearly attributable to a specific CLC stage, and leading to (even more) heterogeneous dynamics at the regional scale (Rérat 2012).

With local contexts and place-specific dynamics assuming a pivotal role in long-term development of contemporary cities in Europe (Brenner and Schmid 2014), we test the apparent and latent influence of selected socioeconomic characteristics and territorial traits on population dynamics, with the aim to verify the differential impact of background contexts on urban cycles in different

European macro-regions. By adopting a restricted number of indicators that provide a basic assessment of local contexts at both city and regional level in Europe, the present study integrates a comprehensive analysis of apparent and latent urban growth mechanisms (distinguishing inner cities from suburbs) with a comparative investigation of population trends at a more aggregate spatial scale, outlining differential dynamics at country and macro-region scale.

The inherent specificity of the European urban cycle between the early 1950s and the late 1990s justifies a comparative investigation of metropolitan growth in Europe, integrating results of statistical analysis at both local and regional scale. A better comprehension of the progressive shift toward spatial complexity and temporal heterogeneity in urban population trends brings further insights to the debate over the future development of metropolitan regions (Salvati and Serra 2016) and may stimulate a reflection on the positive and normative implications of the emergence of a new urban cycle in Europe.

3. Methodology

3.1. Study area

The present study investigated trends over time in total population residing in 174 European cities (excluding Eastern Europe) at six different time points between 1950 and 2000. A total of 17 European countries were considered in the present study (Appendix 1): Austria (4 cities), Belgium (7), Britain (64), Denmark (2), Finland (1), France (52), Germany (27), Greece (2), Ireland (2), Italy (21), Malta (1), The Netherlands (11), Norway (2), Portugal (2), Spain (25), Sweden (3) and Switzerland (8).

Population data included harmonized figures of total population residing in inner cities and suburbs originally published by Le Gales (2005). These figures were derived from a comprehensive database (the so called 'Geopolis' databank) and compiled using official statistical data (mainly based on Population Censuses) covering nearly 26,000 towns and cities worldwide every 10 years since 1950. Assuming the lack of reliable tools providing detailed information on population trends at sub-metropolitan scale over a sufficiently long time interval (Salvati et al. 2013), Geopolis database and its digital application – available on the web in both English (http://e-geopolis.org/en/home/) and French versions (http://e-geopolis.org/) – were developed with the aim to compare long-term expansion of urban settlements worldwide by adopting a harmonized and unique definition of agglomerations that links population statistics from censuses and official registers to local administrative domains (Moriconi-Ebrard 2016). Following a general definition proposed by the United Nations, Geopolis is based on a unique definition of urban areas as a fabric "occupied by continuous building with less than 200 m between buildings and inhabited by at least 10,000 inhabitants" (Moriconi-Ebrard 2000). This approach moves from the official definition of urban units in France developed by the French Statistical Institute (INSEE). While city definition and boundaries may differ across countries (Schmidheiny and Suedekum 2015), this database allows homogeneous analysis of population trends based on a standardized classification of the European metropolitan regions, distinguishing population dynamics in core and ring areas (Salvati and Carlucci 2015).

Boundaries of inner cities, suburbs and metropolitan areas were held constant over the study period, assuring full comparability of population data (Pumain and Moriconi-Ebrard 1997). As any statistical standard, the definition of urban areas adopted in Geopolis database is a subjective operational choice (Perez et al. 2018). However, considering together the form of settlement and a minimum population threshold seems to be a reasonable strategy to formulate a standard definition of urban areas in Europe (Salvati et al. 2013). Geopolis data have been extensively used in previous studies (Pumain and Moriconi-Ebrard 1997; Moriconi-Ebrard 2000, 2016).

3.2. Regional classification of European cities

Following earlier studies by Hall and Hay (1980), Hohenberg and Lees (1985), Cheshire and Hay (1989) and Couch et al. (2007), the investigated countries were grouped into five European macro-regions: Atlantic (A), Western (W), Central (C), Northern (N) and Southern (S). These macro-regions reflect the World Unified Territorial System ESPON classification of European countries (Salvati and Carlucci 2015). More specifically, our definition of Southern Europe coincides with that from ESPON. To outline differences in urban population trends between cities in United Kingdom and in other countries of Northern Europe, this study split the original ESPON 'Northern Europe' class into two categories: Atlantic and Northern cities. For the same reason, to outline differences in urban population trends between cities in France and Germany, as well as in neighbouring countries respectively under French and German planning influence, the ESPON 'Western Central Europe' class was split into two separate categories: Western and Central.

With this classification, the rationale of the original ESPON framework was preserved, since we focused on regional partitions with supposedly important meaning for urban studies (e.g. distinguishing countries under French, German, UK or 'Northern' influence in urban planning and metropolitan dynamics: Hall and Hay 1980). Regional classifications of cities have been used extensively as a reference framework for assessment of similarity (or divergences) in urban morphology and socioeconomic functions (Angel et al. 2011). Although European cities are quite difficult to categorize because of their variable size and diversified economic functions (Hall 1997), the partition into five macro-regions adopted in this study contributes to identify common demographic dynamics at larger scale and specific growth paths at local scale (Salvati and Carlucci 2015).

3.3. Analysis of spatial scale

Assuming metropolitan areas as the elementary analysis unit, a multi-scale approach was adopted in this study, (i) aggregating metropolitan areas within one of the five macro-regions in Europe (see section 3.1) or (ii) considering separately each individual city in the sample (hereafter, city-level analysis). In both cases, population trends were investigated distinguishing dynamics in 'inner cities' from those observed in 'suburbs' (Cheshire 1995; Champion 2001; Rontos et al. 2016).

Regional analysis tries to identify comparable population dynamics and urban trends at a supra-national scale, assuming relatively homogeneous patterns of urban development across geographical clusters of European countries. City-level analysis provides a contextual investigation of factors associated to population growth (or decline) in inner cities and suburbs, based on selected attributes assessing socioeconomic background at each city included in the sample (Petrakos et al. 2000; Overman and Ioannides 2003; Rink et al. 2012; Salvati et al. 2013).

3.4. Population data and indicators

Urban population was considered the basic variable in this study. Annual (per cent) population growth rates were calculated over a time period encompassing 50 years (1950-2000) and, separately, over five consecutive decades (1950-1960, 1960-1970, 1970-1980, 1980-1990, 1990-2000). Identification of urban phases was based on a comprehensive analysis of population growth and decline in each metropolitan area (hereafter 'Metro'), distinguishing demographic dynamics in ‘inner cities’ ('City') and suburbs ('Luz').

A specific metric characterizing urban and metropolitan expansion was developed as the ratio of annual per cent population growth rate in inner city to the annual per cent rate of population growth in suburbs by metropolitan area and decade. This indicator, originally proposed by Salvati et al. (2018), is a measure of elasticity between rates of population increase in cores and surrounding areas and improves the explicative power of the variables mentioned above as far as adherence to the predictions of CLC model is concerned.

3.5. Contextual indicators

The use of contextual variables in city-level analysis contributes to an improved understanding of urban growth patterns and processes in European cities (Andersen and Van Kempem 2003; McCann and Acs 2011; Salvati et al. 2013). To assess the territorial context typical of each city in the sample, selected background variables were considered, including (i) the surface area of each metropolitan area (‘Size’), (ii) the average number of municipalities in each metropolitan area ('Com'), and two dummy variables indicating (iii) metropolitan areas with resident population > 500,000 inhabitants (‘Ran’) and (iv) metropolitan areas acting as the capital city of each country (‘Cap’). Dummies were also calculated to localize cities in the biggest European countries (France, United Kingdom, Germany, Spain and Italy). Contextual variables were supplemented with specific population indicators that included (i) the absolute difference in the annual rate of population growth between suburbs and inner city (‘S-C’) and (ii) the ‘City’-to- ‘Metro’ absolute population ratio (‘C-M’).

3.6. Statistical analysis

A comprehensive analysis framework integrating descriptive statistics (Morelli et al. 2014), multivariate exploratory analysis (Salvati and Serra 2016) and regression techniques (Salvati et al. 2013) was adopted with the aim to identify spatial coherence of population trends and departures from the predictions of CLC model. Descriptive figures include annual population growth rates in both inner cities and suburbs aggregated by macro-region and decade (regional-level analysis). The following sections provide a detailed description of the adopted techniques for city-level analysis.

3.6.1. Analysis of convergence over time in population trends

Convergence (or divergence) in annual (per cent) rates of population growth over sequential decades (e.g. 1950-1970 *vs* 1960-1980; ...; 1970-1990 *vs* 1980-2000) was investigated separately for 'inner city' and 'suburbs' spatial domains, considering together population figures collected for each metropolitan area (n = 174 observations). Pearson linear moment-product coefficients were used for this analysis, testing for significance at $p < 0.05$ after Bonferroni's correction for multiple comparisons (Salvati and Carlucci 2015). The same statistical technique was used to assess spatial convergence (or divergence) in population growth rates between inner city and suburbs (n = 174 metropolitan areas), separately for each decade. By assuming a stable demographic increase over a homogeneous urban cycle (Morelli et al. 2014), the aim of the correlation analysis was to delineate (more or less evident) departures from generalized patterns of urban expansion, identifying temporal breakpoints in the spatial distribution of population growth rates across Europe (Salvati et al. 2018).

3.6.2. Rank size analysis

To assess changes over time in the statistical distribution of cities based on population size (e.g. Bettencourt and Lobo 2016), the level of divergence between city rank and (log) metropolitan population curves was illustrated graphically using a scatterplot (Duvernoy et al. 2018). This approach was intended to provide an enriched overview of urban dynamics (Pumain and Moriconi-Ebrard 1997; Overman and Ioannides 2003; Perez et al. 2018) with respect to more traditional interpretations based on rank-size rule theories (e.g. Guérin-Pace 1995), giving a measure of the overall impact of CLC on the European metropolitan hierarchy.

3.6.3. Multivariate exploratory statistics

A Principal Component Analysis (PCA) was applied to a data matrix composed of annual (per cent) rates of population growth by decade in both 'inner city' and 'suburbs' (a total of 10 variables from 'City(5060)' to 'City(9000)', and from 'Luz(5060)' to 'Luz(9000)'), with the aim to provide a detailed overview of (apparent and latent) changes in the spatial distribution of resident population in European cities over the study period (Colantoni et al. 2016). Contextual variables in the data matrix classified metropolitan areas according to four dummies for European macro-regions ('Northern', 'Southern', 'Atlantic' and 'Western': one dummy excluded to avoid multicollinearity); five dummies for the largest countries in Europe (UK, Germany, France, Spain, Italy); and four dummies assessing (i) metropolitan surface area (‘Size’), (ii) the average number of municipalities in each metropolitan area ('Com'), (iii) metropolitan areas with resident population > 500,000 inhabitants (‘Ran’) and (iv) metropolitan areas including the capital city of the respective country (‘Cap’). Metropolitan size (resident inhabitants, logarithm) and the share of inner city population in total population at the metropolitan scale at the beginning of the study period ('Metro(1950)' and 'City/Metro(1950)') were calculated. These 15 contextual variables acted as supplementary, external variables in the PCA.

To verify the coherence of long-term population trends in urban Europe with the predictions of CLC theory, a separate PCA was run on a matrix containing the absolute difference in annual rates (%) of population growth between inner city and suburbs ('Elas') separately for each of the five decades of study. Five 'Elas' variables (from 'Elas5060' to 'Elas9000') were considered ‘composite metrics’ allowing identification of long-term and short-term urban population dynamics at multiple spatial scales, from regional to local (Salvati et al. 2018). The same contextual variables described above entered this PCA as supplementary variables.

3.6.4. General linear model

A multiple regression analysis was carried out by decade, considering the annual (per cent) rate of total population growth (metropolitan scale) as the dependent variable and 17 contextual variables as predictors (Salvati and Carlucci 2015). Predictors included: the share of inner city population in total population at the metropolitan scale ('City/Metro'); urban and suburban population growth rate ('City' and 'Luz'), four dummies for European macro-regions ('Northern', 'Southern', 'Atlantic' and 'Western': one dummy excluded to avoid multicollinearity); seven dummies for selected countries in

Europe (five large countries: UK, Germany, France, Spain, Italy and two small countries: Switzerland and Belgium); and, finally, three dummies assessing (i) metropolitan surface area ('Size'), (ii) the average number of municipalities in each metropolitan area ('Com') and (iii) metropolitan areas that host the capital city of the respective country ('Cap').

Regression analysis provided an enriched overview of local dynamics influencing population growth and decline in European cities, evaluating the importance of local context, spatial location and territorial features (Salvati et al. 2013). Selection of non-collinear indicators associated with population dynamics was based on a stepwise approach producing models with variable goodness-of-fit over time (Steel et al. 1997). A linear step-wise regression approach was adopted to identify and rank the most significant covariates of population growth based on the F-to-enter statistic for each variable ($p < 0.05$). The relative impact of each predictor was defined with the use of standardized coefficients, separate inference for each coefficient (t-statistic and F-statistic testing for significant coefficients at $p < 0.05$) and a Durbin–Watson statistic testing for serial autocorrelation in the data matrix (Salvati et al. 2018).

4. Results

4.1. Population trends in European cities, 1950-2000

A comparative analysis of annual rates of population growth at both inner cities and suburbs over five decades between 1950 and 2000 was carried out to identify and characterize demographic dynamics in European countries and macro-regions (Table 1). Until the 1980s, Southern European cities experienced the highest growth rates in both inner cities and suburbs. While suburban population grew continuously all over Europe, the highest rate of population growth in inner cities was recorded in Central and Northern Europe (0.1% and 0.7% respectively in 1980-1990 and 1990-2000). Until the 1970s, northern and central European cities showed a particularly high divide in population density between suburbs and inner cores. Since the 1980s, southern European cities showed the highest differentials in population growth between suburbs and inner cores.

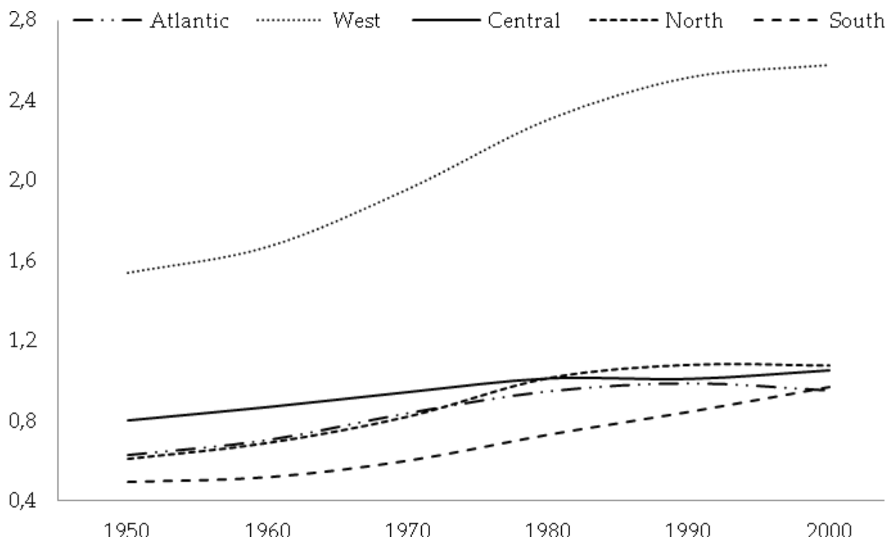
Table 1. Annual population growth rate (%) in European cities and related indicators (R-C, C/M, Size) by European macro-region, distinguishing Inner cities ('City', C), Suburbs ('Luz', S) and the whole metropolitan region ('Metro', M); 'Size': total area of metropolitan region)

Region	1950-1960			1960-1970			1970-1980			1980-1990			1990-2000		
	City	Luz	Metro	City	Luz	Metro	City	Luz	Metro	City	Luz	Metro	City	Luz	Metro
Percent rate of population growth															
Atlantic	-0.06	1.15	0.40	-0.58	1.25	0.18	-0.84	0.37	-0.29	-0.30	0.11	-0.10	0.58	0.19	0.39
Western	0.91	1.84	1.47	0.38	2.17	1.50	-0.58	1.09	0.53	-0.24	0.65	0.38	0.11	0.36	0.29
Central	1.10	2.03	1.51	0.23	1.13	0.65	-0.46	0.23	-0.13	0.08	0.05	0.07	-0.16	0.26	0.06
Northern	0.95	2.38	1.49	0.22	2.18	1.02	-0.88	1.24	0.08	0.04	0.70	0.37	0.73	0.69	0.71
Southern	2.17	2.77	2.37	2.06	3.99	2.72	0.57	2.85	1.43	-0.33	1.18	0.31	-0.52	0.87	0.12
Indicators															
	S-C	C/M	Size	S-C	C/M	Size	S-C	C/M	Size	S-C	C/M	Size	S-C	C/M	Size
Atlantic	1.21	0.61	896	1.83	0.59	932	1.20	0.54	948	0.41	0.51	921	-0.39	0.50	912
Western	0.93	0.39	576	1.79	0.37	661	1.67	0.34	760	0.89	0.30	800	0.25	0.28	830
Central	0.93	0.56	854	0.89	0.54	983	0.69	0.51	1046	-0.03	0.50	1033	0.42	0.50	1040
Northern	1.44	0.62	490	1.96	0.59	564	2.13	0.55	621	0.66	0.50	626	-0.04	0.48	649
Southern	0.60	0.67	489	1.93	0.66	604	2.28	0.62	769	1.50	0.58	879	1.39	0.54	906

Source: Own elaboration on data derived from Le Gales (2005) supplemented with information from Eurostat

Because of intense demographic dynamics, southern European cities also showed the highest share of inner-city population in metropolitan population (C/M). Figure 2 illustrates how suburb-core population ratio changed over time in all European macro-regions. Northern and Western

Figure 2. 'Suburbs-to-Inner city' absolute population ratio in selected European macro-regions, 1950-2000



Source: Own elaboration on data derived from Le Gales (2005) supplemented with information from Eurostat

cities showed similar trends over time, displaying a coherent urban expansion. Atlantic and Southern European cities displayed a population trend coherent with urbanization and suburbanization cycles typical of the decades immediately following World War II. A delay in population growth rates of nearly 10 years was observed between the two macro-regions; early and late urbanization was observed respectively in Atlantic and Southern European cities.

4.2. Correlation analysis

A linear correlation analysis based on Pearson moment-product coefficients was run with the aim to detect converging (or diverging) population dynamics at each metropolitan region over five time intervals covering two sequential decades each (Table 2, next page). Within inner cities, resident population increased consistently in Western and Atlantic Europe up to the late 1970s and 1980s respectively. Between the early 1960s and late 1990s, population increases were consistent over time in both Northern and Southern Europe. Central European cities showed a less coherent pattern, with consistent trends observed during 1960-1980 and 1980-2000. Diverging population trends were observed in the 1980-2000 and 1970-1990 time intervals respectively for Atlantic cities and Western cities. A more mixed pattern was recorded for cities in Central Europe.

Table 2. Pearson linear correlation between population growth rate (%) over two consecutive decades by urban zone and European macro-region, 1950-2000 (and * indicate significant correlation coefficients respectively at $p < 0.001$ and $p < 0.05$)**

Region	1950-1970	1960-1980	1970-1990	1980-2000
		Inner cities		
Atlantic	0.50*	0.83**	0.42*	0.24
Western	0.60**	0.86**	0.28	0.52*
Central	0.23	0.44*	-0.06	0.39*
Northern	0.13	0.47*	0.47*	0.74**
Southern	0.28	0.70**	0.78**	0.53*
		Suburbs		
Atlantic	0.43	0.63**	0.64**	0.71**
Western	0.82**	0.81**	0.92**	0.84**
Central	0.71**	0.79**	0.56	-0.30
Northern	0.59**	0.36	0.38	0.52*
Southern	0.68**	0.60**	0.77**	0.80**
		Metropolitan areas		
Atlantic	0.62**	0.83**	0.67**	0.45*
Western	0.69**	0.87**	0.81**	0.77**
Central	0.71**	0.47*	0.07	0.52*
Northern	0.07	0.40*	0.66**	0.78**
Southern	0.44*	0.65**	0.76**	0.46*

Source: Own elaboration on data derived from Le Gales (2005) supplemented with information from Eurostat

Suburban population increased consistently all over the study period in Western and Southern cities, and since the early 1960s in Atlantic cities. Central and Northern cities showed more mixed demographic patterns, displaying consistent rates of population growth between 1950 and 1980 (Central Europe) and only in the first and last decade of investigation (Northern Europe).

Metropolitan population grew consistently all over the study period in Atlantic and Western European cities. Cities in Central Europe showed a breakpoint between 1970 and 1990. Spatially coherent demographic trends were observed in Northern Europe since the early 1960s. Taken together, more stable population patterns based on correlation patterns were recorded over the last two decades.

A stringent temporal coherency in population growth rates between inner cities and suburbs (Table 3) was observed in the last decade of investigation for Atlantic cities and in the first decade for cities in Southern Europe. Western cities showed a substantial coherency in population dynamics over time, except for 1980-1990. Central European cities displayed coherent dynamics only for the first and last decade and, finally, Northern cities evidenced stably divergent population dynamics

Table 3. Pearson linear correlation analysis between population growth rate (%) in inner cities and suburbs by European macro-region and decade (* indicates significant correlation coefficients at $p < 0.05$)

Region	1950-1960	1960-1970	1970-1980	1980-1990	1990-2000
Atlantic	0.29	0.18	0.32	-0.01	0.39*
Western	0.47*	0.44*	0.46*	0.25	0.46*
Central	0.44*	0.20	-0.09	0.03	-0.58*
Northern	-0.07	-0.40	-0.04	-0.05	0.11
Southern	0.34*	0.19	0.35*	0.26	0.02

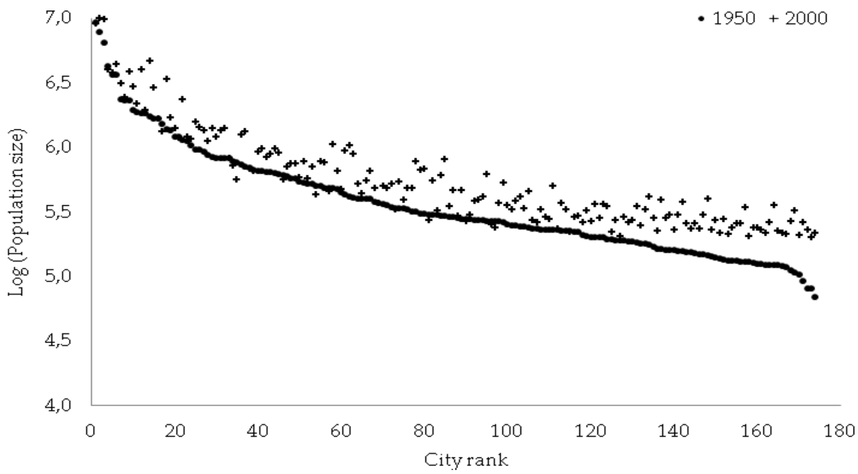
Source: Own elaboration on data derived from Le Gales (2005) supplemented with information from Eurostat

between inner cities and suburbs.

4.3. Rank-size analysis

Figure 3 illustrates a rank-size analysis classifying cities according to their demographic role in

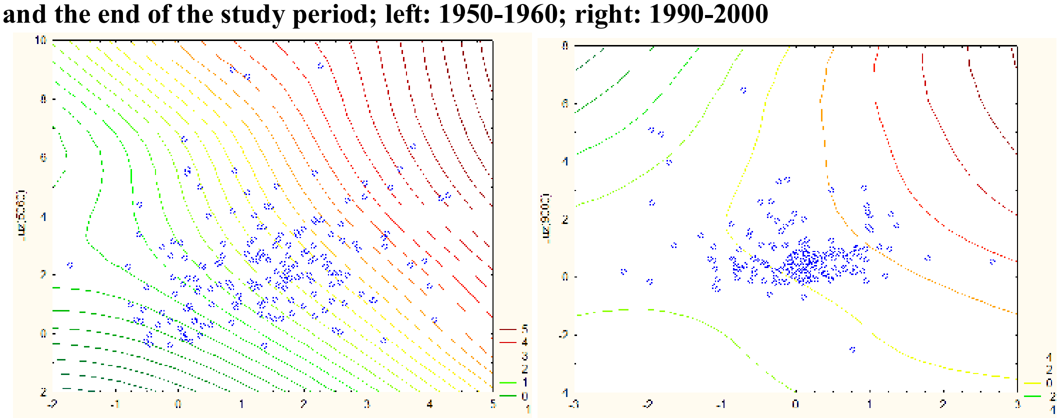
Figure 3. Rank-size plot for selected European metropolitan regions, 1950 and 2000 (city rank ordered the 174 metropolitan areas studied from the largest to the smallest in terms of population size; Log (Population size) is the logarithm of total population residing in each metropolitan area)



Source: Own elaboration on data derived from Le Gales (2005) supplemented with information from Eurostat

the European metropolitan hierarchy. Comparison of city's population size in the first and last years of investigation (1950 and 2000) outlines a convergence process with smaller cities growing faster than the larger ones, especially in the earlier decades. A contour plot was used to group cities with homogeneous population growth rates in inner cores and rings (Figure 4). This analysis was

Figure 4. Contour plot illustrating urban and metropolitan expansion in Europe based on annual population growth rate (%) in inner cities ('Cit') and suburbs ('Luz') at the beginning and the end of the study period; left: 1950-1960; right: 1990-2000



Source: Own elaboration on data derived from Le Gales (2005) supplemented with information from Eurostat

repeated for the first (1950-1960) and the last decade of investigation (1990-2000). In the 1950s, population growth rates in both inner cities and suburbs varied largely across Europe. More homogeneous growth rates across Europe were observed at the end of the study period, with a higher variability in inner cities than in suburbs.

4.4. Principal component analysis

An exploratory investigation of the spatial variability in annual population growth rates by decade in 174 European cities was performed using a Principal Component Analysis, incorporating ancillary indicators as supplementary variables (Table 4). Four components, explaining 79.8% of

Table 4. Loadings of a Principal Component Analysis run on annual per cent rate of population growth in inner cities ('City') and suburbs ('Luz') and changes between 1950 and 2000 in European cities (italics indicate significant correlations with external variables, *p* < 0.05; for abbreviations, see section 2.6.3)

Variable	PC 1	PC 2	PC 3	PC 4
Expl. Var.%	**37.4**	**19.2**	**13.2**	**10.0**
City(5060)				0.75
City(6070)	-0.79			
City(7080)	-0.69			
City(8090)			0.69	
City(9000)			0.83	
Luz(5060)		-0.69		
Luz(6070)		-0.68		
Luz(7080)	-0.82			
Luz(8090)	-0.82			
Luz(9000)	-0.60			
Northern			*0.30*	
Southern	*-0.42*	*0.34*		
United Kingdom	*0.34*			*-0.31*
Italy				*0.29*
Spain	*-0.54*	*0.40*		
Size	*0.37*			
Ran	*-0.32*			
Com	*0.30*			
Metro(1950)	*0.47*			
City/Metro(1950)	*-0.45*			

Source: Own elaboration on data derived from Le Gales (2005) supplemented with information from Eurostat

Total variance, were extracted and both loading structures and score structures were analysed extensively. PC1 (37.4%) clustered large cities (with municipalities administering a larger surface area than the average) in the United Kingdom (London, Glasgow, Newcastle and Manchester) on the positive side of the axis. Cities clustered on the negative side of PC1 were situated in Southern Europe (particularly in Spain) and showed a high C-M ratio (share of inner-city population to metropolitan). These cities (e.g. Valladolid, Palma de Mallorca, Alicante and Madrid) were characterized by high rates of population growth in both 1960-1970 and 1970-1980 and a 10-year delay in urban *vs* suburban population growth rates (Table 5, next page).

Table 5. The five-highest scores of the Principal Component Analysis (see results in Table 4) applied to population growth rates in inner cities and ring areas between 1950 and 2000 in the selected sample of European cities

City	PC 1	City	PC 2	City	PC 3	City	PC 4
			The highest negative scores to component				
Valladolid	-6.8	Helsinki	-3.9	Lisbon	-3.8	Valladolid	-2.1
Palma de Mallorca	-6.5	Reading	-3.2	Valletta	-3.4	Belfast	-2.0
Montpellier	-6.1	Southend on Sea	-2.9	Halle	-2.6	Malaga	-1.9
Alicante	-4.8	Grenoble	-2.6	Leipzig	-2.4	Halle	-1.9
Madrid	-4.6	Madrid	-2.5	Athens	-2.3	Toulouse	-1.8
			The highest positive scores to component				
Charleroi	2.8	Coruna, A	2.9	Elx	2.2	Rimini	1.9
Glasgow	3.1	Valladolid	4.0	Gandia	2.2	Elx	2.1
Newcastle	3.3	Magdeburg	4.0	Murcia	2.5	Coblenz	2.1
Manchester	3.7	Halle	4.1	Cardiff	2.5	Bilbao	2.2
Valletta	3.9	Grenada	4.1	Amersfoort	4.2	Turin	2.4

Source: Own elaboration on data derived from Le Gales (2005) supplemented with information from Eurostat

Cities in Southern Europe (and especially Spanish cities) received positive loadings on PC2 (19.2%) and a negative correlation with suburban population growth rates for earlier decades (1950-1960 and 1960-1970). PC2 was negatively related to some cities in Northern Europe (e.g. Helsinki), United Kingdom (e.g. Reading) and France (e.g. Grenoble). PC3 (13.2%) identified cities situated in Northern Europe with an intense population growth in inner cities over the last two decades (1980-1990 and 1990-2000). PC4 (10%) highlights inherent divergences in long-term demographic dynamics typical of Italy and United Kingdom, based on the differential rate of population growth recorded in the first decade of observation at the inner-city level, with Italian cities totalizing, on average, the highest rates of urban growth in the sample. For both British and Italian cities, demographic changes appeared to be influenced by economic cycles, reorganizing industrial activities in ring districts (such as Belfast in Northern Ireland) or mixing industrial with service activities in inner cities (such as Turin in northern Italy).

A separate PCA was run on the elasticity index emphasizing the relationship between decadal population growth in inner cities and suburbs (Table 6). The first two components (extracting a

Table 6. Loadings of a Principal Component Analysis applied to absolute differences ('Elas') in per cent annual rate of population growth between inner cities and ring areas in the selected sample of European cities, 1950-2000 (italics represent significant correlations with external variables, $p < 0.05$; for abbreviations, see section 2.6.3)

Variable	PC 1	PC 2
Expl. Var.%	**42.8**	**28.5**
Elas(5060)	-0.67	
Elas(6070)	-0.82	
Elas(7080)	-0.85	
Elas(8090)		0.74
Elas(9000)		0.87
Southern		*0.46*
United Kingdom		*-0.36*
France	*-0.29*	
Spain		*0.30*
Cap	*-0.29*	
City/Metro(1950)	*-0.33*	

Source: Own elaboration on data derived from Le Gales (2005) supplemented with information from Eurostat

cumulated variance of 71.3%) identified two spatial regimes reflecting distinctive demographic dynamics in city cores and suburbs during the first three (1950-1980) and last two (1980-2000) decades. More specifically, PC1 (42.8%) characterized French cities, capital cities and, more generally, cities with a high rate of 'C-M' population in 1950 (negative loadings). PC2 (28.5%) illustrated the inherent spatio-temporal divergence in demographic dynamics between British and Spanish cities, the latter being associated with a particularly high elasticity in population trends during the last two decades.

4.5. Step-wise multiple regression

A step-wise multiple regression analysis (Table 7) identified the predictors most associated with the annual rate of population growth at the metropolitan scale, taken as the dependent variable. By examining long-term changes in demographic dynamics and territorial patterns, regression models displayed a particularly high goodness-of-fit up to the 1980s, decreasing moderately in the last two decades. This result may indicate an increasing variability underlying more heterogeneous demographic patterns across Europe since the early 1990s. Values of Durbin–Watson statistic (close to two over the entire study period) indicate negligible serial correlation for all macro-regions.

Table 7. Results of a forward step-wise linear regression with total population growth rate (%) at metropolitan scale as dependent variable and contextual variables as predictors by time interval (and * indicate significant correlation coefficients respectively at $p < 0.001$ and $p < 0.05$; for abbreviations, see section 2.6.4)**

Variable	1950-1960				1960-1970				1970-1980				1980-1990				1990-2000			
	Beta	Coef	t	*p*	Beta	Coef	t	*p*	Beta	Coef	t	*p*	Beta	Coef	t	*p*	Beta	Coef	t	*p*
City	0.71	0.027	25.7	**	0.81	0.029	28.2	**	0.70	0.037	19.2	**	0.66	0.037	17.6	*	0.88	0.043	20.7	**
Luz	0.46	0.027	17.1	**	0.41	0.030	13.6	**	0.44	0.029	15.1	**	0.51	0.037	13.7	*	0.22	0.045	4.8	**
City/Metro	-0.11	0.026	-4.4	**	-0.16	0.035	-4.5	**	-0.25	0.033	-7.6	**	-0.23	0.048	-4.7	*	-0.18	0.043	-4.2	**
France	0.08	0.027	3.0	*																
Southern cities	0.07	0.028	2.4	*													0.16	0.044	3.7	**
Switzerland	0.06	0.026	2.3	*																
Municipalities					0.07	0.036	2.0	*	0.11	0.032	3.4	**	0.12	0.052	2.3	*				
Belgium					-0.09	0.030	-3.1	*	-0.09	0.025	-3.4	**	-0.07	0.036	-2.1	*				
Western cities					0.07	0.031	2.1	*												
Germany									-0.07	0.027	-2.8	*								
United Kingdom									-0.06	0.027	-2.2	*								
Spain									0.08	0.034	2.4	*								
Cap													0.14	0.037	3.9	**	0.14	0.040	3.5	**
Size													-0.15	0.044	-3.4	**				
Adjusted R^2	0.893				0.885				0.906				0.802				0.721			
Fisher F test	242.0				223.2				210.1				101.2				90.6			
Degrees of freedom, *p*	6,167**				6,167**				8,165**				7,166**				5,168**			
Durbin-Watson test	2.22				2.03				2.05				1.89				1.80			

Source: Own elaboration on data derived from Le Gales (2005) supplemented with information from Eurostat

In the first observation decade (1950-1960), demographic growth in inner cities contributed to the overall population increase more than suburban population growth. The highest contribution of inner cities to total population growth was observed in French, Swiss and Southern European cities. Outcomes of the regression model referring to the second time interval (1960-1970) evidenced an even larger contribution of inner-city dynamics in metropolitan population growth. The highest growth rates were observed in Western European cities (except for Belgium), and in cities with large municipalities and a low 'C-M' ratio at the beginning of the study period (1950).

In the 1970s, the contribution of inner cities to total population growth was less intense. The largest contribution to population growth came from Spanish cities and from cities with municipalities administering large areas, while cities in Belgium, Germany and United Kingdom contributed negatively to the overall population growth in metropolitan Europe. As inner cities contributed to metropolitan population growth more than suburbs, spatial divergences in population dynamics between cores and rings decreased moderately in the 1980s. The highest rates of population growth were observed in capital cities and large non-capital metropolitan regions. Population increase in inner cities was increasingly correlated with metropolitan population growth in the 1990s, likely indicating a phase of re-urbanization, particularly evident in Swiss cities and, more generally, in capital cities all over Europe. Cities with a moderately low rate of 'C-M' population ratio at the beginning of the study period contributed negatively to population dynamics in the 1990s.

5. Discussion

Population relocation away from central cities reflects socioeconomic processes, mainly in advanced economies (Eaton and Eckstein 1999; Champion 2001; Overman and Ioannides 2003; Schmidheiny and Suedekum 2015). On this point, multiple socio-demographic dynamics have characterized different urban stages in Europe (Kroll and Kabisch 2012), altering metropolitan spatial structures more or less intensively (Buzar et al. 2007; Partridge et al. 2009; Martinez-Fernandez et al. 2012). However, stability or changes in population trends over different urban stages have been studied less extensively, probably because of the (supposedly differential) impact of heterogeneous demographic dynamics within and between European macro-regions (Buzar et al. 2007; Haase et al. 2010; Kabisch and Haase 2011).

Based on these premises, long-term transformation of 174 European metropolitan regions was assessed combining diachronic information on population dynamics and socioeconomic local contexts (van den Berg et al. 1982). Assuming that a comparative analysis of population growth rates in inner cities and suburbs can shed light on complex trajectories of urban expansion (van Criekingen 2010), results of our study contribute to a better understanding of population dynamics characteristic of a complete urban cycle.

By considering a quite homogeneous time period (1950-2000), urban dynamics were clearly identified according with CLC model and deviations from the predictions of the model – more evident in the last one-two decade(s) – were extensively characterized at regional level and discussed at city level. Analysis of long-term population trends within and between European macro-regions allows a more comprehensive characterization of sequential stages of urban growth and decline in different European regions. Additionally, the city-level analysis identified specific local contexts associated with population growth or decline (Kroll and Kabisch 2012), shedding light on the intrinsic relationship between demographic dynamics and socioeconomic transitions in the most advanced European countries (Kabisch and Haase 2011).

The empirical results of this study indicate that the variable of population growth in inner cities was associated significantly with total metropolitan growth, although its importance declined over time. As a matter of fact, inner city population dynamics followed non-linear waves of growth and decline (Salvati and Serra 2016), evidencing a quite complete cycle with sequential urbanization, suburbanization, counter-urbanization and early signs for re-urbanization, especially in Atlantic and Central European cities. Conversely, analysis of suburban population numbers outlined rather homogeneous trends, except for the last decade (1990-2000). These results suggest the persistence of a suburbanization phase – with population growth rates in suburban areas significantly higher than rates in inner cores – between the early 1960s and the late 1980s, and a marked delay in urban stages between Western/Atlantic/Central European countries (early suburbanization) and Southern European countries (late suburbanization).

Urban dynamics in the 1990s have reflected more stable (or slightly decreasing) population trends in metropolitan regions, with signs of population recovery in both core and ring districts (Buzar et al. 2007; Haase et al. 2010; Kroll and Kabisch 2012; Rérat 2012). Taken together, these results confirm the empirical validity of CLC model (Morelli et al. 2014).

By investigating the intrinsic characteristics of each European macro-region, different groups of cities were distinguished according to their dominant demographic patterns. Northern and Western European cities presented similar trends, as demographic growth took place sequentially (Hall and Hay 1980; Cheshire 1995; Couch et al. 2007). These findings are aligned with the predictions of CLC model. Atlantic and Southern European cities experienced a comparable trend in the aftermath of World War II, reflecting sequential industrialization and de-industrialization waves, with a delayed cycle characterizing population trends in Southern Europe (Leontidou 1995, 1996; Carlucci et al. 2017). Predictions of CLC model resembled long-term dynamics observed in Atlantic cities, at least up to the late 1980s (Champion 1989, 1992; Townsend 1993). Population trends in Southern Europe were overall less coherent with CLC model, especially as far as the latter two stages of the model are concerned (Zambon et al. 2017). Central European cities experienced a more mixed trend, with a shorter urbanization stage, a quite prolonged suburbanization and a relatively intense re-urbanization (Kasanko et al. 2006; Schneider and Woodcock 2008; Rink et al. 2012). In some ways, this pattern is more similar to Atlantic Europe dynamics than those observed in Western Europe.

Results of this regional analysis demonstrate that the notion of sequential stages (from urbanization to re-urbanization) well characterized long-term metropolitan expansion all over Europe (Salvati et al. 2013), although these stages may clearly differ – as far as intensity and length – among European macro-regions (Haase et al. 2010). In other words, differential combinations of intensity and length of the stages predicted by CLC can be regarded as factors discriminating population dynamics across European macro-regions (Morelli et al. 2014). Further studies in this direction are potentially interesting from both positive and normative perspectives (Friedrichs 1993; Andersen and Van Kempem 2003; Janssen-Jansen and Hutton 2011).

Other findings of our study more or less suggest, however, important deviations from CLC theory. First, smaller cities were demonstrated to have a greater population growth than the larger ones in the time period considered. This evidence corroborates the hypothesis that speed of demographic expansion in larger cities decreased over time in advanced economies (Cuberes 2011). Taken together, these findings integrate and enrich CLC model and may explain the increased spatial heterogeneity in population dynamics all over Europe. However, following Bettencourt and Lobo (2016), size and scale of urban systems still maintain a statistical consistency for metropolitan regions based on the rank-size distribution of cities, as our analysis demonstrates. Even if European countries are characterized by different rank-size distributions, agglomeration effects and the ensuing scaling relations maintain a better regularity in each macro-region investigated in our study (Eaton and Eckstein 1999; Angel et al. 2011; Bell et al. 2015). In this regard, developing exploratory approaches that combine theoretical intuitions behind scale and agglomeration effects, and a specific focus on distributional effects within cities may provide a refined analysis of urban systems and metropolitan hierarchy in advanced economies (Martinez-Fernandez et al. 2012).

Second, analysis of elasticity in the rate of population growth between inner cities and suburbs provides a comprehensive overview of the spatial variability in urban population trends, contrasting capital cities with the rest of the sample. Assuming that urbanization, suburbanization and re-urbanization are difficult to characterize because of multiple factors acting at both urban and metropolitan scale (Salvati et al. 2018), our study provides a wide-ranging outline of population dynamics *vis à vis* urban cycles, stressing the contribution of inner cities in long-term expansion of capital cities.

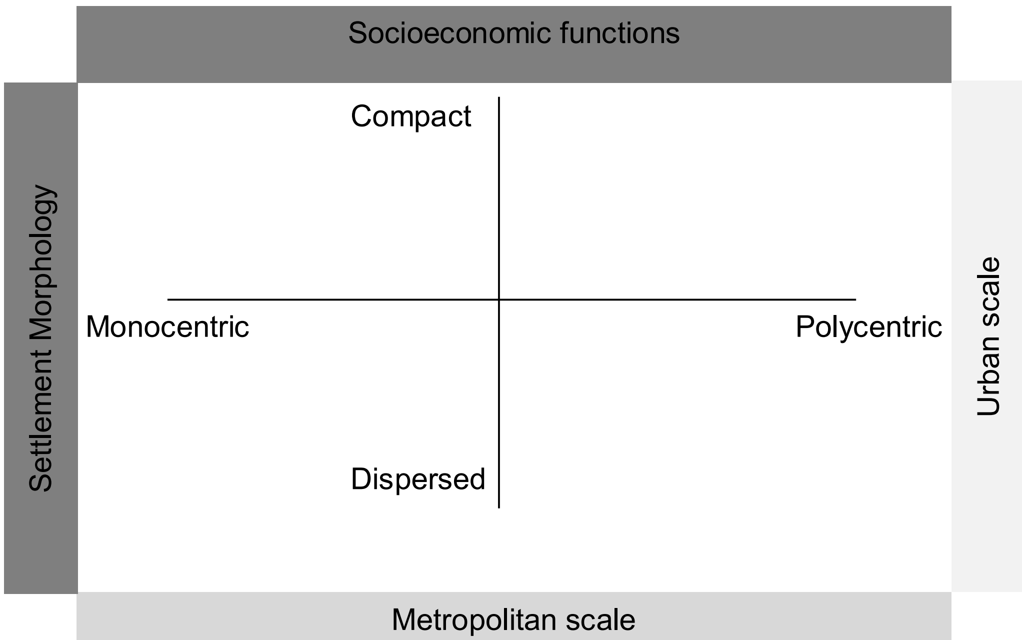
Third, patterns of metropolitan growth in the last decade of investigation were becoming increasingly heterogeneous over space and more sensitive to differential population changes in inner cities and suburbs (Kroll and Kabisch 2012). These dynamics have led to more individualized, spatially heterogeneous dynamics, altering the traditional urban hierarchy in Europe and suggesting the emergence of a new cycle (Brenner and Schmid 2014) with largely variable patterns of growth. These patterns range from the accelerated expansion typical of 'creative' and 'smart' cities (attracting people and economic activities) to the uneven decline of traditional, industrial cities driven by long-term 'shrinkage' processes (Buzar et al. 2007; Lerch 2014; Haase et al. 2016). Especially in Southern Europe, the latter process was sometimes associated with 'austerity urbanism' as a consequence of the 2008 recession (Rontos et al. 2016; Salvati and Serra 2016; Zambon et al. 2017).

Fourth, the role of inner cities and suburbs in metropolitan growth was especially heterogeneous in the last decade suggesting, on the one hand, the dominance of inner-city demographic dynamics as a latent engine of growth and, on the other hand, the progressive decline of suburbs as an engine of growth independent from the respective city core (Lerch 2016). The incipient role of smaller cities and the predominance of inner cores in driving overall metropolitan growth (e.g. Zukin 1987) are reflective of the latent shift from classical mono-centric structures (represented by the network of traditional, compact and large cities dominating the urban hierarchy in Europe in the first two-three decades after World War II: e.g. Bonavero et al. 1999) to more dispersed and heterogeneous polycentric structures involving larger regions with a mixed urban-rural socioeconomic profile (Schneider and Woodcock 2008).

Integrating results of our analysis at multiple scales (regional-level and city-level) stimulates a re-thinking of both CLC model and more recent urban theories. From this perspective, the recent evolution of urban systems in Europe can be interpreted according with two axes of change concerning both forms and functions: (i) settlement compactness *vs* dispersion and (ii) mono-centricity *vs* polycentrism (Figure 5, next page). Although transition toward polycentric and dispersed urban systems is far from being completed, the interplay between socioeconomic forces promoting mono-centric or poly-centric metropolitan assets and those shaping continuous or discontinuous settlements will increasingly shape the future configuration of many European cities (Antrop 2004; Kasanko et al. 2006; Haase et al. 2010; Salvati et al. 2018).

In conclusion, while those findings indicate a progressive deviation of more recent urban dynamics from CLC predictions, this model still remains a logical benchmark to identify different patterns of urban expansion in metropolitan regions (Kroll and Kabisch 2012), leading to distinctive transformations in central cities and suburbs (Leontidou 1996; Sato and Yamamoto 2005; Angel et al. 2011). The increasing heterogeneity in demographic patterns across European cities, progressively diverging from the linear predictions of CLC model, should be taken in due account

Figure 5. The form-function dimensions of urban and metropolitan growth in Europe, 1950-2000



Source: own elaboration

when formulating policies for urban sustainability, considering both socioeconomic development and sprawl containment (Wacquant 1992; Coccossis et al. 2005; Cuberes 2011; Jansseen-Jansen and Hutton 2011).

In this regard, the role of natural balance and migration in total metropolitan growth should be investigated further. Together with population aging and increased mortality, total fertility rate in Europe experienced a huge decline (1975-2000) to lowest-low values after a long period of stability or moderate decline (1950-1975), determining a progressive reduction in the natural rate of population growth at metropolitan scale (Billari 2008; Kulu et al. 2009; Serra et al. 2014; Kotzamanis et al. 2017; Vitali and Billari 2017). The 1990s represented the last stage of transition from high fertility and high mortality (determining population growth in cities) to low fertility and mortality (leading to population shrinkage). At the same time, although international immigration demonstrated to be an important phenomenon fuelling urban growth in the 1980s and the 1990s (at least in more advanced countries, especially in Western and Atlantic Europe), increasingly heterogeneous demographic dynamics shaped by intense migrations since the early 2000s require a renewed analysis of the role of immigration as engine of metropolitan expansion (Berry 1988; Bocquier and Costa 2015; Lerch 2016).

6. Conclusions

Investigating spatio-temporal convergence (or divergence) in population dynamics of inner cities and suburbs contributes to a better understanding of different stages of a complete urban cycle in increasingly heterogeneous metropolitan systems. Comparing long-term and short-term population trends and distinguishing peculiar demographic dynamics at regional (macro-level) and local (city-level) scale seems to be an appropriate tool to disentangle the increasing complexity of current urban expansion mechanisms. Based on the empirical results of this study, CLC theory proved to be an appropriate baseline to assess coherency and divergences from linear development paths. The city scale analysis provides enriched information to identify local-scale drivers of urban growth, in addition to differences in urban development made clear by regional analysis. Future research that expands knowledge of urban stages – based on integrated analysis of population trends and socioeconomic spatial patterns – is essential in order to inform more effective strategies promoting regional development and urban competitiveness. New approaches allowing for a comprehensive socioeconomic profile of European cities based on integrated demographic (natural balance and immigration rates) and socioeconomic indicators will represent the necessary knowledge base to inform policies governing the evolution of metropolitan regions worldwide.

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Appendix 1. List of metropolitan regions considered in the present study

City	Country	Region	City	Country	Region	City	Country	Region
Athens	Greece	Southern	Copenhagen	Denmark	Northern	Paris	France	Western
Salonica			Arhus			Lille		
Milan	Italy		Helsinki	Finland		Lyon		
Naples			Rotterdam	Netherlands		Marseilles		
Rome			Amsterdam			Bordeaux		
Turin			Aachen			Nice		
Genoa			Utrecht			Metz		
Florence			Eindhoven			Toulouse		
Palermo			Enschede			Nantes		
Bari			Arnhem			Saint-Étienne		
Venice			Tilburg			Strasbourg		
Bologna			Nijmegen			Rouen		
Catania			Breda			Toulon		
Salerno			Amersfoort			Nancy		
Padua			Oslo	Norway		Le Havre		
Bergamo			Bergen			Grenoble		
Massa			Stockholm	Sweden		Mulhouse		
Brescia			Gothenburg			Clermont-Ferrand		
Verona			Malmo			Tours		
Taranto			Vienna	Austria	Central	Rennes		
Caserta			Graz			Avignon		
Cagliari			Linz			Dijon		
Rimini			Salzburg			Angers		
Valletta	Malta		Essen	Germany		Reims		
Lisbon	Portugal		Berlin			Brest		
Oporto			Hamburg			Orleans		
Barcelona	Spain		Munich			Montpellier		
Madrid			Frankfurt am Main			Caen		
Valencia			Bielefeld			London	United K.	Atlantic
Seville			Stuttgart			Manchester		
Bilbao			Dresden			Birmingham		
Oviedo			Leipzig			Leeds		
Malaga			Bremen			Glasgow		
Palmas, Las			Mannheim			Newcastle		
Murcia			Hannover			Sheffield		
Zaragoza			Nuremberg			South Hants		
Coruna, A			Chemnitz			Nottingham		
Grenada			Saarbrucken			Belfast		
Vigo			Wiesbaden			Bristol		
Santa Cruz de Tenerife			Halle			Edinburgh		
Donostia-San Sebastian			Kiel			Brighton		
Algeciras			Karlsruhe			Stoke-on-trent		
Cadiz			Lübeck			Leicester		
Palma de Mallorca			Magdeburg			Hull		
Valladolid			Augsburg			Middles-brough		
Alicante			Osnabrück			Swansea		
Santander			Coblenz			Coventry		
Gandia			Kassel			Blackburn		
Pamplona Iruna			Darmstadt			Bourne-mouth		
Tarragona			Freiburg im Breisgau			Cardiff		
Elx			Zurich	Swiss		Southend on Sea		
			Basel			Plymouth		
			Berne			Blackpool		
			Geneva			Barnsley		
			Lausanne			Preston		
			Brussels	Belgium	Western	Aberdeen		
			Douai			The Medway		
			Liege			Reading		
			Charleroi			Aldershot		
			Bruges			Luton		
			Hasselt			Dublin	Ireland	
			Mons					

Source: Own elaboration