OECD Regional Development Working Papers 2015/01

Urban Spatial Structure in OECD Cities: is Urban Population Decentralising or Clustering?

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https://dx.doi.org/10.1787/5js3d834r3q7-en

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Authorised for publication by Rolf Alter, Director, Public Governance and Territorial Development Directorate, OECD.

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URBAN SPATIAL STRUCTURE IN OECD CITIES: IS URBAN POPULATION DECENTRALISING OR CLUSTERING?[1]

by Paolo Veneri

Abstract

This paper presents an analysis of urban spatial structure and its trends in the OECD between 2001 and 2011. It does so by using a standardised definition of urban areas in 29 OECD countries as composed of high density cores and their respective commuting zones. While urban population is growing everywhere, the way in which populations locate throughout the urban space differs across OECD cities and countries. The prevalent trend is an increasing dispersion of the population, with growth taking place outside existing centres. However, in specific countries, there are cities experiencing a higher growth in their central cores, while others are strengthening their polycentric structures. Overall, the population has grown more in relatively low-density locations close to the main centre, but outside it. Closeness to sub-centres also proves to be a strong advantage for growth and suggests the emergence of new centralities shaping urban spatial structures.

JEL classification codes: R10, R12, R14.

Key words: Urban spatial structure, suburbanization, polycentricity, sprawl.

1. The views expressed herein are those of the author and do not necessarily reflect those of the OECD or of its member countries. The author would like to thank Rudiger Ahrend for inspiring this work with valuable comments and suggestions. Comments were provided also by Monica Brezzi, Roberto Basile, Luiz De Mello, Miguel Àngel García-López, Alexander Lembcke and Karen Maguire. Daniel Sanchez-Serra provided impressive help with data collection. Any error remains the author's.

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INTRODUCTION

The nature and form of urban development patterns have been changing markedly in the past five to six decades and they are constantly evolving. The urban population has always increased, although the size-distribution of national urban systems still tends to be stable over time, and it is remarkably well-described by Zipf’s law (Duranton, 2007). On the other hand, urban structure within cities – e.g. the location of the population throughout the urban space – has been changing more radically. First, cities have been expanding physically and functionally, with people and economic activities spreading out from the existing major centres (Paulsen, 2012). This has changed the concept of a city into a more ‘regional’ phenomenon where cities are no longer characterised by high-density settlements alone and include surrounding low-density and functionally connected territories. Second, urban density gradients have on average declined over the decades, meaning that the physical enlargement has been accompanied by a re-distribution of population within the urban space (Kim, 2007).

Contemporary metropolitan areas are increasingly polycentric. A city is polycentric when it includes two or more ‘urban centres’, either through a process of incorporation of already-existing centres or through new centres emerging from decentralisation processes. Such new centres often arise at the ‘edge’ of the city, close to the major nodes of the transport network (Garreau, 1991). However, as people and economic activities have continued to spread out from existing urban centres, many scholars, especially in the US, have begun to talk about “edgeless cities” (Lang, 2003), meaning spatial patterns that go “beyond polycentricity” (Gordon and Richardson, 1996) and are characterised by generalised dispersion and sprawl (Bruegmann, 2006; Bogart, 2006).

The process of urban growth has not always followed the same pattern, and not everywhere. Ongoing processes of urbanisation have often been followed by a decentralisation of the population from congested urban centres to the surrounding – and previously undeveloped – hinterland. In other cases, urban growth have occurred mostly as a result of an integration or coalescence process between old and already-existing cities that started to be incorporated into a wider urban or metropolitan area (Champion, 2001). These two possible patterns have contributed to current differences in urban spatial structures which have potentially several economic and environmental implications. Less sprawl and a higher concentration of people and economic activities – in either monocentric or polycentric structures – have mostly been found to be associated with higher aggregate levels of productivity (Ciccone and Hall, 1996; Meijers and Burger, 2010; Fallah et al., 2011). A more controversial issue concerns the environmental implications of spatial structures: for example, in terms of overall ecological footprint (Muñiz and Galindo, 2005) or in terms of car use and connected transport emissions (Vance and Hedel, 2008; Veneri, 2010). Sprawl has also been associated with social problems for those people that are left behind in a car-based society (Glaeser and Kahn, 2004), although the effect on social segregation seems less clear (Kahn, 2001; Raymond, 2013; Zhao, 2013).

This paper presents an analysis of urban spatial structure in the OECD and of its evolution during the decade 2001-2011. The aim is twofold. First, to identify the patterns of spatial distribution of population within urban areas across OECD countries. Second, to understand whether urban areas are becoming more centralised, dispersed or polycentric. The choice of the time span is constrained by data availability across all considered countries. In this respect, one decade represents a reasonable compromise between the need to perform a robust comparative analysis and that of providing detailed descriptions of urban spatial structure and its trends. The analysis is carried out by using a large set of functional urban areas (FUAs) consistently identified by the OECD (2012). In this paper the term 'FUA' and 'city' are used as synonymous, while a 'metropolitan area' is defined as a FUA with at least 500, 000 inhabitants. On the other hand, the term 'local unit' identifies the small spatial units which compose each FUA (being them municipalities, census tracts or wards, depending on the country considered). FUAs are defined by adding to the cores – high-density places identified using a 1-km^2 global population grid – those territories that are connected to the core through commuting flows.[2] The use of FUAs makes it possible to adopt an economic perspective on the definition of cities, without relying too much on the administrative structure of each country. In this way, the use of FUAs also improves dramatically the comparability of urban spatial structures across different countries. FUAs include all cities with a minimum population of 50 000 inhabitants, thus covering almost the whole urban hierarchy in each country.

To the author's knowledge, there is no other work that compares urban spatial structures across such a large number of countries. Similarly, there is still very little international comparative knowledge on the spatial trends across urban areas in developed countries. Results show that in a context where the urban population grows almost everywhere, the population grows at higher rates outside, but close to, the main urban centres, in places with a relatively low population density. A certain number of Central and Northern European countries, however, has experienced a more sustained population growth in more central locations. In trying to understand whether spatial structures are becoming more polycentric or dispersed, this analysis highlights that in the last decade population shares in the centres and sub-centres remained stable, but population growth within metropolitan areas generated new sub-centres hosting a significant part of the urban population.

The remainder of the paper is organised as follows. Section 2 sets the context of the analysis by briefly describing the patterns of urbanisation across OECD countries. Section 3 describes the intra-urban patterns of population distribution in terms of the core/commuting zone dichotomy. Section 4 goes into more detail by analysing the last decade's trends of population concentration and centralisation within the urban space. Focusing on metropolitan areas alone, Section 5 tries to conceptualise and describe the patterns of metropolitan polycentricity, while Section 6 conducts an empirical analysis to understand how urban centres and sub-centres shaped, during the decade under consideration, the patterns of urban growth within the metropolitan space. Section 7 concludes.

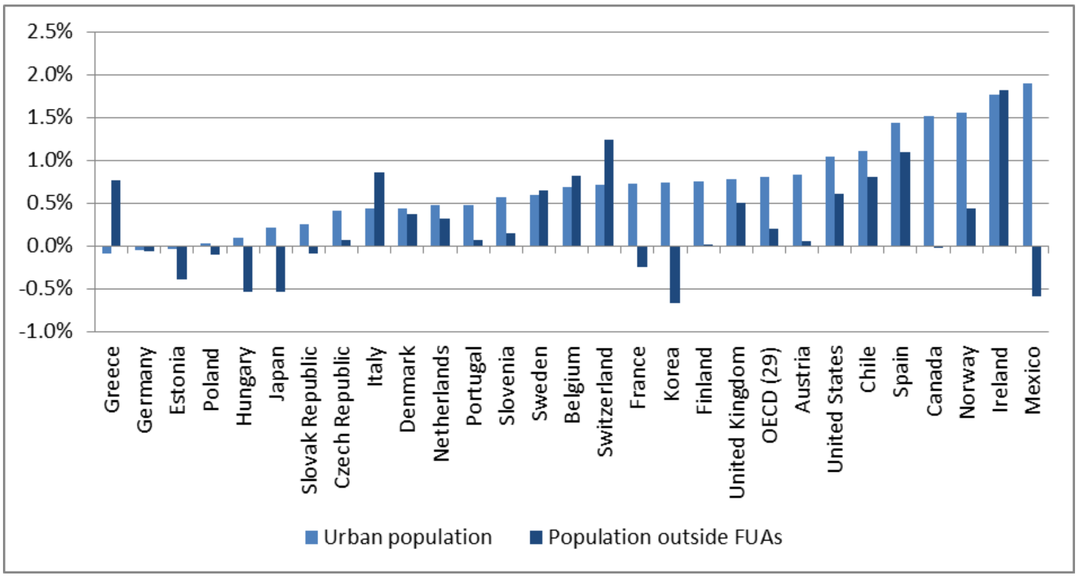
I. Setting the scene: recent urbanisation patterns in OECD countries

OECD countries are characterised by a high degree of urbanisation. Almost 750 million people live in one of the 1179 FUAs identified by the OECD, accounting for 67% of total population in 2011. All the urban population is distributed in cities of different sizes. In 2011, FUAs with a total population higher than 1.5 million accounted for half of the total urban population, while FUAs with fewer than 200 thousand people accounted for 9.5% of the total urban population.

Although the degree of urbanisation was already high in OECD countries compared with the rest of the world, in the last decade the number of urban residents continued to increase. Between 2001 and 2011, the share of urban population increased by 8.3% versus a 2% increase in the rural population. Some countries exhibited a particularly wide gap between growth inside and outside FUAs, such as Canada, Mexico, Korea and France. However, this general pattern does not characterise all the countries under consideration, especially in Europe, where Belgium, Greece, Ireland, Italy and Switzerland experienced higher population growth outside FUAs (Fig. 1).

2. See OECD (2012).

Figure 1. Average annual population growth rate inside and outside functional urban areas, 2001-2011



Source: Authors' elaborations on OECD Metropolitan database.

Urbanisation processes can affect the urban spatial structure substantially. In the context of an overall growth of the urban population, it is important to understand how urban areas have changed their structure to accommodate such growth. The different urban spatial structures in OECD countries have been experiencing sometimes profound changes, which can be driven by several factors, including cultural, geographical and economic ones. Overall, the last decades showed in many countries an outward shift of urban population and employment from central locations to suburbs and more distant locations, which are anyway still within the functional urban area. However, this process can occur while maintaining a compact structure, increasing generalised dispersion or developing around a polycentric structure.

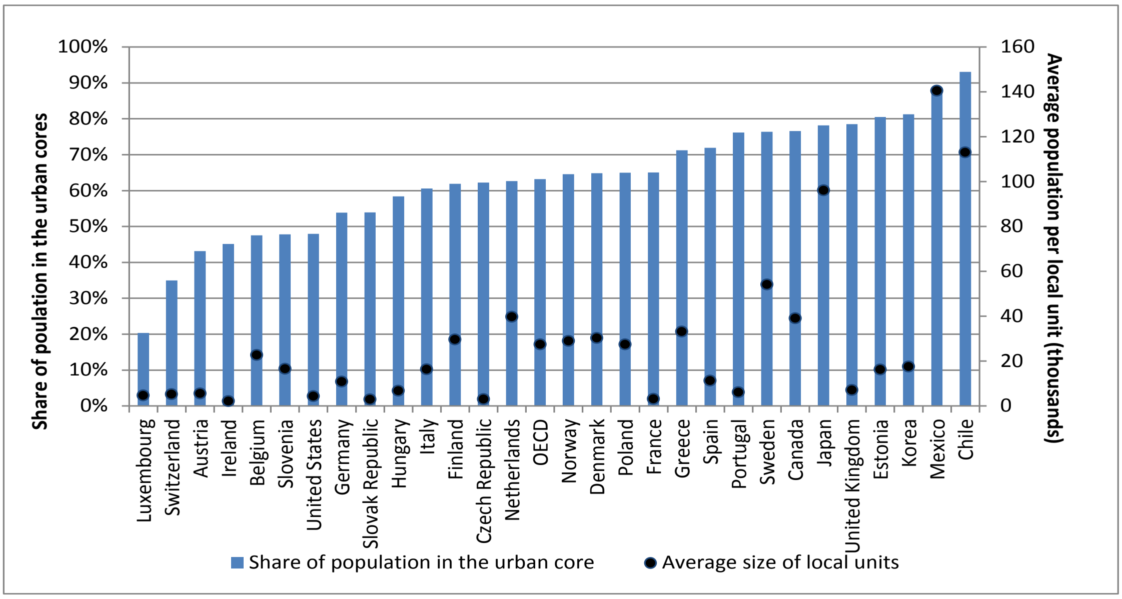
There are many centripetal and centrifugal forces in driving the evolution of urban spatial structures. Among the main reasons underlying a lower weight of the most central locations relative to more distant ones is that people move increasingly faster within the metropolitan space thanks to the improvement of the transport system and to a ubiquitous car access (Gordon and Richardson, 1996). This allows agglomeration economies to be enjoyed also when people live in more distant – but still accessible – locations. Still, places with a certain size and density can ensure more easily a certain level of public services, better consumption amenities and higher general accessibility (i.e. closeness to transport hubs). A polycentric urban structure may emerge as a consequence of this trade-off. The rest of the paper analyses the principal characteristics of urban spatial structure in the OECD and its main evolution over the last decade.

II. Core-periphery relationships in OECD cities

Probably the most common pattern of urban evolution of the last century was suburbanisation, meaning the movement of people from central locations to commuting zones. Some scholars highlighted that suburbanisation was an international phenomenon that occurred throughout the last century in almost all countries (Mieszkowski and Mills, 1993). The traditional explanation of suburbanisation advanced by economists is rooted in the economic models of urban spatial structure based on bid rent theory (Alonso 1964; Mills, 1967; Muth, 1969). The basic idea of these models is that all the employment is concentrated in the central business district (CBD) and that residential choices by individuals are based on the best access (distance) to the CBD. In a standard monocentric structure, the CBD is located at the centre of the urban area, where population density is at its maximum, and it declines exponentially as the distance increases. In a time perspective, as technological progress takes place and income increases, the relative costs of being far from the main centre decreases and people can move further away from the CBD, where land is cheaper, congestion lower and housing size higher. Findings in the literature show that, in the US, during the 1980s and 1990s both population and jobs decentralised from old cores to suburban places and that job dispersion was stronger than the tendency to locate to new centres (polycentricity) (Gordon and Richardson, 1996; Lee, 2007).

Contemporary cities have complex spatial structures. They are no longer identified with very dense settlements alone, since their economic and spatial extent includes an important part of peri-urban and rural territory – what for simplicity we call the *commuting zone*. The latter is characterised by lower-density settlements with respect to the main urban centres. However, these territories are still part of the city, since they encompass the space where people live and work and where households self-organise the bulk of their daily activities. A first assessment of urban spatial structure can be obtained by looking at the weight of commuting zones, which in OECD FUAs account for 44% of the total urban population. This share is heterogeneous across countries (Figure 2). A group of European countries – including Austria, Belgium and Ireland – and the US have less than 50% of their total population in the cores. On the other hand, Korea, Mexico and Chile show shares of core population higher than 80%. From a macro-regional perspective, the two Asian countries are those with the highest average shares of population in the urban cores (79%), followed by European countries and the ones in the Americas (65% and 63%, respectively). Though urban cores are functionally defined spatial units, it should be acknowledged that their boundaries are consistent with existing local administrative boundaries. This implies that the size of local units can affect simple measures of concentration in the core, partly explaining the high values for countries that have local administrative units of larger size on average (i.e. Mexico and Chile). Appendix 1 reports the type, number and size of local units considered for each country.

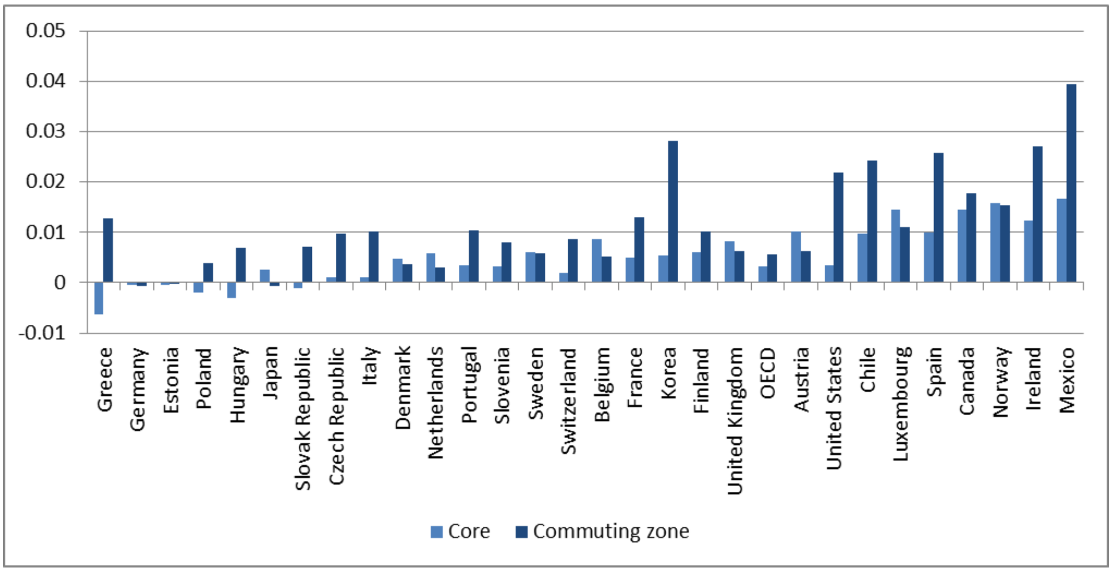
Figure 2. Share of population in the urban core in 2011, by country



Source: Authors' elaborations on OECD Metropolitan database.

Population in the commuting zones grew faster than in the cores during the last decade (Figure 3). In a way, this confirms that suburbanisation trends are currently characterising the spatial evolution of cities in the OECD. Yet suburbanisation trends occurred to different extents across countries. The largest differences between the rates of population growth in the commuting zones and in the cores were observed in Mexico, Korea, Spain, Greece and the United States. On the other hand, several countries in Northern Europe, such as Austria, Belgium, Netherlands, Luxembourg, Denmark, Sweden and the United Kingdom, showed higher growth rates in the urban cores, although the differences were relatively small. There may be various reasons for these different patterns. Core-commuting zone population trends may be related to different stages of industrialisation, economic development and technological progress (Hall and Hay, 1980; van der Berg et al., 1982). A faster growth in the cores may suggest either that, especially in a developing economy, people move to cities from the rural countryside, or, at a more advanced stage of development, that face-to-face contacts are relatively more important or that the consumption amenities supplied by cities have a stronger role. Another important interpretation is the existence of a specific policy in place at country or regional level to revitalise city centres, where people and economic activities are incentivised to locate. These policies are present in several countries, such as the US (Hortas-Rico, 2014) or the UK with its "Town Centres First" initiative (Cheshire et al., 2013). In many OECD countries, the effects of these anti-sprawl policies are not entirely clear, since they often coexist with property tax systems that favour single-family homes over multi-occupancy dwellings, thus generating further suburbanisation (OECD, 2014).

Figure 3. Average annual growth rates of the population between 2001-11 in cores and the commuting zones of OECD FUAs



Source: Authors' elaborations on OECD Metropolitan database.

The acceleration of population growth in commuting zones was particularly high in the largest FUAs, which also experienced higher total population increase. Agglomeration economies and consumption externalities may have played an important role in this respect. In the decade considered, commuting zones of FUAs with more than 1.5 million inhabitants grew on average by 1.9% yearly, while in the commuting zones of the other groups of smaller FUAs population growth ranged between 0.9% and 1.4%. In the FUAs with more than 1.5 million inhabitants it is more likely that congestion costs were higher in the urban core and more urban dwellers decided to locate in the commuting zone.

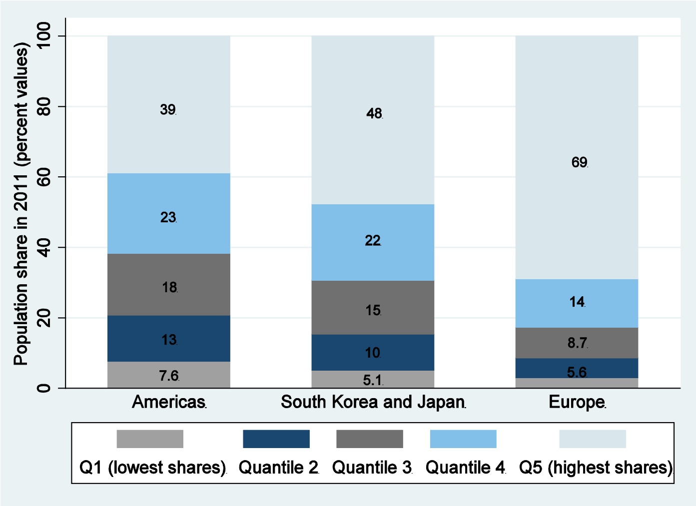
In this respect, Fujita and Ogawa (1982) argue that decentralisation of the population and the emergence of new sub-centres increase with population size. This argument was empirically tested by McMillen and Smith (2003).

III. Trends in population de-concentration and de-centralisation

Besides the core-periphery dynamics, urban spatial structure is assessed here according to the framework developed by Anas et al. (1998) and Lee (2007), which considers two main dimensions that characterise urban spatial trends: centralisation and concentration. Each of them can be measured through appropriate indicators related to the distribution of the population throughout the urban space. The joint patterns of these indicators are expected to describe the overall spatial evolution of urban areas. Concentration indicators measure the extent to which people are spatially clustered, meaning if they are concentrated in a few locations rather than being dispersed throughout the whole urban space. Centralisation measures account for the extent to which people are located close to the main urban centre, which we call here Central District (CD). To be stressed is that the CD should not be confused with the urban core, as presented in the previous section, since the latter encompasses a high-density space that may be composed of one or more local authorities and is already a functionally defined spatial object. The CD is always composed of one single local unit, the one with the largest and densest population. In the case of US FUAs, a CD is identified as the highest-density census tract within the largest county in each FUA. In the case of many European FUAs, where the local units correspond to municipalities, the CD is the most populous municipality that gives the name to the whole FUA.

Concentration and centralisation measures may be closely associated, but they do not necessarily move in the same direction. In general, when a trend of concentration is accompanied by a trend of decentralisation of people from the CD, it is likely that a FUA is evolving towards a more polycentric structure (or decentralised concentration). On the other hand, a decrease in both concentration and centralisation suggests a spatial trend towards a more dispersed and fragmented structure. As far as concentration is concerned, there are substantial macro-regional differences across FUAs already at the continent level. In this respect, a broad overview is provided by Figure 4, in which all local units within FUAs (e.g. municipalities, census tracts, etc.) are grouped into five quintiles by population shares in 2011. Figure 4 represents with a bar chart each group's shares of total population by continent. For example, 69% of the population of European cities lives in the largest 25% of local units, while in cities of the Americas (Canada, Chile, Mexico and the United States) this occurs only for 39% of the population. The figure suggests that European cities are those where the population is most concentrated in the smallest number of units, followed by Asian countries and those in the Americas.

Figure 4. Population shares within urban areas by density quintile



Note: numbers in the bars represent the shares (in percent values) of population for each quintile.

Source: Authors' elaborations on OECD Metropolitan database and National Census data.

The two spatial dimensions of concentration and centralisation are measured in this work by using a selection of indicators, as reported in Table 1. The first indicator of concentration, the Delta index, measures how unevenly the population in the urban area is distributed. The indicator ranges from 0 to 1 where 0 indicates perfectly even distribution and 1 a concentration of all the population in one local unit only. The entropy indicator (*ENTR*) also ranges between 0 and 1, with 0 indicating perfect concentration. Differently from other indicators of concentration, entropy measures are not influenced by the number of local units within each urban area, which is actually very heterogeneous across OECD FUAs. Centralisation indices measure how quickly the cumulative proportion of urban population increases as one moves from the CD towards the urban edge. The Modified Wheaton Index (*MWI*) ranges from -1 to 1, with 1 indicating perfect centralization. In order to compute this indicator, all local units must be sorted in ascending order by the distance from the main urban centre (CD). The ADC index is a simple measure of the weighted average distance of the population from the main urban centre. It ranges from 0 to the maximum distance from the CD.

Table 1. List of concentration and centralisation indicators

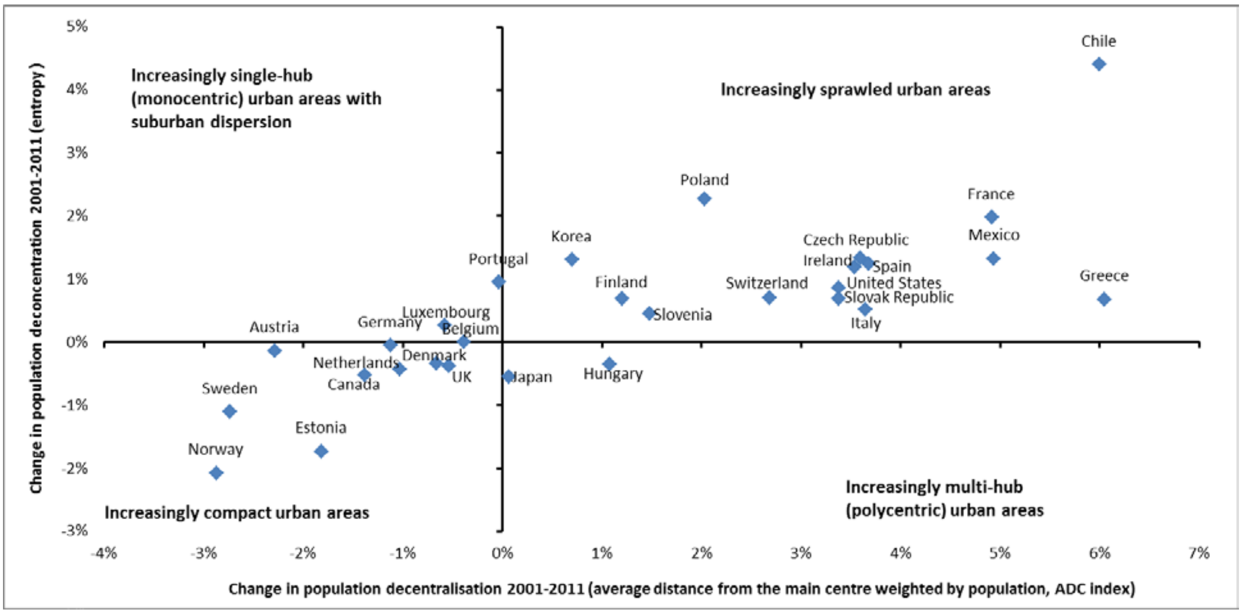
Concentration indices	
Delta index (Galster et al., 2001)	$DELTA = \frac{1}{2}\sum_{i=1}^{N}\left\|\frac{p_i}{P} - \frac{a_i}{A}\right\|$
Theil's Entropy (Tsai, 2005; Limtanakool et al., 2007)	$ENTR = \sum_{i=1}^{n} PDEN_i * log\left(\frac{1}{PDEN_i}\right)/\log(N)$ where $PDEN_i = DEN_i/\sum_{i=1}^{N} DEN_i$
Centralisation indices	
Modified Wheaton index (Wheaton, 2004)	$MWI = \left(\sum_{i=1}^{n} P_{i-1}DCD_i - \sum_{i=1}^{n} P_i DCD_{i-1}\right)/DCD^*$
Weighted average distance (Galster et al., 2001)	$ADC = \sum_{i=1}^{n} p_i DCD_i / P$

Notes: p_i: share of population in the *i*-th local unit; *P*: total population in the urban area; a_i: land area in the *i*-th local unit; *A*: total surface of the urban area; p_i/P: share of urban population in the *i*-th local unit; DEN_i: population density in the local unit *i*; *N*: number of local units (e.g. municipalities, census tracts, etc.); P_i: cumulative proportion of population in the *i*-th local unit; DCD_i: distance of the local unit *i* from the Central district (CD); DCD^*: distance of the outermost local unit from the CD.

By applying the indicators presented in Table 1 to the FUAs with at least 500 000 inhabitants – i.e. metropolitan areas – it is possible to capture how heterogeneous OECD countries are in terms of spatial structure (Figure A2 in the Appendix 2). Some countries, e.g. the UK, emerge as highly centralised, but they do not rank particularly high in terms of spatial concentration of the population. Japan shows high centralisation, but low levels of concentration. These low values may be due to relatively more uniform density patterns within the urban space hiding a compact and high-density pattern of development. Greece shows a decentralised and at the same time concentrated urban population, suggesting that urban spatial structures are relatively more polycentric than in other countries. Assessment by means of the indicators proposed of the extent to which the population in urban areas is centralised, dispersed or concentrated in several clusters may be affected by the average size of the local units in the different countries. Looking at how urban spatial structures changed in the last decade, instead of focusing on levels, can provide a more robust picture.

Figure 5 plots the average change, during the last decade and by country, in the concentration and centralisation of metropolitan populations. Two main issues emerge. First, concentration and centralisation are two closely correlated dimensions of spatial structure, since in most cases they move in the same direction. Second, in most countries a general process of decentralisation and de-concentration within metropolitan areas took place in the last decade. This process was relatively faster in Greece, Mexico, Chile, Italy, France and Spain. However, a group of countries, mainly located in Northern and Central Europe, showed a tendency towards more compact urban spatial structures characterised by the growing concentration and centralisation of urban residents. A few countries showed an increased concentration of the population and at the same time a decreasing centralisation. This pattern, which is apparent in the cases of Japan and Hungary, is intuitively consistent with the strengthening of metropolitan polycentricity. In the case of Japan, the observed trend confirms the finding of previous research that Japanese metropolitan areas are becoming increasingly polycentric, and this may have also been boosted by several years of planning in that direction (Sorensen, 2001).

Figure 5. Change in centralisation and concentration of people living in metropolitan areas, 2001-11



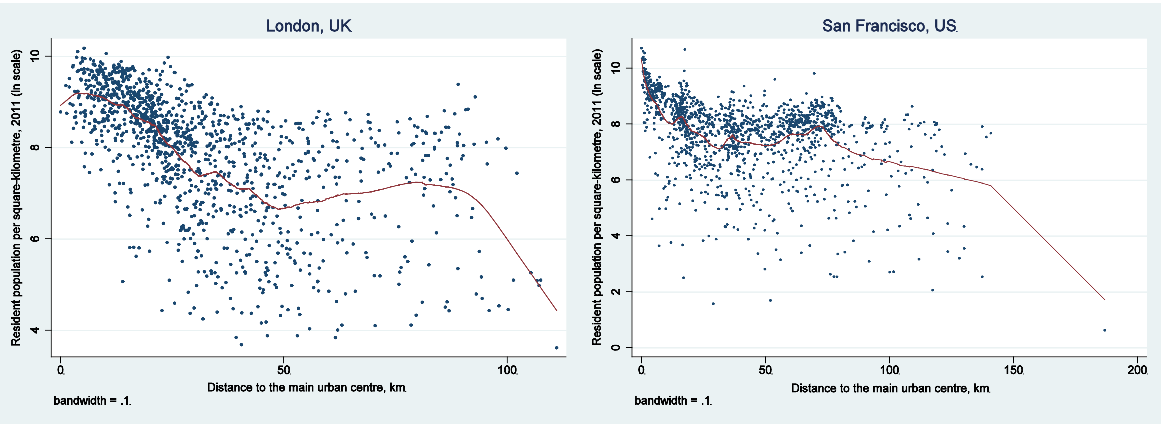
Source: Author's elaboration on OECD data.

IV. Assessing metropolitan polycentricity

Are spatial changes making metropolitan areas more polycentric? At the metropolitan scale, polycentricity is characterised by the presence of two or more ‘urban centres’, places with a high concentration of population and economic activities that functionally organise their surrounding territory (Brezzi and Veneri, 2014). In polycentric urban structures, the patterns of population density throughout the metropolitan space are not expected to follow the traditional pattern explained by the bid-rent theory (Alonso, 1963). In such a framework, density is at maximum level in correspondence to the CD, located at the centre of the city, and it then decreases smoothly and exponentially as distance from the CD increases. Conversely, polycentric urban structure should show, in correspondence to metropolitan sub-centres, local peaks in the density patterns. Figure 6 shows the examples of two large metropolitan areas, London and San Francisco, whose density patterns appear complex and not fully consistent with a negative exponential function. Although density decreases as distance from the main centre increases, after a certain distance it tends to increase (London) and several local peaks are visible along the urban space (San Francisco). Polycentric spatial structures may be particularly developed in large metropolitan areas, where secondary centres of population (or employment) may emerge or be strengthened due to increasing congestion costs.

Figure 6. Density patterns in metropolitan areas, 2011

Density does not decrease smoothly as distance to the main centre increases



Source: Author's elaboration on OECD data.

1. Sub-centres identification

The identification of sub-centres is the first step in the analysis of polycentricity at the metropolitan scale. For at least the last two decades, many urban economists have worked on this issue, with a particular focus on centres of employment rather than of population. In this study, the choice of population rather than employment is also due to limited data availability, given the purpose of this paper to compare across 29 countries. The methods most commonly employed to identify sub-centres make use of density measures. A straightforward procedure is the one used by Giuliano and Small (1991), which is based on thresholds of total employment and density. In trying to identify the sub-centres of Los Angeles, the two authors selected those local units (transportation analysis zones) with a gross employment density of at least 10 jobs per acre and a total employment of at least 10,000 units. Other authors have applied similar thresholds for other metropolitan areas, almost always in the US. A more advanced method consists in identification of the residuals of an estimation of the urban density function. The latter can be empirically specified through a parametric (e.g. negative exponential function) or non-parametric approach, depending on the strength of the assumptions on the urban structure. The residuals that are statistically diverse from zero can be considered to be candidates for sub-centres (McDonald and Prather, 1994; McMillen, 2001). In a second step, actual sub-centres are those that have a significant effect in a density function specified as polycentric. Finally, other authors use commuting data in order to identify those local units that attract relatively more flows, so that they can be considered more 'central' (Veneri, 2013). However, such methods require higher data availability and are difficult to apply in international comparisons.

The method applied in the analysis to identify sub-centres of OECD FUAs was based on a combination of population threshold and local-density peaks and it consisted in an adaptation of the method introduced by McDonald and Prather (1994). Consistent with these authors, candidate sub-centres were identified by estimating the negative exponential density function, specified as $D_i=e^{-d(x)}$, where D_i is the population density in local unit i and d is the distance from the main centre (CD) of the FUAs. In order to reduce inconsistencies due to the application of the same method to very different units, sub-centres were identified only for metropolitan areas, hence for those FUAs with at least 500 000 inhabitants.

By putting the density function in natural logarithm it is possible to simply estimate, through OLS, an equation like [1].

$$\ln(D_i) = \propto + \beta d_i + \varepsilon_i \qquad [1]$$

where α and β are the estimated coefficients and ε_i are the residuals. For each metropolitan area, those observations whose residuals were positive and statistically different from zero at 95% confidence level were selected as candidate sub-centres. This specification was found to be the most unbiased and homoskedastic functional form among several different specifications tested by McDonald and Prather (1994).

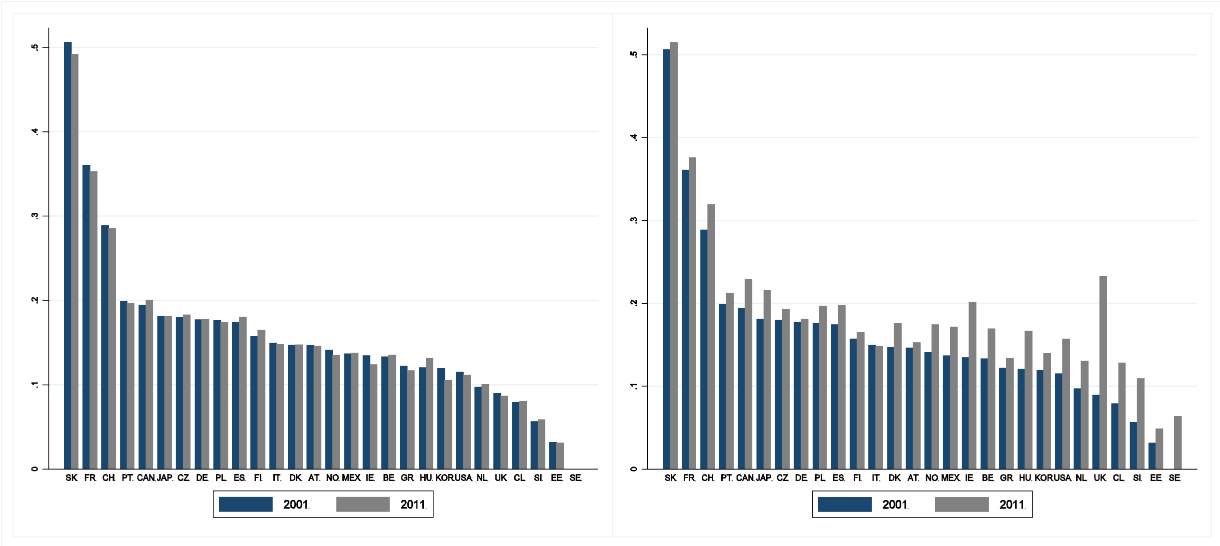
In a second step, final sub-centres were identified as those candidate sub-centres with a total population equal or higher than the value of the 90^{th} percentile of the population in the local units within each MA. Those local units that fulfilled both criteria were considered to be part of metropolitan sub-centres. The same procedure was repeated with both 2001 and 2011 data, identifying one set of sub-centres for each census year. This criterion allows density outliers to be excluded, and it is a simple way to identify actual centralities across so many metropolitan areas presenting important differences also in terms of relative size (and numbers) of local units.

An overall picture of the differences in the degree of polycentricity of OECD metropolitan areas can be obtained by looking at the evolution of the population (and employment) shares in the sub-centres identified. The change in the shares of metropolitan population located in sub-centres can provide a clearer answer to the question of whether cities and metropolitan areas are evolving towards more polycentric or more dispersed structures. In regard to sub-centres identified in 2001 only, these shares did not change substantially during the decade between 2001 and 2011 (Fig. 7a). However, when the sub-centres identified in 2001 are compared with those identified in 2011, and when the population shares in their respective years are computed, the concentration of people in centres shows an increase in most countries (Fig. 7b). This last picture did not emerge clearly from the index of centralisation and concentration analysed in the previous section. The positive trends in sub-centres can be interpreted as an increase in polycentricity driven by the emergence of new sub-centres rather than by the growth of already-existing ones – i.e. local units that already had relatively high levels of size and density in 2001. However, the increase in the degree of polycentricity did not occur with the same intensity everywhere. The largest trends towards polycentric structures were observed in the UK, Slovenia, Korea, US and Japan (Fig. 7b). At the same time, some countries, such as Germany and Austria, showed more stable urban structures.

Figure 7. Average share of population in sub-centres over total metro population, by country (2001 and 2011)

a) Population shares in 2001 and 2011 in sub-centres identified in 2001.

b) Population shares in 2001 and 2011 in sub-centres identified in their respective years



Source: Author's elaboration on OECD data.

2. Evolution of sub-centres

Changes in the degree of polycentricity of metropolitan areas are due to a significant extent to new local units acquiring the status of sub-centre during the period under analysis. Table 2 reports the average number, by country, of local units included in sub-centres, as well as their respective population shares in the two years considered. It should be acknowledged that the method employed to identify sub-centres did not allow the exact number of sub-centres to be identified, but only the number of local units that compose sub-centres. This is because sub-centres can consist of several contiguous local units which should be aggregated in order to know the exact number of sub-centres. However, a complete set of geo-referenced information on the boundaries and locations of local units was not available. This limitation is particularly significant in the countries where local units are particularly small, such as the UK and US, where wards and census tracts, respectively, were considered. However, this limitation did not prevent assessment of the degree of metropolitan polycentricity in terms of the population shares in the local units considered as sub-centres and their changes over time. Table 2 also shows that some local units lost their status of sub-centres in the ten years considered, while in almost all countries the number of central units increased because of the emergence of new centralities.

Table 2. Local units in sub-centres and their population shares, by country (2001-11)

	Number of metropolitan areas considered	Average number of local units considered as sub-centres		Average share of metro population in sub-centres		Number of local units changing status between 2001 and 2011	
		2001	2011	2001	2011	N. of units losing status of sub-centre	N. of local units as new sub-centres
Austria	3	16.3	18	15.5%	16.1%	0	5
Belgium	4	2.3	3.3	8.4%	11.2%	0	4
Canada	6	3.2	4.5	14.0%	19.6%	0	8
Switzerland	3	11	13	31.5%	34.3%	1	7
Chile	1	1	2	7.9%	12.8%	0	1
Czech Republic	3	23	27.3	19.9%	21.3%	1	14
Germany	21	6.4	6.7	15.0%	15.0%	6	12
Denmark	1	4	5	14.7%	17.6%	0	1
Estonia	1	1	2	3.1%	4.9%	0	1
Spain	8	5.9	7.6	12.2%	18.2%	5	19
Finland	1	1	1	15.7%	16.5%	0	0
France	19	17.9	20.8	30.1%	31.3%	7	61
Greece	2	2.5	3	11.2%	14.6%	0	1
Hungary	1	14	20	12.0%	16.6%	1	7
Ireland	1	25	37	13.5%	20.1%	3	15
Italy	11	4.6	4.8	8.1%	9.0%	5	7
Japan	17	2.3	2.9	6.5%	10.7%	2	12
Korea	10	10.6	12.6	8.4%	14.1%	43	63
Mexico	8	1.3	2	8.9%	12.1%	0	6
Netherlands	5	1	1.4	5.4%	10.6%	1	3
Norway	1	2	3	14.1%	17.4%	0	1
Poland	8	2.3	3.3	13.0%	15.9%	0	8
Portugal	2	10.5	12	20.9%	21.7%	1	4
Sweden	3	0	0.7	0.0%	6.8%	0	2
Slovenia	1	1	2	5.6%	10.9%	0	1
Slovak Republic	1	12	13	50.6%	51.5%	0	1
United Kingdom	15	9.6	26.1	6.9%	17.8%	28	276
United States	70	28.1	38.1	10.1%	16.3%	321	1 021

Source: author's elaborations on OECD and national population census data

V. Where does the population grow within metropolitan areas?

The previous sections provided comparative evidence on the main trends in urban spatial structures. They described core-periphery relationships, patterns of concentration and centralisation of the population, as well as changing levels of polycentricity. In order to identify how these general trends emerged, this section examines the role of some of the main factors explaining changes in the spatial structure. The objective is to assess some of the factors driving population growth in the local units within the metropolitan space during the last decade. To this end, a regression analysis was carried out in order to assess whether and how the CDs and sub-centres are important in shaping the patterns of density and growth in metropolitan areas. The influence of centres of various hierarchical levels on population growth – and hence on changes in the metropolitan structure – can be measured by the physical distance of each local unit from these centres, as well as the effect of initial density. By determining the role of these factors, it is possible to describe the current evolution of spatial structures in metropolitan areas and to shed some light, from an international comparative perspective, on the net effect of agglomeration forces vs. congestion costs in determining residential locations.

1. Empirical specification

This work applies a simplified version of the model proposed by Partridge et al., 2008, where population growth in each local unit within the metropolitan space is regressed on the distance to urban centres and sub-centres. In principle, the effect of distance is ambiguous, since both agglomeration and congestion forces can operate. Households can maximise their utility by locating close to places endowed with more natural amenities, less traffic congestion, lower crime rates, or a more rural lifestyle. On the other hand, higher-tier urban centres provide a wider set of services, more complex consumption opportunities, and a more active social environment. It should be acknowledged that distance to job (not just population) centres may have also a significant impact on local population growth within the metropolitan space, as predicted by theory (Lucas and Rossi-Hansberg, 2002) and recently demonstrated empirically (Koster and Rouwendal, 2013). However, the large international database used here lacks data on employment at local unit level. The empirical model is specified as follows:

$$\%\Delta pop_{i,t-0} = \alpha + \beta * GEOG_{i,0} + \gamma * DENS_{i,0} + \sigma_j + \epsilon_i \qquad [2]$$

where $\%\Delta pop_{i,t-0}$ is the annual average growth rate of the population between 2001 and 2011 for the *i*-th local unit within each metropolitan area; $GEOG_{i,0}$ is a vector containing the variables measuring distance to the CD and to the closest sub-centre within each metropolitan area; $DENS_{i,0}$ is a vector containing the initial population density of the *i*-th local unit and of the closest sub-centre; σ_j accounts for metropolitan fixed effects and, finally, $\epsilon_{i,t}$ are i.i.d. error terms. The underlying idea is that large and dense urban centres are important for the growth of the surrounding more peripheral areas, since the former provide services and access to amenities that can be important for residential choices, even within a daily commuting distance (Glaeser et al., 2001). As a further control, the total population of each metropolitan area was also included in the model. The lagged density of each local unit accounts for its own level of agglomeration benefits and costs, hence the expected sign associated with this variable is also ambiguous. The precise list of variables considered in the analysis is presented in Table 3. Coefficients of equation [2] were first estimated by country and subsequently for the whole set of OECD metropolitan areas.

Table 3. Variables used in the regression analysis

Variable	Description	Spatial scale
PopGr	Annual average growth rate of total population between 2001 and 2011 (or the two last Census years)	Local unit (municipality, census tract, etc.)
PopFua	Ln of total FUA population in 2001 (or closest Census year available)	FUA
Density	Ln of population density in the local unit (inhabitants per square km)	Local unit
DistCentre	Ln of distance from the Central District of the FUA (km)	Local unit
DensSubcentre	Ln of population density of the closest sub-centre (inhabitants per square km)	Local unit
DistSubcentre	Ln of the distance from the centroid of the closest sub-centre (km)	Local unit

In the proposed model the units of analysis differed, sometimes substantially, in terms of size and number per metropolitan area. When comparing cities internationally, this issue may entail biases in the estimations and difficulties in interpreting results. One specific issue is the potential spatial heterogeneity, meaning the variability of the relationship under study across space, which may be due to differences in the units of analysis and in the location considered. This issue can bias OLS estimation, and an alternative approach accounting for the spatial patterns of the relationship under investigation is needed. For this purpose, a semi-parametric specification was adopted, where the non-parametric component consisted in a smoothing function of latitude and longitude, as suggested in McMillen (2012) and Basile et al. (2014). The idea behind this empirical strategy is that the smoothing function of latitude and longitude – together with metropolitan fixed effects – helps account for both potential differences in the investigated relationship across space and differences in the units of analysis. The proposed empirical specification is known as the penalised spline geo-additive model (PS-GAM) and the relative equation is indicated in [3].

$$PopGr_i = X_i\theta_i + \sigma_j + f(no_i, e_i) + \varepsilon_i \qquad [3]$$

where $PopGr_i$ is the dependent variable (population growth rate in the *i*-th local unit), X_{ij} are the other independent variables listed in Table 3 and θ_i their associated coefficients, respectively; σ_j is the dummy associated with each metropolitan area, which accounts for unobserved characteristics at metropolitan level; ε_i is an independent and identically distributed error term; the term $f(no_i, e_i)$ is a smooth spatial trend surface based on thin plate regression splines, which account for the interaction between latitude (northing, no_i) and longitude (easting, e_i). More details are provided by Wood (2003). The smoothing parameter estimation problem is solved by using the Generalised Cross Validation Criterion (GCV) as in Wood (2008). The remainder of the section shows the results of estimation of equation [3] using the PS-GAM approach. For reasons of robustness, OLS results are also reported in the Appendix A3. Results are first obtained by country and in a second step for the whole sample of OECD FUAs of at least 500 thousand inhabitants.

2. Results by country

The extent to which the location of metropolitan centres explains the change in the population of local units is remarkably different across OECD countries. These differences may also depend on the units of analysis (local units), which are heterogeneous in terms of their number and size. However, the results of regression analysis reported in Table 4 allow some general patterns to be detected. The first result that emerges from Table 4 is that the sign of the coefficient related to the distance from the CD is almost always negative, though often not statistically significant. France is the only country where a stable and positive relationship was found between distance to the CD and population growth. This confirms the picture depicted in the previous sections, where France emerged as one of the countries with the fastest dispersion of urban population throughout the metropolitan space.

The distance to metropolitan sub-centres was negatively associated with population growth in eight countries (results confirmed with OLS). Again, the sign of the relative coefficient was almost always negative, as expected, while in no country was a positive and significant coefficient found. This suggests that a general trend in OECD countries is that sub-centres have an important role in driving population growth within metropolitan areas, more than that of the CD. The coefficient relative to the initial density of local units is also negative in most cases, which might suggest a general preference for people to locate in low density areas, though close to centres. Stable exceptions were found only for Canada and Japan. These two countries, however, are quite different in terms of settlement patterns, and the reasons for these findings may be also different and a matter for further research. Overall, fairly consistent results were obtained also by using OLS estimators (Table A3.1 in the Appendix 3). The only remarkable difference was found in the coefficient controlling for the total size of FUAs, which was often not statistically significant when PS-GAM was used, while it was negative in the case of OLS results.

Table 4. PS-GAM results by country. Dependent variable: Average annual growth rate of population 2001-11

	PopFua	Density	DistCentre	Dist-Subcentre	Dens-Subcentre	Intercept	N. obs.	Adj. R-squared	Smooth term
Austria	0.0031	0.0011***	-0.0006	-0.0033***	-0.0002	0.0075	627	0.45	22.62***
Belgium	0.0012	0.0007	-0.0025**	-0.0006	-0.0008	0.0137*	159	0.45	21.85***
Canada	-0.0109	0.0029***	0.0045**	-0.0028	-0.0003	0.0187	287	0.22	20.74***
Switzerland	-0.0086	-0.0010	-0.0007	-0.0032	-0.0007	0.0196	293	0.03	4.216
Chile		-0.0118***	-0.0110*	0.0023		0.1283*	45	0.65	12.29
Czech Rep.	0.0231	-0.0048***	-0.0062*	-0.0035	0.0013	0.0360	747	0.34	23.72***
Germany	-0.0089	0.0002	-0.0016***	-0.0023***	0.0007	0.0220	1,687	0.37	26.25***
Denmark		0.0005	-0.0050*	0.0037	-0.0013	0.0171	57	0.08	2
Spain	0.0025	-0.0056***	0.0041	-0.0010***	0.0016	-0.0015	726	0.47	24.99***
France	-0.0215**	-0.0020***	0.0027***	-0.0002	-0.0004	0.0691***	4,396	0.25	
Greece	0.0108	0.0003	0.0074**	-0.0038	-0.0012	-0.0041	118	0.84	26.33***
Hungary		0.0009	0.0069*	-0.0017	0.0030	-0.0331	183	0.41	15.66***
Ireland		-0.0134***	-0.020**	0.0004	0.0066*	0.1164***	484	0.28	18.59***
Italy	-0.0227	-0.0048***	0.0016	-0.0001	-0.0004	0.1311***	711	0.37	27.83***
Japan	0.0018	0.0024***	-0.0010	-0.0006	0.0010	-0.0394	548	0.33	
Korea	0.0111	-0.0101***	-0.0140***	-0.0127***	-0.0030	0.1453**	1,698	0.25	21.86***
Mexico	-0.0032	-0.0069***	-0.0009	-0.0043	-0.0010	0.0358	174	0.21	4.536
Netherlands	-0.0186	-0.0004	-0.0015	-0.0023	0.0178*	-0.1157*	108	0.13	10.32
Poland	0.0125*	-0.0029***	-0.0006	-0.0076***	0.0006	0.0259**	281	0.32	10.16
Portugal	0.0039	-0.0053***	0.0038	-0.0026	0.0004	0.0150	385	0.21	16.08***
Slovak Rep.	0.0115	-0.0056***	0.0041	-0.0086***	0.0014	0.0339	136	0.28	7.023**
UK	0.0073**	-0.0002	-0.0009	-0.0017***	0.0038***	-0.0266***	2,805	0.06	7.664
US	0.0076	-0.0114***	-0.0026***	-0.0066***	0.0012***	0.0873***	33,368	0.19	27.9***

Note: * statistically significant at 10% confidence level; ** statistically significant at 5%; *** statistically significant at 1%.

3. Overall results

Tables 5 present the estimation results using the whole sample of OECD metropolitan areas. Again, Table 5 shows PS-GAM results, while those obtained through OLS are reported in the Appendix 3, Table A3.2). Overall, in the last decade, population grew more in the local units with initial lower density and located relatively closer to the urban centres. Proximity to urban sub-centres – hence to those local units outside the main centre which have a particularly high density and large size – was found to have a stronger association with population growth than proximity to CD. An initial higher density of the closest sub-centre is associated with lower population growth, suggesting preferences for low density residential settlements, and that congestion costs may be relevant in sub-centres as well. The positive association between population growth and distance from the main centre and from the sub-centre does not prove to be amplified by the total size of the FUA, since the interactions between the latter and the distance variables are never statistically significant. These results are robust to the estimation method employed, and they should be interpreted as general evidence for all OECD metropolitan areas.

Table 5. PS-GAM results. Dependent variable: Average annual growth rate of population 2001-11

	PS-GAM- 1		PS-GAM- 2		PS-GAM- 3		PS-GAM- 4	
PopFua	0.1023		0.0735		0.1000		0.0728	
	0.1036		0.1093		0.1035		0.1095	
Density	-0.0088	***	-0.0088	***	-0.0088	***	-0.0088	***
	0.0001		0.0001		0.0001		0.0001	
DistCentre	-0.0021	***	-0.0008	**	-0.0021	***	-0.0008	*
	0.0003		0.0004		0.0003		0.0004	
DistSubcentre	-0.0064	***	-0.0064	***	-0.0059	***	-0.0066	***
	0.0002		0.0002		0.0004		0.0004	
DensSubcentre	0.0006	**	0.0002		0.0005	**	0.0003	
	0.0002		0.0003		0.0002		0.0003	
PopFua*DistCentre			-0.0008	***			-0.0008	***
			0.0002				0.0002	
PopFua*DistSubcentre					-0.0003		0.0001	
					0.0002		0.0002	
Intercept	0.2006		0.1331		0.1961		0.1312	
	0.1834		0.1939		0.1832		0.1943	
s(no, e)	27.02	***	27.51	***	27.01	***	27.53	***
Number of obs.	50122		50122		50122		50122	
Adjusted R-squared	0.168		0.169		0.168		0.169	
GCV	0.00079113		0.00079084		0.00079112		0.00079086	
Metro dummies	yes		yes		yes		yes	

Note: * statistically significant at 10% confidence level; ** statistically significant at 5%; *** statistically significant at 1%.

A large part of the observations considered in the regressions were represented by US metropolitan areas. In principle, this may have affected the capacity to describe patterns of urban spatial structure across a large and diversified set of countries. However, on dropping all the US observations, the signs and statistical significance of coefficients were largely consistent with those reported in Tables 5 and A3.2.[3] More specifically, the only notable change was a higher role played by the CD, which appeared to be approximately equal to the role of sub-centres. In addition, slightly significant evidence emerged that the role of sub-centres increases with the size of FUAs.

Conclusion

This study has presented an analysis of the urban spatial structure in the functional urban areas of the OECD and described its evolution during the last decade. Given data limitations for wide international comparisons, spatial structure was described only in terms of population distribution across metropolitan and urban space. During the 2000s, the total urban population grew everywhere, and in most countries this increase followed a pattern of spatial dispersion of the urban population. However, there are exceptions to this trend, especially in some Northern and Central European countries, where urban cores grew on average more than their respective commuting zones. European countries are also those characterised by higher levels of concentration of population within FUAs, compared with American and Asian countries.

An important characteristic of metropolitan areas is their increasing polycentric spatial structure. A large share of the total metropolitan population locates in sub-centres. However, sub-centring seems to be evolving substantially. While there is no strong evidence of population growth in sub-centres that

3. Table of results are available upon request.

were already sub-centres in 2001, the decentralisation of people has created new sub-centres. In the decade considered in this work, the degree of metropolitan polycentricity increased on average in most OECD countries. The analysis also provided evidence that changes in urban spatial structure are driven by specific patterns in population growth within the metropolitan space. Population grew more in locations with relatively low density and close to the CD and sub-centres, but outside them. These results may suggest that people tend to prefer to locate in accessible places while maintaining a relatively low-density living environment. Polycentric structures might be the result of this type of behaviour. The latter determines a decentralisation from the densest places towards more peripheral locations, which in turn might become sub-centres over time.

Notwithstanding the acknowledged data limitations, this work provides comprehensive international evidence on the urban spatial structure across a large set of OECD cities, and on their evolution. This evidence may be of great policy interest for countries that want to monitor how urban population distributes within functional urban areas in order to understand local needs in terms of, among others, provision of public services and infrastructure investments. The evidence provided here also furnishes basic comparative evidence for reflecting on the possible need to deal with tendencies of urban dispersion, in cases when the latter entails excessive collective costs.

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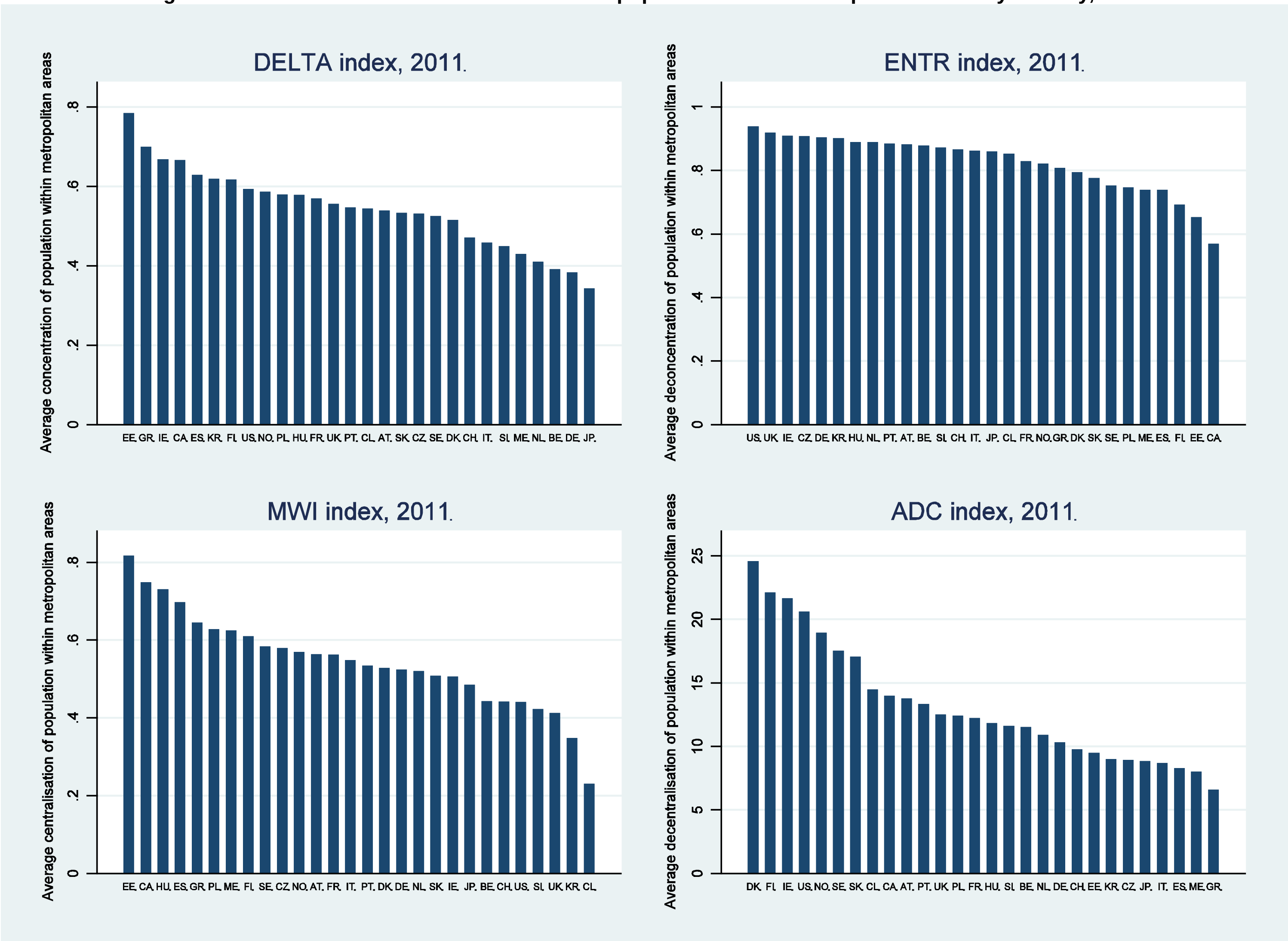
APPENDIX A1

Table A1.1. Type and characteristics of local units by country

Country	Local unit	First year	Last year	Average population per local unit in the last year		
				Mean	Standard Dev.	N. of local units
Austria	Municipality	2001	2011	6,092	62,886	794
Belgium	Municipality	2001	2011	24,289	41,362	268
Canada	Census sub-division	2001	2011	45,395	172,302	553
Switzerland	Municipality	2000	2010	4,926	18,203	783
Chile	Municipality	2002	2012	126,189	103,192	101
Czech Republic	Municipality	2001	2010	3,137	34,558	1,562
Germany	Municipality	2001	2010	10,847	68,679	4,824
Denmark	Municipality	2001	2011	31,679	65,787	96
Estonia	Municipality	2000	2011	16,154	60,167	46
Spain	Municipality	2001	2011	13,001	84,689	2,417
Finland	Municipality	2000	2011	31,938	74,356	88
France	Municipality	1999	2010	3,403	25,245	12,117
Greece	Municipality	2001	2011	32,790	63,135	169
Hungary	Municipality	2001	2011	6,839	65,091	734
Ireland	Municipality	2002	2011	2,531	3,178	985
Italy	Municipality	2001	2011	17,044	82,331	1,794
Japan	Municipality	2000	2010	99,194	126,813	998
Korea	City	2000	2010	18,878	12,248	2,217
Luxembourg	Municipality	2001	2012	5,230	10,427	83
Mexico	Municipality	2000	2010	169,598	288,645	410
Netherlands	Municipality	2001	2010	41,665	73,297	294
Norway	Municipality	2001	2012	33,842	81,622	70
Poland	Municipality	2002	2010	27,553	73,219	765
Portugal	Municipality	2001	2011	6,389	9,242	910
Sweden	Municipality	2000	2010	57,440	104,507	87
Slovenia	Municipality	2002	2010	17,570	42,532	46
Slovak Republic	Municipality	2001	2011	2,985	9,795	679
United Kingdom	Ward	2001	2011	7,641	4,935	6,075
United States	Census tract	2000	2010	4,880	3,398	43,037

APPENDIX A2

Figure A2.1 Centralisation and concentration of population within metropolitan areas by country, 2011



Source: Author's elaboration on OECD data.

APPENDIX A3

Table A3.1. OLS results by country. Dependent variable: average annual growth rate of population 2001-11

	PopFua	Density	DistCentre	DistSubcentre	DensSubcentre	Intercept	N. obs.	Adj. R-squared
Austria	.0029**	0.0013	-0.0026	-.0039**	-4.20E-04	.0178*	627	0.32
Belgium	2.80E-04	0.001	2.30E-04	0.0015	0.0015	-0.0158	159	0.11
Canada	-.0052***	.0026**	0.0032	-0.0019	.0024*	-0.0025	287	0.07
Switzerland	.0087***	-8.70E-04	0.0027	-0.0033	-5.80E-04	0.0129	293	0.00
Chile		-0.0066	1.60E-06	-0.0016		0.0671	45	0.42
Czech Rep.	.0204***	-.0045**	-.0179*	-.0069*	.0016*	.0819*	747	0.24
Germany	-.0055***	1.60E-04	-.0026***	-.0022**	8.70E-04	0.0123	1,687	0.32
Denmark		0.001	-0.004	0.0069	-0.0025	0.0094	57	0.07
Estonia		7.10E-05	-9.00E-04	-0.0032		0.0146	27	0.28
Spain	.0234***	-.0046***	-0.0093	-.0159**	1.40E-04	.0845**	726	0.27
Finland		-0.0021	-0.0011	-0.0017		0.0293	21	0.02
France	.625***	-.0019***	.0018**	-7.20E-04	-7.70E-04	-.171***	4,396	0.23
Greece	-0.0043	-0.0024	0.0089	0.0054	-.0031*	.0304*	118	0.54
Hungary		0.0021	-0.0029	-0.0063	0.0045	-0.0015	183	0.23
Ireland		-0.0098	-0.0092	-0.0027	0.0101	0.0392	484	0.20
Italy	2.60E-04	-0.0037	-0.0022	-8.20E-04	-0.0021	.0558***	711	0.20
Japan	7.90E-04	.0028***	-3.00E-04	-9.70E-04	.0015**	-.0248***	548	0.29
Korea	.0107***	-.0103***	1.40E-04	-.0101***	-.0123***	.2071***	1,698	0.17
Mexico	.0169***	-.0075*	-3.20E-04	-0.0055	8.70E-04	.075**	174	0.20
Netherlands	-0.0113	-5.40E-04	-0.0013	0.0013	0.0083	-0.0516	108	-0.03
Norway		5.50E-04	-3.80E-04	0.0039	-0.0387	0.2401	27	-0.11
Poland	.0992***	-.0023***	-7.20E-04	-.0071***	5.20E-04	-.1373***	281	0.26
Portugal	0.006	-0.0058	-0.0028	-0.0015	0.005	0.0056	385	0.11
Slovenia		-0.0042	-0.0021	-0.0057		0.0549	24	0.10
Slovak Rep.		-0.0062	-0.0064	-0.0064	9.60E-04	0.0728	136	0.14
Sweden	0.0007*	-0.001*	-0.0016**			0.0078***	51	0.08
UK	.0022***	-1.10E-04	-2.70E-04	-.0016***	.0029***	-0.0153	2,805	0.06
US	-.0061***	-.0113***	-.0019*	-.0072***	0.0017	.1054***	33,368	0.18

Notes: * statistically significant at 10% confidence level; ** statistically significant at 5%; *** statistically significant at 1%. All specifications include metropolitan dummies, and coefficients are estimated through OLS with standard errors clustered at metropolitan level.

Source: Author's elaboration on OECD and National Census data.

Table A3.2. OLS results. Dependent variable: average annual growth rate of population 2001-11

	OLS- 1		OLS- 2		OLS- 3		OLS- 4	
PopFua	-0.0196	***	-0.0186	***	-0.0189	***	-0.0185	***
	0.0008		0.0026		0.0023		0.0031	
Density	-0.0088	***	-0.0087	***	-0.0088	***	-0.0087	***
	0.0008		0.0008		0.0008		0.0008	
DistCentre	-0.0017	**	-0.0010		-0.0017	**	-0.0010	
	0.0006		0.0017		0.0006		0.0015	
DistSubcentre	-0.0066	***	-0.0066	***	-0.0061	***	-0.0064	***
	0.0007		0.0007		0.0016		0.0012	
DensSubcentre	0.0005		0.0003		0.0004		0.0003	
	0.0011		0.0008		0.0009		0.0008	
PopFua*DistCentre			-0.0004				-0.0004	
			0.0009				0.0008	
PopFua*DistSubcentre					-0.0003		-0.0001	
					0.0008		0.0005	
Intercept	0.0982	***	0.0974	***	0.0974	***	0.0972	***
	0.0106		0.0115		0.0119		0.012	
Number of obs.	50122		50122		50122		50122	
Adjusted R-squared	0.164		0.1641		0.164		0.1641	
Metro dummies	yes		yes		yes		yes	
Clustered standard errors at metro level								

Note: * statistically significant at 10% confidence level; ** statistically significant at 5%; *** statistically significant at 1%.

Source: Author's elaborations on National Census data