

EXPLORING THE RELATIONSHIP BETWEEN URBAN SPRAWL AND THE URBAN SYSTEM. EVIDENCE FROM THESSALONIKI, 1991-2011.

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The article explores the relationship between urban sprawl and the urban system. Urban sprawl is not considered to be a static, unsustainable urban form, but rather a dynamic process of urban deconcentration through which the urban structure evolves. After identifying the main characteristics of urban sprawl, this article investigates the connection between urban sprawl and the urban system through the concept of polycentricity. Finally, the two-way relationship between urban sprawl and the urban system is highlighted. Based on the above, an integrated theoretical, conceptual and methodological framework is formulated. A key finding was the emergence of 'small-scale' polycentricity, which implies increasing monocentricity over a wider spatial area. This raises questions over the distinction between the negative phenomenon of urban sprawl and sustainable polycentric forms, and points out a need to review the explanatory devices and theories used in spatial analysis and planning. Empirical evidence was extracted from Thessaloniki's Influence Area.

Key words: urban sprawl, polycentricity, urban system, deconcentration, spatial analysis and planning.

INTRODUCTION

There is growing concern over urban sprawl from professionals, politicians and academics. Although European cities have traditionally been much more compact compared to most American cities, sprawl constitutes a common challenge throughout Europe due to its environmental, social and economic impacts (CEC, 1999). Urban sprawl is generally considered to be an undesirable type of urban development (Hennig *et al.*, 2015; Zeković *et al.*, 2015), usually related to low-density urban expansion into surrounding rural areas (EEA, 2006).

In Europe, urban sprawl originated back in the post-war decades and since the 1970s, it has been associated with suburbanisation. However, there are significant differences regarding the processes and patterns of sprawl between North and South European cities. The anti-urban geographical imaginations of Northern cultures drove life-styled urban sprawl creating satellite suburbs in the search for a rural idyll within a 50km commuter range. Contrary to controlled suburbanisation, in Mediterranean Europe middle classes left the inner-city-area sprawling outwards at

relatively short distances (around 20km) (Leontidou, 1990). Urban sprawl has intensified in large Northern European cities since the 1980s through deconcentration trends along with the parallel absolute loss of population and workplaces from the inner urban areas (Hall and Pain, 2006). Further, urban sprawl has become even more far-reaching through the emergence of secondary economic poles at railroad intersections (Bontje and Burdack, 2005). In Southern Europe, population and workplace deconcentration intensified in the 1990s (Leontidou, 1990; Paul and Tonts, 2005). In particular, large-scale infrastructural projects have driven urban sprawl via ribbon development patterns and the conversion of secondary homes into primary ones (Leontidou *et al.*, 2007).

Urban sprawl is usually examined in the metropolitan level (Laidley, 2016; Hamidi and Ewing 2014; Sarzynski *et al.*, 2014; Ewing *et al.*, 2002; Galster *et al.*, 2001; Fulton *et al.*, 2001; Downs, 1998 etc.), even though sprawl seems also to have a multi-scalar approach (Hennig *et al.*, 2015), ranging from local to regional scales. The urban structure seems to evolve through the intensification of the urban sprawl phenomenon in contradictory ways. Therefore, several scholars focus on polycentric aspects of urban sprawl (Sarzynski *et al.*, 2014; Hamidi and Ewing, 2014; Cutsinger

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et al., 2005), whereas others (Salvati, 2016; Gordon et al, 1998) equate sprawl – often in monocentric cities – with suburbanisation resulting in dispersed urban form.

Taking these into account, this study aims to formulate an integrated theoretical, conceptual and methodological framework regarding the relationship between urban sprawl and the urban system. In short, it dissociates urban sprawl from its usual conceptualisation as an urban-scale low density expansion, and it reconsiders sprawl as a dynamic process of urban deconcentration that may gradually change the spatial urban structure at the metropolitan level towards a more polycentric pattern.

The main steps in this study’s methodology are the following and they are identified with the structural parts of this study:

1. Review the approaches regarding urban sprawl so as to develop a new definition.
2. Consider the urban system through the concept of polycentricity.
3. Analyse the theoretical and conceptual relationships between urban sprawl and the urban system, with polycentricity as the bridging concept and framework for the central hypothesis to be formulated.
4. Develop a methodological framework that can be applied in any empirical field that meets the necessary requirements.
5. Test the hypothesis in the selected empirical field and use the results to reflect on the explanatory devices and theories used in spatial analysis and development.

DEFINING URBAN SPRAWL: A LITERATURE REVIEW

Urban sprawl is broadly used to describe many phenomena related to urbanisation, the processes of urban change and urban growth (Slaev and Nikiforov, 2013). In fact, there are a variety of urban sprawl definitions and approaches coming from different scientific fields such as urban planning, urban economics and urban geography. These can be classified into three basic categories depending on a) low density (low density, population or workplaces deconcentration, land over-consumption), b) land use (or urban form) patterns, the majority of which are related to land use mixing, activity centring or centrality, accessibility, and c) impacts (environmental, economic, social). However, the majority of definitions are based on a combination of specific properties included in more than one category. These definitions may be qualitative or quantitative, and can be divided into either: 1) those that identify sprawl as a dynamic phenomenon and 2) those that consider sprawl as a static situation (Table 1).

The aforementioned approaches underline that urban sprawl is a multi-dimensional phenomenon that has no widely accepted definition or absolute form. However, the following basic principles can be accepted:

- Urban sprawl is conceived as the physical expansion of a city to its surrounding area. This expansion may take place using various spatial forms, including low-density, linear, scattered, leapfrog or even compact development in remote areas that are functionally dependent on the city.

Table 1. Review of basic considerations of urban sprawl

References (by year and alphabetical order)	Low Density			Land Use Patterns			Impacts			Main features of urban sprawl definitions and approaches		
	Low density	Deconcentration	Land over-consumption	Land use mixing	Activity centering/ centrality	Accessibility	Environmental, economic, social	Quantitative definition	Qualitative definition	Dynamic phenomenon	Static situation	
Hamidi and Ewing, 2014	•			•	•	•		•		•		
Lowry and Lowry, 2014	•			•	•	•		•		•		
Sarzynski et al. 2014	•			•	•			•			•	
Arribas-Bel and Schmidt, 2013	•	•		•	•	•		•			•	
Sohn et al. 2012						•		•			•	
Frenkel and Ashkenazi, 2008	•	•			•				•	•		
Torrens, 2008	•	•	•		•	•			•	•		
CEMAT, 2006,	•		•	•				•			•	
EEA, 2006	•		•	•				•	•	•		
Cutsinger et al., 2005												
Tsai, 2005	•	•							•		•	
Wassmer and Edwards, 2005		•		•				•		•		
Hasse and Kornbluh, 2004						•		•			•	
Glaeser and Kahn, 2003	•	•							•		•	
Ewing et al., 2002	•	•		•		•			•		•	
Hasse and Lathrop, 2003	•						•					
Galster et al., 2001	•	•		•	•	•			•		•	
Fulton et al., 2001	•		•						•	•		
Hess et al., 2001		•	•	•		•			•		•	
Johnson, 2001								•	•		•	
Peiser, 2001			•		•			•	•			
Brueckner, 2000			•					•	•			
Razin and Rosentraub, 2000	•			•					•		•	
Torrens and Alberti, 2000	•				•	•	•		•		•	
Pendall, 1999				•				•				
Burchell et al., 1998	•	•	•	•		•	•	•	•	•	•	
Downs, 1998				•				•	•			
Ewing, 1997					•	•		•			•	

(Source: edited by the author)

- Urban sprawl assumes the existence of a major urban pole or monocentric urban structure, as many definitions focus on the decline in density (often in relation to the distance from a city centre), or describe it as deconcentration from a central pole.

- Poor accessibility from one activity to another – commuting likely being the most common index – is an indication of urban sprawl. Specifically, the shift in accessibility or increase in travel distance denotes sprawl intensification, and is related to housing or workplaces in more remote areas.
- Urban sprawl is commonly perceived as a negative and unsustainable type of urban development related to inadequate planning.
- Urban sprawl can be considered a static urban form regarding its spatial characteristics, or a spatiotemporal, dynamic process regarding its socioeconomic shifts and spatial changes.

Therefore, when taking into account that urban sprawl is a dynamic phenomenon, it can be recognised through three considerations (Figure 1):

1. *Urban expansion* of a city to its surrounding area.
2. *Urban deconcentration* of a city to its surrounding area.
3. *Enlargement of the city's periphery* because of increased commuting distances.

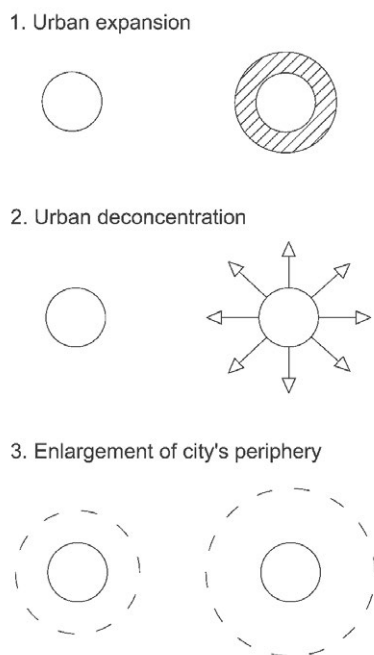


Figure 1. Basic considerations of urban sprawl
(Source: edited by the author)

These considerations relate the phenomenon of urban sprawl to the key assumption of the existence of a monocentric urban structure, since the dominance of a (focal) city surrounded by its periphery shapes, by definition, a spatial structure organised on the principles of centrality and, therefore, a monocentric structure clearly distinguished from a polycentric one (Parr, 2004:234).

Taking these considerations into account, urban sprawl is defined as a dynamic process of deconcentration from an urban centre to its surrounding influence area alongside spatial expansion.

CONSIDERING THE URBAN SYSTEM THROUGH THE POLYCENTRICITY CONCEPT

The central place theory of Christaller (1966/1933) and the theory of urbanisation cycle (Berry, 1976, Klaassen *et al.*, 1981, Van den Berg *et al.*, 1982), usually used to describe the organisation of the urban system, have currently been displaced by the concept of polycentricity. Polycentricity has been used both as an analytical tool to explain the structure of the urban system and as a planning tool or vision to promote spatial development (Davoudi, 2003:979).

Even though polycentricity is a multi-scalar concept that encompasses different levels ranging from the intra-urban to the European (Davoudi, 2003; ESPON, 2003b; Kloosterman and Musterd, 2001; Parr, 2004), it is most commonly applied to functional urban areas (Vasanen, 2012:3628) or inter-urban levels.

From an etymological point of view, polycentricity concerns the plurality of centres. Studies on polycentricity consider three dimensions of centres: 1) size, 2) (spatial) position and 3) connectivity. Dimensions (1) and (2) express the morphological approach of polycentricity and dimension (3) encompasses the functional one (ESPO, 2005:60-61).

However, the definition and the weighting of factors used to measure centrality are not uniform. Population is the prime indicator for ranking the size of centres in an urban system (Champion, 2001:664), although the number of workplaces is also commonly used (Hall and Pain, 2006:20). Networking in terms of material and immaterial flows is also gaining increasing importance in the analysis of urban systems (Burger *et al.*, 2015; Vasanen, 2012; Hall and Pain, 2006). However, there is no clear method to measure polycentricity (Burger and Meijers, 2012:1144; Meijers, 2008; Davoudi, 2003:979). The empirical assessment of polycentricity predominantly considers national scales and is based on strict quantitative indicators – such as the slope of the regression line of the rank-size distribution of Functional Urban Areas – whereas there are no specifications ‘about the rationales for using their indicators and their weighting’ (Meijers, 2008:1319).

Polycentricity is a state between concentration and deconcentration, or in other words, between the theoretical extremes of: 1) monocentricity, referring to the gathering of people and activities at one unique location and 2) dispersal, referring to the equal distribution of people and activities over space (ESPO, 2003a:6,7,13). The optimum degree of polycentricity represents an intermediate state between monocentricity and dispersal (ESPO, 2003a:7), and constitutes a balanced distribution of centres in a territory. Morphological and functional polycentricity are both concerned with ‘the balance in the importance of urban centres in a given area’ (Burger and Meijers, 2012:1144).

The ideal degree of polycentricity may be defined qualitatively through the concepts of ‘concentrated deconcentration’ (Bontje, 2001:770), ‘decentralized concentration’ (Knaap, 1998:385) or ‘deconcentrated clustering’ (Albrechts, 1998:417, 422). In truth, all of these approaches envisage a new balance that could be termed ‘deconcentrated concentration’ that reflects the guided deconcentration (usually) of population and urban activities

to selected centres clustered around the central pole in order to reduce inequalities.

To sum up, the degree of polycentricity increases the most when the size of centres, their spatial position and the interrelationships between them are evenly distributed. Thus, an urban system becomes more polycentric when: 1) the differences in size between centres decreases, 2) old and emerging centres have a more uniform distribution in a territory 3) the flows between the centres increase and have a criss-cross multidirectional pattern.

The ideal form of polycentricity constitutes a totally functionally and spatially balanced urban system in which all centres are of equal size and situated at equal distances (ESPON, 2005).

FORMULATING THE HYPOTHESIS: FROM URBAN SPRAWL TO POLYCENTRIC DEVELOPMENT

Champion (2001:663-666) analysed the ways in which an urban area or a region's structure may evolve into a Polycentric Urban Region by taking into account the number and size of centres, their spatial extent and level of interaction. According to Champion there are at least three alternative paths from which a polycentric urban region may emerge: the centrifugal mode, the incorporation mode and the fusion mode. The centrifugal mode refers to a monocentric city whose continuing growth leads to the creation of alternative centres that are smaller or equivalent in size to the original centre. The incorporation mode refers to the expansion of the urban field of a large urban centre by incorporating smaller pre-existing centres from the surrounding area. The fusion mode refers to the fusion of two or more centres or cities that have been previously developed more or less independently of each other and are situated in close proximity, as a result of their own separate growth both in overall size and spatial extension.

In fact, the incorporation and centrifugal modes assume the presence of a monocentric urban structure, whereas the fusion mode is based on the premise of a polycentric urban structure. The outcome of these modes is increased polycentricity of all new urban structures.

Taking into account the three aforementioned basic considerations of urban sprawl and Champion's views on the alternative processes for a more polycentric structure, the central hypothesis is formulated as follows:

Urban sprawl may change the structure of the urban system towards polycentricity. More specifically:

1. The approach of urban sprawl as urban deconcentration corresponds to the centrifugal mode, and consequently to the formulation or strengthening of secondary centres.
2. Urban expansion, which is a main feature of urban sprawl, simulates the fusion mode through the merging of existing centres, implying a plurality of centres in a given territory.
3. The approach of urban sprawl as an enlargement of the city's periphery corresponds with the spatial and functional expansion of an urban centre's influence area, which leads to the incorporation of pre-existing centres, and thus an increase in polycentricity.

Urban deconcentration refers to the deconcentration of population and urban functions, such as workplaces, tertiary sector activities or specialised services. The notion of deconcentration is approached in many ways (Mitchell, 2004:17-21). Traditionally, it is associated with the movement (relocation) of population and urban functions from a centre to its periphery and a decrease in the percentage share of the population or urban functions occupying the centre. Urban expansion is associated with an increase in land use for urban purposes, reflecting the spatial and morphological dimension of urban sprawl. However, the change in land use presumes a focus on the lowest spatial level. Finally, the geographical expansion of a city's boundaries into peripheral areas also implies deconcentration because of the peripheral increases in population and urban functions caused by the incorporation of pre-existing settlements.

Thus, the main research question is:

Can urban sprawl contribute to a more polycentric urban system, through the process of 'deconcentrated concentration'? (Figure 2).

Such an investigation is of crucial importance because urban sprawl is considered an unsustainable type of urban growth, contrary to the concept of polycentricity that is a strategic key policy option for sustainable development.

The secondary methodological research questions are the following:

- How are the deconcentration trends distributed in the influence area of the central city? Are they distributed in a uniform way, showing trends of generalised dispersion or in an uneven way showing signs of selective reconcentration trends around lower class centres which transform them to secondary or third class centres?
- How are these trends related to the pre-existing structure of the urban system?

METHODOLOGICAL FRAMEWORK AND FIELD OF APPLICATION

Basic methodological approach

The basic principle of the methodological approach for studying the urban system shift – being more or less polycentric – is the investigation of the deconcentration process, and particularly the identification of centres that appear as characteristics of deconcentrated concentration, namely centres that attract influxes from the prime centre. Therefore, urban sprawl and deconcentration are studied through overall urban growth trends that highlight urban system dynamics.

The relative change in the sizes of centres is based on a dynamic process of concentration and deconcentration that takes place within the urban system. This shift is influenced by two factors: 1) the internal changes, namely the movements that take place within the urban system, and 2) the external input and its distribution in the urban system. According to Berry and Horton (1970:88), the emergence of new centres and the shift in the relative sizes of old ones

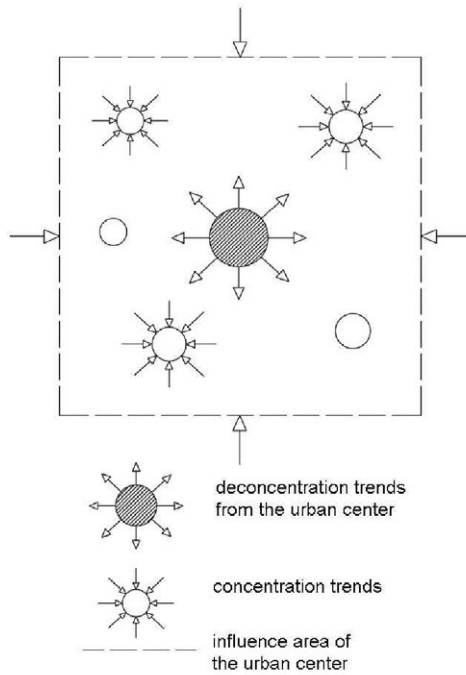


Figure 2. Urban sprawl may result in a more polycentric urban system through the process of deconcentrated concentration (Source: edited by the author)

depends on the introduction of new urban activities (i.e. population, workplaces, etc.) in the wider area, rather than upon the redistribution of existing activities. Therefore, deconcentration becomes evident through an increasing share of urban activities taking place in the wider area that is increasingly networked into the urban centre.

A basic assumption for the application of the proposed methodology is the selection of a study area that meets the following conditions: 1) it is monocentric, characterised by a dominant city (prime centre), and 2) it displays the phenomenon of urban sprawl through deconcentration alongside spatial expansion (i.e. increasing urban land use).

However, it should be taken into account that despite the existence of deconcentration trends in a monocentric urban system, the prime urban centre continues to be dominant as its size greatly exceeds all other class centres. Therefore, the study of the polycentricity has to focus on the secondary or lower class centres.

Criteria and indices

The criteria and indices chosen to describe the structure of the urban system and its shift reflect both qualitatively and quantitatively the concept of urban sprawl and polycentricity. In particular, the study of polycentricity is based on the: a) size, b) position and c) connectivity of the centres (Table 2).

Deconcentration from an urban centre takes place when the percentage share of the urban centre in its total influence area has been reduced. Under the condition of deconcentration, it is important to distinguish the sub-areas, or more specifically the secondary or lower class centres that appear to be characteristic of concentrating the deconcentration. These are the sub-areas where urban sprawl is directed to. Therefore, a statistical index has been developed that compares the local growth or decline with the overall average change. This index is equal to the change in the percentage share of the population in a sub-area (A_i) divided by the change in population in the total study area (A), and it reflects the dynamics of each sub-area in a time period $t1-t2$:

$$\frac{(A_i(t2) \div A(t2)) - (A_i(t1) \div A(t1))}{A_i(t1) \div A(t1)}$$

The above relation is a simple and generalised version of the shift-share analysis method and it shows which sub-areas are becoming more dominant or fall short in relation to the growth of the whole area, even though they have positive growth rates (Scatter D3, 2002). Having a graphical representation of the results in maps is essential for the spatial analysis of urban sprawl.

Investigation of the degree of polycentricity and its change is based on the number of centres per class. For the classification of centres, the population percentage share of sub-areas in the total influence area is calculated for two different years. The urban system is classified into six classes of centres, each of which represents a specific breadth of the population percentage share in the entire area which is diachronically stable. The results are shown in graphs and maps in order to assess morphological polycentricity.

The analysis of commuter flows (spatial patterns, intensity) and their change through time indicates functional polycentricity. The connectivity between centres is expressed through the commuter flows as a percentage

Table 2. Criteria and indices used to explore urban sprawl trends and the urban system shift

Polycentricity dimensions	Criteria	Index	Results
Size	Population	percentage share: centers' classification into classes for two time shots	size of centres / number of centres per class - (morphological) polycentricity change
		shift of percentage share	urban sprawl trends - deconcentrated concentration
Spatial position	Centres per class	representation of centres per class in maps for two time shots	(morphological) polycentricity change
Connectivity	Commuter flows	percentage of workers that commute daily from the place of residence to the place of work for two time shots	(functional) polycentricity change

(Source: edited by the author)

of the number of workers that commute daily from their place of residence to their workplace, to the total number of workers.

Application Field: Thessaloniki's Influence Area

The Influence Area of Thessaloniki is considered as an appropriate field for the empirical testing of the above-formulated hypothesis and research questions because it is a monocentric urban structure in which urban sprawl trends are identified. Thessaloniki is the second-largest city in Greece, with almost 800,000 inhabitants. Its metropolitan area, referred to as the Greater Area of Thessaloniki in the Master Plan (1986), has dynamic economic and demographic growth rates and its population has reached almost one million people.

Thessaloniki is a compact city with high densities, formed by an urban explosion before the end of the 1960s and diffuse urbanisation in the 1970s. Since the late 1980s urban sprawl trends have been relatively limited and spatially confined to smaller adjacent settlements. However, middle class suburbanisation and the generalised expansion of urban activities, mainly in the tertiary sector, intensified in the 1990s. The booming speculative building sector, ring road construction, the planning of new major roads and the increase in private car ownership increased distances between workplaces and residences and set off urban sprawl.

Currently, the Influence Area of Thessaloniki has exceeded the boundaries of the institutionally defined metropolitan area, shaping a larger city-region. It is divided into two macro-zones: 1) the Urban Centre, which coincides with the Urban Agglomeration of Thessaloniki (UATH) and has more than 300,000 workplaces, and 2) the Larger Urban Zone, which represents the whole area impacted by the UATH. This is comprised of 23 Municipal Units, considered to be sub-areas, of which more than 7.5% of the employed residents commute daily in the urban centre.

This study explored the research question in the empirical field from the period of 1991-2011 for two reasons. First, the migration from Athens and Thessaloniki to rural areas began in the 1980s, resulting in rural and semi-urban areas experiencing population growth and urban sprawl, which is likely to be intensified in the next decade. Second, since the early 1990s, Greek cities have witnessed the consequences of the new conditions: accession into the European Union and open boundaries, escalating competition, market deregulation, infrastructure completion and the influx of economic immigrants, along with a period of economic growth that drove in entry into the Euro-zone in 2001. Increased income, completion of transportation infrastructure, increased private car ownership, middle-class land speculations and private investments in new home developments fuelled urban sprawl. However, the financial crisis that broke out in 2009 almost halted urban sprawl.

EMPIRICAL TESTING: ANALYSIS AND FINDINGS

Population deconcentration and polycentricity trends in the influence area of Thessaloniki, 1991-2011

The Urban Centre of Thessaloniki (UATH) constituted 81.6% of the total population in 1991, which had fallen to 73.3% by 2011. Even though population concentration remained strong, the decreased percentage share hints at deconcentration, and consequently urban sprawl. However, there are significant differences in the spatial distribution of deconcentration trends from the UATH to its entire Influence Area (Figure 3). In short, the population spread is directed to the area around the UATH and its eastern part, mainly because of the improved accessibility from road upgrades that connect the UATH with coastal areas and the high quality physical environment.

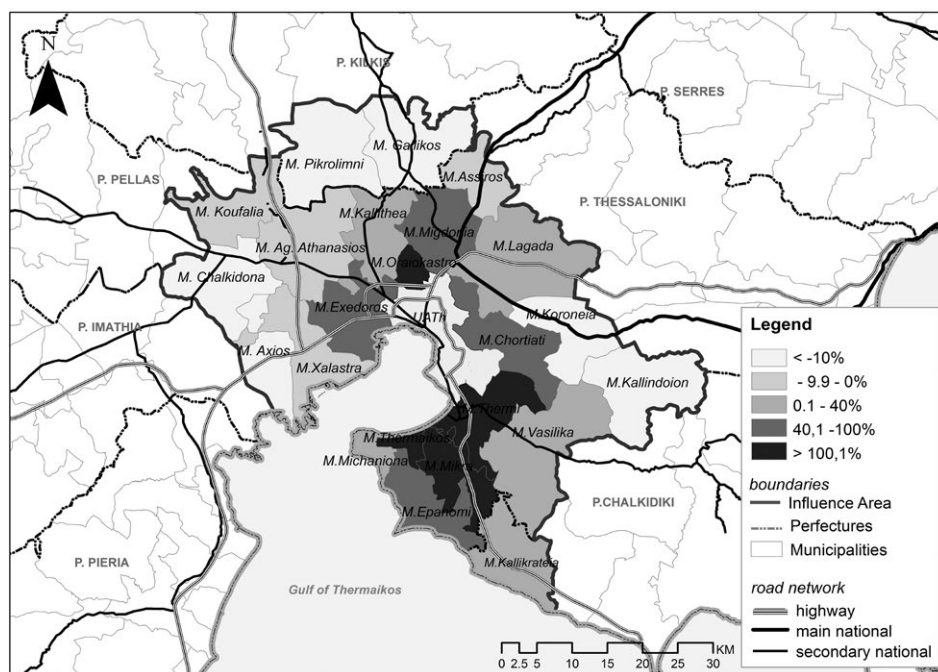


Figure 3. Deconcentration trends: shift of population percentage share, 1991-2011. (Source: edited by the author; source data: HELSTAT 1991, 2011)

Therefore, a spatial redistribution of the population is noticeable in 2011 along with an increase in the number of second and third class centres (Figures 4a/b). In 1991, the most significant (third class) centres (Exedoros, Ag.Athanasios, Lagada) are situated in the western and northern parts of the study area, which results in an unbalanced spatial organisation of the urban system. In 2011, two of the eastern Municipalities (Thermi, Thermaikos) manifest themselves as new settlement receivers and are ranked as second class centres, escalating three and four positions respectively in the urban system

hierarchy. Exedoros Municipality is also transformed from a third to a second class centre. The Municipalities adjacent to the UATH in the north (Hortiati, Oraiokastro) and one from the east (Mikra) improve their position on the urban system hierarchy as third class centres (Table 3).

Within the study area, the first-class centre corresponds to the UATH, which excels compared with the second-class centres. For this reason, even though the UATH's percentage share in the entire Influence Area decreases over time, the UATH is excluded from the investigation on centre changes.

Table 3. Population indices and centres class, 1991, 2011

Centers	population		% population share		centre class		shift of percentage share
	2011	1991	2011	1991	2011	1991	
UATH	806396	783151	73,31%	81,61%	1	1	-10,17%
M.Agiou Athanasiou	14753	13302	1,34%	1,39%	3	3	-3,24%
M.Assirou	3638	3388	0,33%	0,35%	6	6	-6,32%
M.Axiou	6613	6485	0,60%	0,68%	6	5	-11,03%
M.Vasilikon	9911	6476	0,90%	0,67%	5	5	33,52%
M.Epanomis	10810	6276	0,98%	0,65%	4	5	50,27%
M.Exedorou	29367	17702	2,67%	1,84%	2	3	44,73%
M.Thermaikou	27553	5788	2,50%	0,60%	2	6	315,31%
M.Thermis	25145	7901	2,29%	0,82%	2	5	177,65%
M.Kallitheas	6110	4679	0,56%	0,49%	6	6	13,92%
M.Kallindoion	3592	4296	0,33%	0,45%	6	6	-27,05%
M.Koroneias	4092	4212	0,37%	0,44%	6	6	-15,24%
M.Koufalion	10579	9665	0,96%	1,01%	4	4	-4,51%
M.Lagada	19587	14932	1,78%	1,56%	3	3	14,44%
M.Mihanionas	11901	7428	1,08%	0,77%	4	5	39,78%
M.Mikras	18145	5549	1,65%	0,58%	3	6	185,28%
M.Mugdonias	10491	5498	0,95%	0,57%	4	6	66,47%
M.Halastras	9859	9525	0,90%	0,99%	5	4	-9,70%
M.Halkidonos	8341	8956	0,76%	0,93%	5	4	-18,75%
M.Hortiati	18041	8299	1,64%	0,86%	3	5	89,66%
M.Oraiokastrou	21716	5348	1,97%	0,56%	3	6	254,26%
M.Gallikou	6343	6589	0,58%	0,69%	6	5	-16,01%
M.Pikrolimnis	5442	6599	0,49%	0,69%	6	5	-28,05%
M.Kallikrateias	11571	7626	1,05%	0,79%	4	5	32,37%
Influence Area	1099996	959670	100,00%	100,00%			

(Source: HELSTAT 1991, 2011, edited by the author)

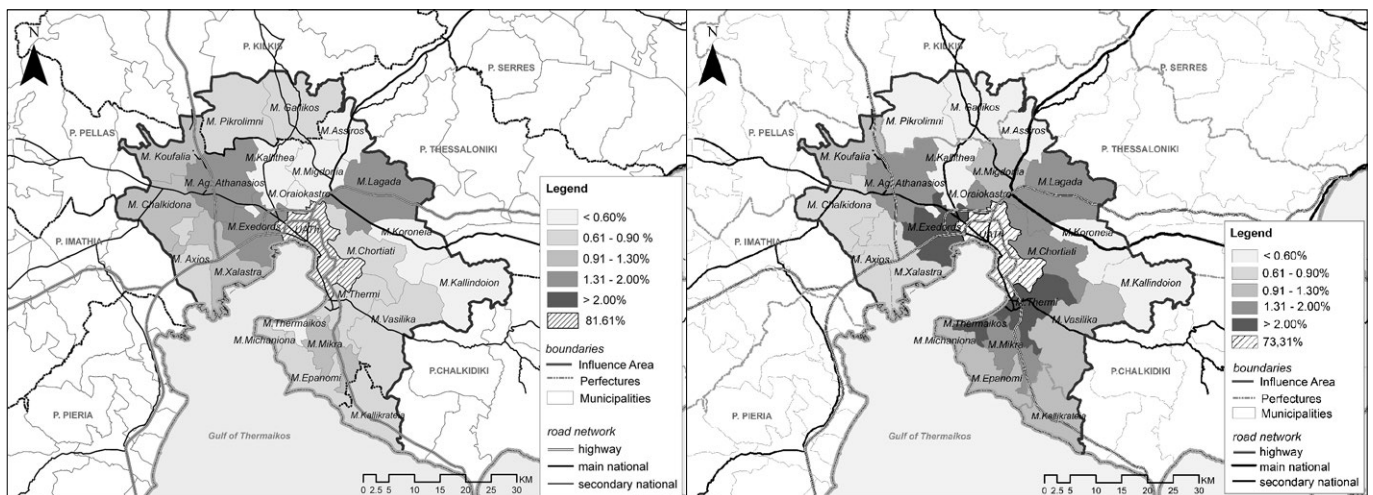


Figure 4 a/b. Percentage share of population, 1991 (left), 2011 (right)
(Source: edited by the author; source data: HELSTAT 1991, 2011)

A homogeneous population trend is observed around the UATH, while centres adjacent to the UATH, significantly reduce the discrepancies between them.

Therefore, concerning the size of the centres, the urban system becomes more polycentric as the number of higher class centres (second to fourth) increases, and therefore the percentage share of their population increases as well (Figure 5a/b). Concerning the spatial position of the centres, the polycentricity of the urban system is strengthened by a more balanced spatial distribution of the centres (per class) between the east and west of the influence area (Figure 4a/b).

Commuter flows: an index for functional polycentricity, 2011

The change of the commuter flows is a significant index for the study of functional polycentricity change. Since there are no available statistical data for 1991, the empirical study focuses on the study of existing functional polycentricity using 2011 data.

The most powerful commuting flows (>20%) are recorded between the UATH and the municipalities in the eastern area as well as the municipalities in the western area with a larger population (Figure 6). Echedoros Municipality in the west and Thermi Municipality in the east are among the most significant secondary (population and workplace) centres, but they are the only centres that simultaneously constitute the second more powerful poles for commuters (Table 4). In general, the western subsystem of the study area is characterised by more complicated commuting patterns compared to the eastern one. It also shows weaker dependency on the UATH, since several western and south-western municipalities show very weak (5-9.9%) or weak (10-19.9%) commuting flows. This relates to the western area’s historical evolution and concentration of industrial activity. In 2011, the entire eastern area shows strong dependency on the UATH (>20%). This is a sign of its recent growth as an integral, functional part of Thessaloniki as a settlement receiver. The one-way strong commuter flows in combination with the deconcentrated concentration

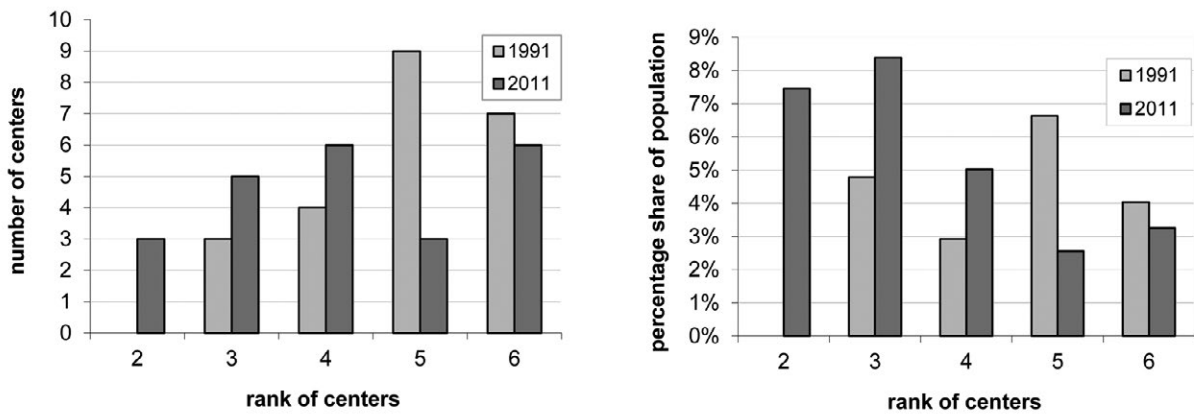


Figure 5a and b. Number of centres and percentage share of population per class, 1991, 2011. (Source: edited by the author; source data: Figures 4a/b)

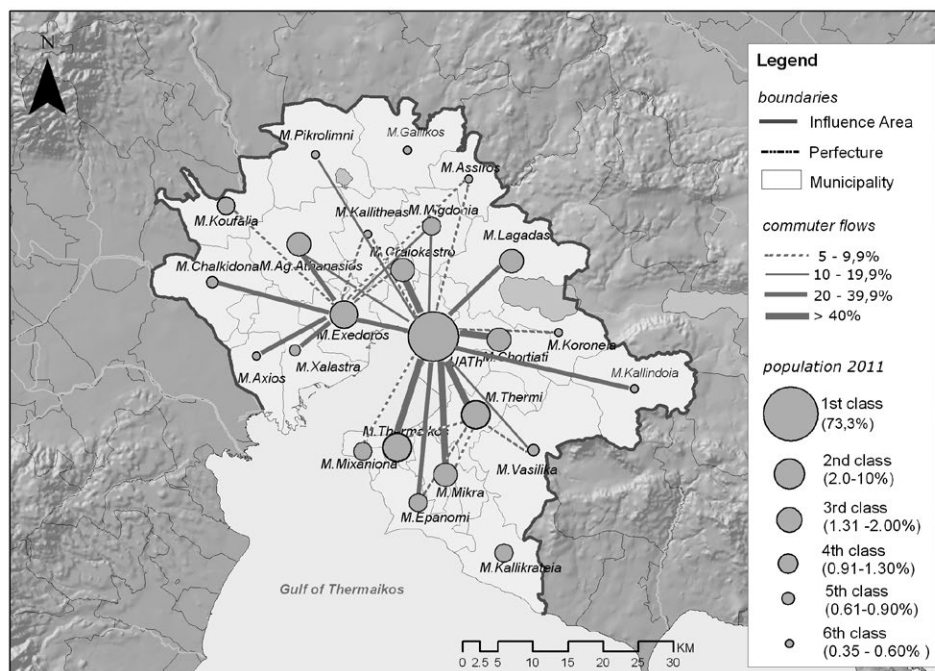


Figure 6. Commuter flows, 2011 (Source: edited by the author; source data: HELSTAT 2011)

trends certify that this area has been developed due to urban sprawl from the urban centre. In addition, this one-directional dependency signifies the functional and spatial expansion of the urban centre eastwards, resulting in the incorporation of towns and settlements already situated in this part in the long run.

Table 4. Commuter flows (%) to the most powerful centres

Centers	class center	UATH	M.Exedorou	M.Thermis
UATH	1	-	5,6%	2,9%
M.Exedorou	2	20,0%	-	0,9%
M.Thermaikou	2	42,3%	2,6%	9,3%
M.Thermis	2	42,8%	2,9%	-
M.Agiou Athanasiou	3	15,8%	16,1%	0,4%
M.Lagada	3	20,2%	4,0%	1,0%
M.Mikras	3	48,7%	3,0%	9,0%
M.Hortiati	3	55,7%	5,4%	3,5%
M.Oraiakastrou	3	46,5%	9,6%	1,6%
M.Epanomis	4	32,3%	1,5%	6,1%
M.Koufalion	4	2,0%	7,5%	0,6%
M.Mihanionas	4	8,9%	1,2%	4,6%
M.Mugdonias	4	12,9%	6,2%	1,5%
M.Kallikrateias	4	3,4%	0,8%	2,2%
M.Vasilikon	5	9,7%	1,9%	9,6%
M.Halastras	5	11,8%	24,8%	0,6%
M.Halkidonos	5	1,1%	10,0%	0,4%
M.Assirou	6	6,5%	6,2%	0,8%
M.Axiou	6	13,0%	19,4%	0,6%
M.Kallitheas	6	5,3%	9,5%	1,4%
M.Kallindoion	6	31,7%	2,7%	1,8%
M.Koroneias	6	5,1%	4,7%	1,7%
M.Gallikou	6	4,3%	2,7%	0,7%
M.Pikrolimnis	6	12,7%	6,7%	0,5%

(Source: HELSTAT 2011, unpublished data, edited by the author)

CONCLUSIONS: INTERLINKAGES BETWEEN THE URBAN SYSTEM AND URBAN SPRAWL

Urban sprawl, expressed through population deconcentration, changes the structure of the urban system towards a more polycentric pattern. However, the relationship between urban sprawl and the urban system is not unilateral, as the trends of deconcentrated concentration depend upon the pre-existing structure of the urban system. In general, sub-areas directly adjacent to the urban centre are those that undergo more concentration.

Based on the above, the main conclusion is that the main feature of the two-way relationship between urban sprawl and the urban system is the emergence of 'small-scale' polycentricity. More specifically, small-scale polycentricity is seen in terms of spatial position, since the new centres are coiled spatially around the urban centre (UATH), as well as in terms of the size of the centres, since no significant changes are observed at a macro-level. This emergent polycentricity is not considered integrated, but rather fragmentary because deconcentration did not affect all three dimensions of polycentricity: size, position and connectivity. The process of deconcentrated concentration is not accompanied by high

connectivity between centres of different sizes in terms of criss-cross commuting patterns. However, the investigation of the change of commuter flows would extract more clear results about the movement of the urban system towards a more polycentric direction in terms of the connectivity.

In fact, this small-scale polycentricity reflects a trend of spatial and functional merging of the urban centre and its surrounding areas, taking place part through parallel dispersion and reconcentration patterns around the urban centre, which weaken urban and rural characteristics. The strong one-way commuting patterns to the urban centre are an additional hint on the functional and spatial expansion of the urban centre into an adjacent area. As the urban centre expands outwards to the adjacent areas through deconcentration, the lower class centres grow both in size and in spatial expansion. Taking into account their geographical vicinity and strong functional dependence on the urban centre, these lower class centres tend to become incorporated into the urban centre, shaping an expanded, yet coherent urban area. As a result, the new larger urban centre may extend its urban field to more distant areas and shape a new extended influence area, or in other words a larger city-region. In short, this small-scale and fragmentary polycentricity intensifies the phenomenon of metropolisation.

The second conclusion regarding the hypothesis is the influence of urban sprawl on the urban system in relation to polycentricity as a matter of scale. More specifically, at the city-region level urban sprawl results in greater polycentricity, even if it is small-scale polycentricity. However, at a macro-level urban sprawl leads through small-scale polycentricity to increased monocentricity, as the new extended city-region forms a high-class centre in the urban system at a regional or national level.

This small-scale polycentricity emerging from the urban sprawl process raises questions about the distinction between the (negative) phenomenon of urban sprawl and the increase in (sustainable) polycentric development. Considering the theoretical and methodological approaches, it is unclear what the turning point is that distinguishes urban sprawl from polycentricity. Even though both concepts have different meanings for sustainable spatial development, they both are a matter of the degree of deconcentration. However, they have unclear definitions and pose difficulties in objective measurement. Therefore, further research should focus on the clarification of the number of centres, their threshold size and density, their in-between distance and their degree of connectivity in terms of commuter flows. These have to be estimated quantitatively, so that a polycentric urban area (characterised by an organised system of ranked urban centres) can be distinguished from a dispersed city-region (characterised by the random distribution of centres, often dissolved, in a low-density area).

The bottom line is that the interpretation of new, complex spatial patterns and urban deconcentration (characteristics of urban sprawl) as emergent polycentric patterns and vice versa, and the use of polycentricity as an analytical tool for describing new forms of cities spreading into adjacent or

very extended areas, emphasizes the need to review the explanatory devices and theories used in spatial analysis and planning.

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