Evolving polycentricities

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Evolving polycentricities

The development of urban spatial structure in Finnish urban regions

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1. Introduction

1.1. Focus on urban region

An urban region, reaching far beyond the limits of the traditional physical city, has been commonly acknowledged as an urban form that determines the contemporary settlement structure in the developed countries. Whether named the urban region, city-region, metropolitan area or some other of the numerous similar terms, analogous to all these concepts is that their spatial structure is no longer described by the physical borders of concise built-up urban fabric. Instead, it is described by the flows of people, goods and information that tie the region together as a functionally rather than morphologically consistent urban constellation. Therefore, in order to understand the functional structure of contemporary city, one has to pay attention to its surrounding region as well.

The focus on urban region, however, has long roots in the 20th century urban research. Almost a hundred years ago, Patrick Geddes (1915) introduced the concept of conurbation to describe the urban regions that have grown beyond the historical boundaries of their core cities. Similarly, Dickinson (1947, p. 165) argued that "city cannot be fully understood by reference only to its arbitrarily defined administrative area." Moreover, already in the 1930s, McKenzie (1933, p. 70) emphasised the importance of motor transportation and highway networks which "have brought the city and its hinterland into a closer functional relation." He stressed that the urban region is primarily a functional entity. In these early writings, however, the perspective on the urban region was above all morphological and the notions to urban region as a functional entity were, in practice, equivalent to Christallerian market area approach where attention was paid to the flows of raw material and goods rather than flows of people or information (cf. Christaller, 1933/1966).

The conceptual limits of urban region were further stretched in the 1960s when two new terms describing the enlarged urban reality were introduced. The first one was Jean Gottmann's (1961) renowned *megalopolis*, which he defined as an almost continuous corridor of urban and suburban areas in the eastern coast of the United States, reaching from Washington D.C. to Boston. Although Gottmann (1961, p. 4) calls for a profound revision of conceptual understanding about urban regions, the definition of megalopolis suggested primarily a physical structure: a conurbation of urbanised area similarly to Geddes (1915; cf. Hall, 2009). Another conceptual approach to the enlarged scale of urban region, the *urban field*, was introduced by John Friedmann and John Miller (1965). They defined the urban field as "a new scale of urban living that will extend far beyond existing metropolitan cores and penetrate deeply into the periphery" (p. 313). The concept represents a new element of spatial order, which covers an area within a two-hour driving time from the central city and is defined primarily by commuting to the urban core but also by the use of peripheral parts of the urban field for recreation (Friedmann and Miller, 1965). Hence, contrary to Gottmann's megalopolis, the urban field is fundamentally a functional concept.

Another approach to conceptualise urban region, a *metropolitan statistical area* (MSA)[1], was developed in the mid-20th century in the United States. The MSA was developed for statistical classification purposes and it defines urban regions in functional terms to encompass the built-up area of the core city and all areas that have a daily relationship with the core city (Hall, 2009). The MSA has worked as a starting point for a wider discussion of defining functional urban regions, in the United States and elsewhere. This discussion was triggered by Berry *et al.* (1968) who introduced the concept of *functional economic area* in order to refine the area definition of the MSA. The functional economic areas were defined as all "counties for which the proportion of resident workers commuting to a given central county exceeds the proportion commuting to alternative central counties" (Berry *et al.*, 1968, pp. 24–25). Later, Peter Hall and Dennis Hay (1980) applied the concept in western Europe and defined 539 uniform *metropolitan economic labour areas* (cf. Pumain, 2004; Hall, 2009), which were further converted to *functional urban regions* (FUR) (Cheshire *et al.*, 1988; Cheshire and Hay, 1989). In general, the extent of FUR is defined by including each locality having a certain share of employed labour force working in the core city (Parr, 2005). This threshold has often been set as low as ten per cent, which has been problematised as resulting in an extremely large urban region for any larger city (Parr, 2007).

1 The term was first used in official nomenclature in 1949 as the *standard metropolitan area* (SMA). In 1959, the term was renamed the *standard metropolitan statistical area* (SMSA), in 1983, the *metropolitan statistical area* (MSA), in 1990, the *metropolitan area* (MA) and finally, in 2000, the *core based statistical area* (CBSA). Although slight variations have occurred in defining the terms, they are basically variants of the same concept (Hall, 2009).

Similarly to the metropolitan statistical area in the United States, in Europe, the functional urban region has gained ground as a statistical area unit rather than as an analytical concept. In more analytical terms, the discussion about the regional aspects in urban research has employed the term '*city-region*' to represent the complex spatial relations between the city and its environment (Davoudi, 2008). Although the term was coined already over half a century ago by Robert Dickinson (1947), it lacks a common definition and is often used in a rather fuzzy way to refer simply to the enlarged metropolitan territory (Parr, 2005; Davoudi, 2008). A recent contribution aimed at clarifying the vagueness that appears to envelope the term 'city-region' was made by John Parr (2008). He emphasised the nodality in defining the concept: characteristic of the city-region is that it consists of a core (sometimes two cores) and a surrounding region. According to Parr, an essential feature of a city-region is the symbiotic relationship between these two spatial components. Moreover, he made a difference between the city-region and FUR by stating that the city-region may contain other, smaller, city-regions which are often regarded as functional urban regions. Parr emphasised the economic interaction, such as commuting, trade or monetary flows, as building blocks of relationship between the core and surrounding area of the city region. This notion, however, has been criticised for omitting the complexity of interactions that takes place within (and between) the city-regions. Indeed, Simin Davoudi (2008, p. 51) stressed that the "city-region relations constitute a complex web of visible and invisible multi-directional flows of not only economic but also social, cultural and environmental activities."

In addition to the concept of city-region, Parr (2008) highlighted another regional type that has come into prominence during the past couple of decades: the *polycentric urban region* (PUR). The PUR as an analytical concept emerged in the mid-1990s in a number of different names – the *urban network* (Camagni and Salone, 1993), the *network city* (Batten, 1995) and the *polynucleated metropolitan region* (Dieleman and Faludi, 1998) – before the term 'polycentric urban region' took root through the special issue of *Urban Studies* (Kloosterman and Musterd, 2001). Common to all these terms, however, is that they define the PUR as a dense network of distinct but adjacent historical cities with functional criss-cross interactions existing between the centres (Kloosterman and Musterd, 2001; Parr, 2004). In contrast to city-region, as described by Parr (2008), the main difference between the two regional types is the dominance of the leading urban centre. Although the city-region may include a number of distinct urban centres as well, it builds around one dominant core city whereas this kind of dominance is much less pronounced in the polycentric urban region (Parr, 2008). Issues addressing polycentricity in urban regions are discussed in more detail in next section.

In the early 2000s, a new approach to conceptualise the complexity of large urban regions, the *mega-city region* (MCR), was introduced by the Polynet project, which

aimed at exploring the association between information flows and polycentric development in western Europe (Hall and Pain, 2006). The MCR is argued to be a new urban phenomenon: "a series of anything between 10 and 50 cities and towns, physically separate but functionally networked, clustered around one or more larger central cities" (Hall and Pain, 2006, p. 3). Although the Polynet project concentrated on European mega-city regions, the term originates from eastern Asia (e.g. McGee and Robinson, 1995) and similar regional development have been reported from the United States through the concept of *megapolitan region* (Lang and Knox, 2009). According to Hall (2009), MCRs are aggregations of adjacent functional urban regions, which are linked together by a complex web of flows. John Parr (2008), however, raised a question of whether the MCR represents a distinct regional form or whether it is merely a conflation of the city-region and PUR. He argues that the urban structure of some MCRs, analysed in the Polynet project, resembled clearly the traditional city-region whereas others had the distribution of urban centres characteristic of the PUR.

In Finland, the increasing interaction between core cities and their surrounding municipalities has been conceptualised thorough the term '*regionalisation*' (Antikainen and Vartiainen, 2002). The concept has its roots in the 1970s counterurbanisation debate but, in addition to intra-regional population dispersion, the term refers to simultaneous population concentration to the major urban regions. The concept gained gradually more policy-oriented connotations describing the increasing importance of the urban region in Finnish planning and regional policies (Antikainen and Vartiainen, 2005; Vartiainen, 2006). This conceptual shift led to the series of research emphasising the national network of urban regions as a backbone of the Finnish settlement system (Vartiainen and Antikainen, 1998; Antikainen, 2001; Antikainen *et al.*, 2006). More recently, Sami Moisio (2012) has argued that the notion of a nation-wide polycentric urban network is giving way to a new thinking where the largest national metropolitan regions play the central role in the regional policy in Finland.

From the late 1990s, academic research on the internal structure of urban regions in Finland has been increasingly directed towards the social structure of cities, particularly towards social differentiation and segregation. Although such topics are by no means new in Finnish urban research (e.g. Andersson, 1983), the availability of more detailed statistical data and advanced GIS technologies has enabled new analytical approaches to study the social structure of urban regions. This line of research was triggered by Mari Vaattovaara's (1998) dissertation in which she concluded that, although there is evidence of evolving social differentiation, clear signs of residential segregation were not visible in the Helsinki region (see also Vaattovaara and Kortteinen, 2003). In a more recent research on the subject, a focus has been on the ethnic segregation of immigrant population (Dhalmann, 2011; Vilkama, 2011) and on the impact of lifestyle on residential mobility in the Helsinki region (Ratvio, 2012). In another recent ap-

proach to Finnish urban regions, the networked urban structure has been conceptualised through the term '*metapolis*' (Alppi and Ylä-Anttila, 2007; Joutsiniemi, 2010; Ylä-Anttila, 2010). The metapolis is a large conurbation, made up of complex networks of daily activities of people and characterised by diversity, heterogeneity and polycentricity. In Finnish context, the metapolisation process has been demonstrated through the changes in road network connectivity where the highest accessibility in the road network has shifted from central cities towards ring road locations (Ylä-Anttila, 2010).

1.2. The rise of polycentricity[2]

Polycentricity, as describing urban spatial structure, has gained a lot of attention during the past couple of decades. However, it is far from being a new phenomenon. Different kinds of multi-nodal urban forms have been reported over a half-a-century ago when Harris and Ullman (1945) published their classic model of a multiple nuclei city. Moreover, concepts such as Geddes' (1915) conurbation or Gottmann's (1961) megalopolis include a significant polycentric aspect. Yet, only recently, polycentricity has been commonly acknowledged as a central characteristic of contemporary cities and urban regions (Hall, 1997; Anas *et al.*, 1998; Kloosterman and Musterd, 2001; Parr, 2004).

Certain fuzziness, however, encompasses the concept of polycentricity. As Martijn Burger (2011, p. 5) points out, polycentricity is currently among one of the most versatile terms in use. In addition to the fact that the concept has gained notable normative connotations, concerning particularly European strategic planning (Davoudi, 2003), there is also fundamental fuzziness in its use in more analytical context (Green, 2007; Meijers, 2008). First, the term 'polycentricity' may refer to the spatial clustering of a number of different phenomena. Principally, as Kloosterman and Musterd (2001) point out, polycentricity can refer to the multi-nodal development of basically any human activity. Second, the concept of polycentricity may be used in both morphological and functional contexts (Meijers, 2008; Burger and Meijers, 2012) and, third, the concept of polycentricity is highly scale-dependent. A system which may be polycentric at one scale may be monocentric when examined at another scale (Hall and Pain, 2006). These aspects on polycentricity are discussed in more detail in the remainder of this section.

Polycentricity, as a normative concept, originates from the European Spatial Development Perspective (ESDP), which was aimed at achieving regionally balanced development at the European scale through the promotion of polycentricity (European Commission, 1999; Krätke, 2001; Davoudi, 2003). Thus, in the ESDP, polycentricity

2 This section draws largely on the literature reviews of articles III and IV.

is not seen as describing existing spatial structure but rather as a guiding principle for strategic planning (Davoudi, 2003). In addition to the European scale, many European countries have followed the example set by the EU and adopted polycentric development policies for promoting balanced national development (Waterhout *et al.*, 2005; Meijers *et al.*, 2007; Meijers, 2008). At the national scale, however, there is a lot of variability in the objectives of polycentric policies; and even more in the implementation of these strategies (Waterhout *et al.*, 2005). In Finland, for instance, the polycentric development has aimed at balancing the national urban network by fostering the development of a large number of urban regions. This policy objective, however, was changed to a new perspective, which increasingly stressed the competiveness of the regions (Antikainen and Vartiainen, 2005; see also Jauhiainen, 2011).

Another source of conceptual confusion surrounding the term 'polycentricity' is its usage in both morphological and functional contexts. In strictly morphological terms, the concept of polycentricity refers to several adjacent centres that are located in the same urban system. This has been a common approach on polycentricity in the United States where a large number of research literature has been written about the subject of identifying employment sub-centres in metropolitan regions (e.g. Giuliano and Small, 1991; McDonald and Prather, 1994; Anas *et al.*, 1998; McMillen, 2001). These *edge cities*, as coined by Joel Garreau (1991), are primarily defined in the terms of employment density using various different methods. Another approach on morphological polycentricity originates from European research literature and is closely connected with the PUR debate (e.g. Kloosterman and Musterd, 2001; Meijers, 2008; Burger and Meijers, 2012). In this approach, polycentricity does not refer only to the size and territorial distribution of the centres, but the definition of polycentricity includes also more or less equal size of the centres (Kloosterman and Musterd, 2001; Parr, 2004).

Recently, however, research on polycentricity in urban and regional context has been increasingly focused on functional linkages between the centres in polycentric urban systems (e.g. Hall and Pain, 2006; Green, 2007; de Goei *et al.*, 2010; Burger *et al.*, 2011; Burger and Meijers, 2012; Vasanen, 2012; 2013). Although functional connections are often assumed to exist also in morphologically polycentric systems, a dense network of flows forms the conceptual basis of functional polycentricity where the topological connections between the centres tie the region together as a functionally polycentric urban network (Green, 2007). Empirical research on functional polycentricity has typically included the measuring of flows between the centres of the polycentric region. However, although an increasing amount of research literature aimed at formally defining and analytically measuring the concept of functional polycentricity has been published, research on the subject is still in a development phase.

In the context of urban regions, functional polycentricity is linked to two theoretically distinct concepts (Lambregts, 2009; Burger, 2011; Burger *et al.*, 2011; Burger

and Meijers, 2012). The first focuses on the direction of functional linkages between the centres in a polycentric urban system. It has its roots in transportation research where the directions of commuter flows were no longer found to follow the traditional monocentric model but to be increasingly complex (Hamilton, 1982; Cervero and Wu, 1998; van der Laan *et al.*, 1998). Accordingly, an urban system can be described as functionally polycentric when two-way flows between a region's core and its sub-centres as well as those between the individual sub-centres exist (van der Laan, 1998; Schwanen *et al.*, 2004; Limtanakool, 2007; Burger *et al.*, 2011). Herein, the balanced distribution of functional linkages between the centres is essential as a notably unbalanced distribution would by definition yield a functionally monocentric urban structure (Burger *et al.*, 2011; Burger and Meijers, 2012).

The other concept associated with functional polycentricity, spatial integration, concentrates on the functional connections between separate centres within the urban system (Burger, 2011). Instead of the direction of flows, the spatial integration approach addresses the strength of functional linkages between the centres. In a spatially integrated polycentric system, the actual flows between the centres under examination do not differ markedly from the total potential flows. Different methods of measuring the degree of spatial integration have been introduced including, for instance, network density (Green, 2007) and the gravity model (de Goei *et al.*, 2010; van Oort *et al.*, 2010). It is important to make a distinction between these two concepts because spatially integrated urban systems may have a highly unbalanced functional structure whereas functionally balanced urban systems may be weakly spatially integrated (Burger *et al.*, 2011; Burger and Meijers, 2012). Although both concepts are necessary characteristics of functionally polycentric urban regions, they determine different aspects of the functional structure of such regions. While the balanced distribution of flows is a distinguishing feature between polycentric and monocentric urban regions, spatial integration is in fact a prerequisite of an urban region per se since an urban region necessitates some extent of integration in order to be considered a single functional entity.

A third point, which obscures the conceptual clarity of polycentricity, is that the term is often understood differently when measured at different scales (Davoudi, 2003). Traditionally, the concept of polycentricity has been applied at the intra-urban scale where focus has been on the emerging (employment) sub-centres in metropolitan regions. Such approaches have a strong tradition in the United States (e.g. Garreau, 1991; Anas *et al.*, 1998) but issues regarding intra-urban polycentricity have also been addressed elsewhere (Bontje and Burdack, 2005; Suárez and Delgado, 2009; Garcia-López and Muñiz, 2010). A new scalar approach to polycentricity, the polycentric urban region (PUR), was introduced in the 1990s (Batten, 1995; Klosterman and Musterd, 2001; Parr, 2004). PUR refers to an inter-urban scale where a dense network of distinct but adjacent historical cities exists without a clear leading centre. Most exam-

ples of PURs come from Europe (e.g. Hall and Pain, 2006; Meijers, 2007a; Lambregts, 2009) but similar regional structures have also been identified in Japan or the United States, for instance (Batten, 1995; Lang and Knox, 2009). The most extensive scale on which the concept of polycentricity has been examined is the inter-regional scale (Davoudi, 2003). As discussed above, this approach is tightly linked with European spatial development policies, which aim at achieving balanced spatial development within the European Union through promoting territorial polycentric development (European Commission, 1999).

Polycentricity in itself is also a highly scale-dependent phenomenon: a system which may be polycentric at one scale may be monocentric when examined at another scale (Hall and Pain, 2006). However, only recently, research addressing the scale-dependent nature of the concept of polycentricity has emerged. A major contribution to introducing scale to the research of functional polycentricity was made by the Polynet project, which aimed at exploring the association between information flows and polycentric development (Hall and Pain, 2006). In the project, Taylor *et al*. (2008) carried out a pivotal analysis across a number of different scales, in which they applied a combined approach of spatial integration and functional balance in eight city-regions in northwestern Europe. Their results emphasised the complexity and scale-dependency of functional polycentricity (Hall and Pain, 2006; Taylor *et al*., 2008; 2009). First of all, the degree of functional polycentricity of the studied city-regions declined as the scale of analysis grew from regional to global with the clearest drop taking place between the national and European scales. Furthermore, and more intriguingly, the scale decline gradients were not uniform. For example, Greater Dublin and Rhine-Main were effectively monocentric at the European and global scale, highlighting the primacy of Dublin and Frankfurt. In contrast, South-East England and the Paris region were found to be more or less polycentric at all examined scales implying that also the smaller cities surrounding London and Paris are well connected to the world economy.

Another approach to examine the scalar dynamics of functional polycentricity was adopted by de Goei *et al*. (2010) and van Oort *et al*. (2010) who utilised the gravity model in order to analyse spatial integration in polycentric urban systems across both intra-urban and inter-urban scales. Focusing on the Randstad region in the Netherlands, van Oort *et al*. (2010) used data on inter-firm relationships in order to assess the degree of spatial integration at intra-urban and inter-urban scales. Their findings indicated that spatial integration was significantly stronger at the intra-urban than inter-urban scale, suggesting that Randstad does not function as a spatially integrated polycentric urban region (van Oort *et al*., 2010). Similar evidence was found in the study of de Goei *et al*. (2010) regarding South-East England where polycentric commuting patterns were found at the intra-urban scale but to a lesser extent at the inter-urban scale. In a more recent study, Burger *et al*. (2013) addressed various types of

urban spatial interactions in order to assess the multiplicity of urban networks. Focusing on the Randstad region, they analysed the spatial patterns of twelve different types of flows, including daily activity patterns (commuting, business travel, shopping trips etc.), intra-firm (headquarter–subsidiary) relations and inter-firm (buyer–supplier) relations. Their findings indicated that the scale of spatial integration seemed to be highly dependent on the types of flows being observed. A vast majority of all journeys to school and shopping trips, for instance, took place within the same municipality, whereas most of the intra-firm networks extended across national boundaries. Therefore, the scale of functional polycentricity can vary from local to predominantly international in the same region depending on the type of interaction in question (Burger *et al.*, 2013).

1.3. Objectives and research design

This dissertation builds on the long tradition of research on spatial structure of urban regions as presented earlier in this chapter. The focus of the dissertation is on the functional organisation of contemporary urban regions with a particular emphasis on the polycentric development of these regions. The empirical context of the research articles, of which this dissertation is comprised, is the urban regions in southern Finland and the Turku urban region, in particular. However, in addition to the geographical context of the case studies, this dissertation contributes to the scholarly debate about polycentric formation of functional urban regions in more general terms.

The overarching research objective of this dissertation is to advance the understanding about how the urban spatial structure of Finnish urban regions has developed from the early 1980s until the 2010s and what kind of functional and spatial forms this development has taken. This general objective is divided into two related research strands. First, this dissertation aims at understanding the processes that shape the urban spatial structure of the Turku urban region. Particular focus here is on the impact of residential preferences on the urban structure. This research strand is reflected in papers I and II. Second, the dissertation seeks to analyse on what degree the spatial structure of the urban regions in southern Finland is structured in polycentric terms, the main emphasis being on the functional polycentricity. Here, the objective is not only to analyse polycentric development in the Finnish context but to offer a wider perception on functional polycentricity, both conceptually and methodologically. This second research objective is responded in articles III and IV, which introduce and evaluate a new method for analysing functional polycentricity across different spatial scales.

Both key concepts of this dissertation – urban region and polycentricity – are rather ambiguous and require clarification. In this work, an urban region is understood as a functional urban region (FUR) (cf. Cheshire *et al.*, 1988; Chesire and Hay, 1989).

Here, the definition of FUR comes close to what John Parr (2007) called the 'employment city'. Parr described the employment city as an area which is dependent from the workplaces of the continuously built-up urban core. This employment dependence applies to each locality from which majority of workforce commutes to the core area. According to Parr, however, a notably smaller threshold for employment dependence than 50 per cent is applicable since the commuter workforce supports also local employment in their place of residence. In this dissertation, the threshold of 25 per cent has been used.[3]

Another concept in need for clarification is 'polycentricity'. In this dissertation, polycentricity is defined in similar analytic terms than in the work of Burger and Meijers (2012). As such, in morphological terms, mere existence of numerous centres within a multi-nodal urban system is not sufficient definition for polycentricity. Instead, a more or less balanced distribution of population (or workplaces) is required in order to call a multi-nodal urban system polycentric. In similar terms, functionally polycentric urban system necessitates a balanced distribution of flows between the centres. In this dissertation functional polycentricity is understood in its general meaning encompassing both, multidirectional flows and spatial integration within a multi-nodal urban system. This conceptual issue, however, is discussed in more detail in chapter 3.

The dissertation builds theoretically on two key concepts: scale and network. Different theoretical perspectives to these concepts are reviewed in the following chapter. In chapter 3, which is largely based on article IV, the methodological contribution of this dissertation is presented. In the proceeding chapter, the empirical findings from the articles I–IV are discussed followed by the concluding chapter where these findings are reflected against the theoretical background.

3 The same commuting rate has been used to define FURs in other similar studies (e.g. Jauhiainen, 2006). See article I for a more detailed description about the demarcation of functional urban regions in the context of this dissertation.

2. Theoretical foundations

2.1. Recent conceptualisations of scale

As discussed in previous chapter, the concept of scale has been recognised as a fundamental feature in understanding the polycentric formation of functional urban regions. First, it is important to regard the scale, at which any polycentric urban system is analysed, because the degree of polycentricity may differ across different scales. Paris, for instance, may be part of a polycentric urban system at the global or European scale but more or less monocentric at the national scale, whereas the internal urban structure of the Paris region may be, yet again, polycentric. Furthermore, the concept of polycentricity may be understood differently when applied at different scales. At the European scale, the concept of polycentricity has been predominantly associated with normative agenda within the European Union aimed at achieving balanced territorial development whereas, at the regional scale, polycentricity has been often connected with the complimentary urban functions within dense network of adjacent but separate cities. Consequently, it is obvious that any research approach concerning polycentricity also necessitate considering the scale, at which the empirical or theoretical analysis takes place.

The significance of the concept of scale, however, reaches far beyond the rather narrowly focused debate on polycentricity. Indeed, scale has in recent decades become one of the key concepts in theorising sociospatial phenomena and processes in human geography. Particularly in political geography, there has been active debate about scale and its implications for critical geopolitics (Howitt, 2003). Nonetheless, as Andrew Herod (2011, p. 5) reminds, "[s]cale has long been one of Geography's core concepts." In earlier approaches, however, scale was understood largely as a taken-for-granted concept, which described different areal frames of geographical research such as 'the

urban', 'the regional' or 'the national'. It was not until the 1980s that human geographers became interested in theorising the relational nature of scale itself (Paasi, 2004; Herod, 2011).

Amongst the first human geographers to theorise scale in the early 1980s, perhaps the most influential were Peter J. Taylor and Neil Smith. Building on Immanuel Wallerstein's (1976) world-economy approach, Taylor (1981; 1982) introduced a three-scale structure, with which he defined the political economy of scale. According to Taylor (1982), the global scale is the scale of reality, at which the capitalist world-economy is organised. Furthermore, the national scale, the scale of ideology, is reflected in the organisation of political systems primarily at the scale of nation-states whereas the urban scale, the scale of experience, becomes manifested in the everyday practises of people (Taylor, 1982). Taylor's thinking on scale has been criticised to take these three scalar levels for granted and not to problematise their origins (e.g. Marston, 2000; Herod, 2011). In fact, Taylor (1982, p. 21) himself stated that "this spatial organization [of three scales] is simply given."

The issue of the origin of scale, however, was treated in Neil Smith's (1984) book *Uneven Development*. Maintaining Taylor's scalar hierarchy, Smith argued that

> Three primary scales emerge with the production of space under capitalism: urban scale, the scale of nation-state, and global scale. […] The vital point here is not simply to take these spatial scales given, no matter how self-evident they appear, but to understand their origins, determination and inner coherence and differentiation of each scale as already contained in the structure of capital. (Smith, 1984, pp. 135–136)

Drawing on Marxist theory, Smith (1984) suggested that the urban scale is the expression of the centralisation of capital which is materially manifested through the geographical limits of local labour market, in other words, the travel-to-work area. The global scale, on the other hand, is a result of universalisation of wage labour form of production, which enables the expansion of capitalist production around the globe. Smith maintained that, while the urban and global scales are more or less direct products of capitalist economy, the scale of the nation-state is a scale where capitalist production is organised politically. According to Smith, the nation-state forms a relatively stable absolute space, which provides mechanisms, for instance, to protect national capital in the case of global economic crisis. He argued that it is through these economic and political processes that different scales are actively produced.

The early Marxist interpretations of the production of scale were soon criticised of being rather economy-centric and missing some of the nuances of scale-making process (Herod, 1997; 2011). As an early contribution to such critique, Andrew Herod (1991) suggested that Neil Smith's (1984) theorisation on scale raises three concerns. According to Herod, Smith's analysis over-emphasises capitalist economy over other

social mechanisms, disregards other social agencies over capital and ignores the dialectical nature of scale-making process. Later, however, Smith (1992; 1993) departed from the narrowly focused capital-centric approach to the production of scale. By using a Homeless Vehicle (a modification of a shopping trolley which enables homeless people to move their belongings with them) as an example he demonstrated that,

> While there is obviously an economic dimension to the functionality of the Homeless Vehicle, its significance is much broader, involving political and cultural access to, and production of, the space of the community. The Homeless Vehicle highlights the connection between everyday details of social reproduction and the construction of scale at different scales. (Smith, 1993, p. 100)

Moreover, at the same time when the economy-centric approaches to scale-making gave way to broader interpretations, also the theoretical terminology departed from the notions of *production* of scale and approaches advocating the *construction* of scale started to emerge (Delaney and Leitner, 1997; Marston, 2000). As Herod (2011) points out, the construction of scale is often associated with a more bottom-up and non-capital-centric connotations of scale-making compared to the production of scale. As an addition to the large number of discussions focusing on the capitalist production, Sallie Marston (2000) argued that also social reproduction and consumption are involved in the process of scale-making. Using late nineteenth and early twentieth century American urban middle-class women as an example, Marston demonstrated how women's evolvement on various movements and on political affairs at different administrative levels eventually enabled them to extend their influence beyond the home to other scales of social life. According to Marston (2000, p. 238), "[n]ineteenth-century middle-class women altered the prevailing '*Gestalt* of scale' by altering the structures and practices of social reproduction and consumption."[4]

Meanwhile, however, Neil Brenner (2001) questioned whether the outpouring of research on scalar processes and scale-making has resulted in an "analytical blunting" of a concept of geographical scale. Informed by the critical reading of Marston's (2000) article, Brenner (2001, p. 598) argued that "Marston appears to subsume all geographical aspects of the household under the rubric of '*Gestalt* of scale'" and her "use of the lexicon of scale to theorize the diverse transformations of household space […] thus appears to entail a problematic overextension of this singular dimension of capitalist spatiality to encompass the totality of sociospatial relations." Thereby, according to

4 Marston refers to Erik Swyngedouw's (1997b, p. 169) text: "Geographical configurations as a set of interacting and nested scales (the 'gestalt of scale') become produced as temporary stand-offs in a perpetual transformative, and on occasion transgressive, social–spatial power struggle. These struggles change the importance and role of certain geographical scales, reassert the importance of others, and sometimes create entirely new significant scales, but – most importantly – these scale redefinitions alter and express changes in the geometry of social power by strengthening power and control by some while disempowering others."

Brenner, the theorisations of scale in general would benefit significantly if scaling processes were distinguished more precisely from other dimensions of sociospatial structuration, such as place, locality, territory and space.

Another strain of criticism, concerning the early theorisations of scale, was pointed towards the apprehension of the different levels of scale, such as the urban, the national or the global, as fixed hierarchies. Richard Howitt (1993) challenged the idea that these scale categories are ontological givens. He argued that the question is not how to define borders between the scale categories but how to deal with the linkages between the scales. Additionally, in his editorial in *Society and Space*, Andrew Jonas (1994) brought up a similar concern about geographers "lacking in concepts capable of capturing the various nuances of scale" (p. 257). Later, using musical scale as a metaphor for geographical scale, Howitt (1998) argued that scale has three facets – size, level and relation – of which the latter, alone, is relevant in conceptualising scale in the context of contemporary human geography. According to Howitt, like the change of musical scale does not alter the tones that constitute the scale, similarly in geographical examination, changing the scale of analysis does not alter the geographical features or processes themselves but "the relationship that we perceive between them and the ways in which we might emphasize specific elements for analytical attention" (Howitt, 1998, p. 55). In short, different aspects of the same phenomenon are often stressed at different scales of analysis.

Additionally, an alternative metaphor often used to conceptualise the non-hierarchical nature of scale is the metaphor of scale as networks, such as tree roots or earthworms burrows (Herod, 2003; 2011). As Bruno Latour (1996, p. 370) has put it, "[i]nstead of thinking in terms of surfaces […] or spheres […] one is asked to think in terms of nodes that have as many dimensions as they have connections." According to Latour, the nature of modern societies cannot be understood by notions like levels or territories but they need to be recognised as having a fibrous, thread-like character.[5] Putting this reasoning in scalar terms, different scales need to be understood rather as relational objects in a network. In network metaphors, as Andrew Herod (2011, p. 51) argues, "scales are portrayed not as separate from one another but as linked together in a single, interconnected whole, with the result that whilst different scales may be recognized […], it is tricky to establish precisely where one scale ends and another commences."

Yet another, a slightly different contribution relating scale and networks, came from Kevin Cox (1998) who made distinction between 'spaces of dependence' and 'spaces of engagement'. Cox (1998, p. 2) outlined a space of dependence as more or less localised

5 Anssi Paasi (2004), however, have criticised the network-centric approach. He argues that, although networks do matter in sociospatial theorisation, territories and boundaries are similarly important as reflections of social practices, discourses and power.

social relations which "define place-specific conditions for our material well-being and our sense of significance." These spaces of dependence are linked with broader set of relationships, which engage social actors to other social actors and entities of social power. Through these networks of association, the actors construct a different form of space, the space of engagement. The construction of networked spaces of engagements is therefore tantamount to the process of scale-making where scale is seen as a networked process rather than areal concept. As Cox (1998, p. 20) puts it, moving between different scales "is not a movement from one discrete arena to another."

Moreover, further contributing to the discussion about the intertwined nature of scales, Erik Swyngedouw (1992; 1997a; 2004) argued that the two scales, local and global, which are often seen at the opposite ends of scalar hierarchy, are actually so deeply intertwined that they should not be treated as separate domains. Linked to the wider debate about the scalar restructuring of state spaces (e.g. Jessop, 2002; Brenner, 2004; 2009), Swyngedouw suggested that instead of talking about local and global, the complexity of contemporary societies would be better understood through the term of *glocalisation*. According to Swyngedouw (2004, p. 25),

> 'Glocalisation' refers to the twin process whereby, firstly, institutional/regulatory arrangements shift from the national scale both upwards to supra-national or global scales and downwards to the scale of the individual body or to local, urban or regional configurations and, secondly, economic activities and inter-firm networks are becoming simultaneously more localised/regionalised and transnational.

Hence, through the term 'glocalisation', Swyngedouw (2004) not only combines the global and local scales, but also interlinks the rescaling processes of both, territorial entities of governance and networked economic relations and financial system.

A new leaf in the scale debate was turned by Marston, Jones and Woodward (2005) who suggested provocatively that the concept of scale should be eliminated from the vocabulary of human geography. They argued that "hierarchical scale comes with a number of foundational weaknesses that cannot be overcome simply by adding on to or integrating with network theorizing" (p. 417). Instead, they proposed a flat ontology, which treats space as multiple social sites of practice, relations, events and processes. These sites are not isolated, but rather they inhabit "a 'neighbourhood' of practices, events and orders that are folded variously into other unfolding sites" (p. 426). Thus, the flat ontology rejects the scalar idea of locales being simply networked with other locales elsewhere. In contrast, the flat ontology comprehends people and objects being in interaction across a multiplicity of intertwined social sites.[6] As might be expected, the proposal of abandoning the concept of scale from human geography raised soon

6 In their more recent papers, Woodward, Jones and Marston (2010; 2012) maintained to refine the methodological premises and politics of site ontology. These interventions, however, are not discussed here in detail.

a series of commentaries (e.g. Collinge, 2006; Jonas, 2006; Escobar, 2007). In one of the more critical responses, Andrew Jonas (2006, p. 402) argued that, "by replacing scalar constructs with the site-based epistemology, Marston *et al*. seem to be privileging non-scalar representation and categories over and above spatial (scalar) concepts and identities." He continues that, although attempts to theorise scale have met challenges, abandoning the concept of scale from human geography would create a "world without spatial differences or connection, devoid of identities and hierarchies of a territorial nature" (p. 405). According to Jonas, this would, in effect, create a world without human geography.

Moreover, Adam Moore (2008) presented an additional critique on the scale as a geographical category. According to Moore, "scale has become an unwieldy concept laden with multiple, contradictory and problematic meanings" (p. 203). Although Moore acknowledges the critical commentaries on scale, such as Jonas (1994), Brenner (2001) and Marston *et al*. (2005), he argues that their critique fails to capture the fundamental problem, that the "accounts of geographic scales […] are flawed by an unreflexive conflation of scale as an everyday category of practice with their treatment of scale as a substantial category of analysis" (p. 207). Geographical scales such as local and global, Moore continued, reflect the practical understanding of the spatial organisation of the world. However, the idea that scales are actually existing sociospatial levels "is often taken for granted in social scientists' research" (p. 208), which "directs attention away from the various social actors and practices involved in the scale politics" (p. 211) and flattens the complexity of sociospatial processes. Moore (2008; cf. Jones, 1998) argued that scale is an epistemological rather than ontological reality and, thus, research attention should be directed to investigating how scale operates as a category of practice rather that maintaining scale as a category of analysis.

Given that much of the recent theoretical discussion on scale has concerned the concept's ontological status, a rather different intervention on the scale debate was provided by Bob Jessop, Neil Brenner and Martin Jones (2008; see also Jessop, 2009; Jones and Jessop, 2010). They questioned the one-dimensional theorisations of sociospatial relations, whether concerning scale or other spatial concepts. Jessop *et al*. recognised four spatial turns, comprised of distinct but closely intertwined spatial lexicons that have emerged during recent decades: territory, place, scale and network[7]. However, the supporters of these spatial frameworks, they argued, have often been "tempted to focus on one dimension of spatial relations, neglecting the roles of other forms of sociospatial organizations" (p. 391). In order to confront the limitations of one-sided sociospatial theory, Jessop *et al*. proposed the TPSN (territory-place-scale-network) framework which conjoins the major dimensions of polymorphic sociospatial relations. Jessop *et*

7 Similar approach on multiple spatialities was promoted by Leitner *et al*. (2008) who highlighted scale, place, networks, positionality and mobility in shaping contentious politics.

al. (2008, pp. 392–393) argued that this framework, although does not alone resolve the problems of one-dimensionalism, enables a "more systematic, reflexive investigations of the interconnections among the [four] dimensions of social relations". A series of commentaries to the paper by Jessop *et al*. was published in the same issue of *Society and Space*. In these critiques, Edward Casey (2008) and Michael Shapiro (2008) questioned the TPSN framework for being confined to a "quaternion schema" whereas Anssi Paasi (2008) called for deeper methodological discussion on how to study the polymorphic dimensions of the TPSN framework.

2.2. On network spatialities

As mentioned in the above section, the concepts of scale and network are entangled in many ways and a number of scholars have drawn parallels between the concepts (e.g. Amin, 2002; Leitner *et al*., 2002; Paasi, 2004; Herod, 2011; Jonas, 2011; Jones *et al*., 2011). Networks, however, have for long been theorised in social sciences, particularly under the umbrella of social network analysis, which make use of a line graph where different actors are linked together with social relations (Wasserman and Faust, 1994). The idea of network has a long history also within geography. The early network approaches were inspired by the positivist works such as Haggett's (1965) *Locational analysis in human geography*. Along with the critique of positivism, however, the popularity of networks fell rapidly. It was not until in the 1990s that the network approaches were re-adopted to spatial theory, largely due to the emergence of globalisation discourses in spatial and political sciences (Smith, 2003; Jones *et al*., 2011).

One of the most influential contributions in developing network-based spatial theory was provided by Manuel Castells' massive three-volume study of the information age (Castells, 1996; 1997; 1998). In the first volume of his trilogy, *The rise of network society*, Castells (1996) outlined how the emerging information society is increasingly organised around networks. According to Castells, these networks constitute the new social morphology of societies and information technology provides the material basis of expanding the networks throughout the society. Castells interlinked social practice with space – as he puts it, "spatial forms and processes are formed by the dynamics of the overall societal structure" (p. 410).[8] Furthermore, as the information society is constructed around flows, Castells (1996; also 1989) argued that a new spatial form, the *space of flows*, has emerged from the social practices that shape the network society.

According to Castells (2000, p. 14), "[t]he space of flows refers to the technological and organizational possibility of organizing the simultaneity of social practices without geographical continuity." The space of flows constitutes of three material supports: the

8 Here, Castells draws parallels to David Harvey's (1989) thinking about time and space being deeply interlinked with social action.

technological infrastructure that enable information to flow through the network, the nodes and hubs which ties the space of flows to places and the managerial elites that maintains the networked spatial logic in societies (Castells, 1996). Castells continued that, although the space of flows is not the only spatial logic in contemporary societies, it dominates the network society because it is the spatial logic of the dominant functions in the society. Indeed, Castells made a clear distinction between the spatial logic behind the space of flows and what he called the "historically rooted spatial organization of our common experience" (p. 378) or the *space of places*. The vast majority of people live in places and perceive their space through place-based spatial logic. However, as Castells argued, "because function and power in our societies are organized in the space of flows, the structural domination of its logic essentially alters the meaning and dynamic of places" (p. 428). On that account, Castells (2010) saw a widening contradiction between the two spatial realities, as the space of places and space of flows are increasingly unrelated to each other.

Castells' monumental attempt to make sense of the economy and society in the information age has expectedly raised a large number of comments and critique. Amongst the early critics, Neil Smith (1996, p. 69) argued that, although the concept of space of flows "captures admirably the increasingly fluid social, technical and economic arrangements of production and consumption", the concept overemphasises the fluidity of networked societies. Smith stressed that spatial fluidity is accompanied with *spatial fixity* as the capital and information is always bound to places. Smith continued that rather than place is annihilated in the space of flows, "the relationship between the fluidity and fixity of space is itself restructured" (p. 71). In line with Smith's critique, John Friedmann (2000) questioned the binary framework of Castells' analysis in which the network society is controlled by all-powerful, godlike space of flows, dominating the increasingly irrelevant nation-states and individuals in the space of places. Friedmann also criticised Castells for disregarding many relevant discussions in contemporary social theory, which enables him to rather freely formulate the "Castellsian spaces of flows and places" (p. 115). As Friedmann (2000, p. 120) has put it,

> I find these [theoretical] claims seriously flawed, chiefly because Castells adopts a meta-theoretical framework which consistently leads him down analytical dead-ends. His two-tier model of the world, his unwillingness to entertain dialectical formulation and the resulting polarization lead him to extreme interpretations that, despite his contrary claims, remain unsupported in the empirical evidence.

Another early critique to Castells' spatial theory was presented by Nigel Thrift (1995). He criticised Castells (and also David Harvey and Fredric Jameson) of whom each portrays the world "as having come under sway of a new form of capitalism" (p. 19). Thrift continued that these analyses of contemporary capitalism "produce a partial rep-

resentation which does not recognise its own partiality" (p. 24). Using the foreign exchange trade as a model example of a system operating through space of flows, Thrift showed that the space of flows is actually produced by concrete communication between people. According to Thrift (1995, pp. 34–35),

> The space of flows is revealed as a partial and contingent affair, just like all other human enterprises, which is not abstract or abstracted but consists of social networks, often of a quite limited size even though they might span the globe.

Richard G. Smith (2003) goes along with Thrift's critique about abstractness and a lack of attention to human practices in Castells' analysis. He, however, added several points to Thrift's critique. Smith criticised Castells' argument about networks for being exaggerated and arrogant for trying to explain the totality of network society through information flows. Furthermore, he argued that Castells' account is technically deterministic, despite "having been mobilized and disguised through the metaphor of the network" (p. 33). Similarly, Ida Susser (1996) questioned Castells' idea that the post-industrial society can be understood by examination of technology alone. In a more recent contribution, Smith and Doel (2011) critiqued Castells' spatial theory in its entirety. For Castells (1996, p. 411), "space is the material support of time-sharing social practice." As Smith and Doel (2011, p. 28) put it, "the twist that Castells gives to this conception is the observation that, whilst these material supports were once 'assimilated to contiguity' [railway tracks etc.], they are now given over to discontinuity" in the form of information flows. Smith and Doel, however, highlighted two flaws with the metaphor of flows. First, they argued, "a non-contiguous flow, be it abstract of material, is self-evidently oxymoronic" (p. 29). Second, Castells treats flow as an instrument of power, disregarding the presence of human agency. Hence, "in the hands of Castells, flows (and the spaces thereof) are deprived of their fluidity and divested of their agency" (Smith and Doel, 2011, p. 29).

In order to overcome the problem of lacking agency in theories of networked space, Smith (2003) proposed actor network theory (ANT) (Latour, 2005) and non-representational theory (Thrift, 2008) as an alternative approach to analyse and understand networks. While for Castells, networked space is reduced to structural forces of political economy, ANT and non-representational theory emphasises actor-relations and human practices that make up spatial orderings (Smith, 2003). On the one hand, ANT assumes that networks are constantly made by both human and non-human actors and, therefore, there is nothing abstract about networks. Quite contrary, as Latour (1993, p. 122) explicitly put it, networks are "not made from some substance different from what they are aggregating". On the other hand, non-representational theory highlights that the emphasis of human geography should be on practices because "practices rather than representations are at the root of geographies that humans

make every day" (Smith, 2003, p. 37). Hence, through non-representational theory, space can be seen as a network of relations that is aware of agency, practices and performance.

Moreover, Ash Amin (2002; 2004) rejected the idea that place and space are territorially configured. For Amin (2002, p. 389), global networks do not represent the "dematerialisation of life owing to the rise of the knowledge economy and informatics, or the displacement of a space of places by a space of flows". Quite the contrary, building on the work of Nigel Thrift and Doreen Massey, he conceptualised place as a site of network practices. With this understanding of place, Amin argued that local and global spatial practices are ontologically inseparable and, thus, that place cannot be conceptualised as bounded and territorial but as spatially stretched, topological sphere. In line with Smith (2003), Amin emphasised the importance of ANT and non-representational theory. For him, the "actor-networks of varying length and duration as well as the world of practices" (Amin, 2002, p. 385) are the central components in understanding the topological organisation of the world.

Amin's argument about stretching and dynamic topological space is embedded to a wider debate about 'thinking space relationally'. The key idea of this relational turn in geography, which builds on David Harvey's (1973) tripartite division of the nature of space, is that, instead of territorial or topographical conceptions, space is "no more than the sum of relations, connections, embodiments and practices" (Massey, 2004, p. 8). Therefore, as Hetherington and Law (2000, p. 127) have put it, "[t]he network metaphor fits well […] with a relational approach to space that stresses a nonhierarchical way of thinking about difference and the space that it constitutes as seemingly fluid, complex, and unfinished in character". Martin Jones (2009), however, has criticised the relational thinking for seeing networks as non-spatial and without a geographical anchor. He opposed the juxtaposition of networks and territories and argued that

> One way to take thinks forward might be to consider a conceptual middle road between space as territorial anchorage and fixity and conceptions of space as topological, fluid and relationally mobile. (Jones, 2009, p. 496; cf. Paasi, 2004; Jonas, 2012)

Jones proposed that this middle road could be conceptualised thorough the notion of 'phase space' which "captures all possible spaces in which a spatiotemporal system might exist in theoretical terms" (p. 499) and "acknowledges relationality but insists on the confined, sometimes inertial, and always context-specific nature of geography" (p. 487). The concept of phase space originates from theoretical physics and Jones admited that applying such ensemble ontology to human geography is challenging. However, he advocated that "phase space is a philosophical perspective that is curiously absent from human geographical thinking and […] one that is worthy of further discussion and debate" (p. 500).

Shifting focus to urban systems research, Evert Meijers (2007b) has approached network spatialities from a totally different angle. He considered Walter Christaller's (1933/1966) central place theory from the vantage point of Kuhnian paradigm shifts and argued that, although the central place model has proved major difficulties in explaining spatial reality, no other clearly defined approach has replaced it. However, Meijers continued, a new model of networked spatial organisation of urban systems gradually emerged in the 1990s (e.g. Camagni and Salone, 1993; Batten, 1995). According to Meijers, this new model is "essentially opposite to the central place model" (p. 246); the relations between the nodes of an urban system are horizontal instead of vertical and non-hierarchical instead of hierarchical. Meijers emphasised the notion of complementarity as the key feature of the network model. In the networked urban system, "functions such as urban facilities are spread over the different cities in such way that they complement each other" (p. 257). Consequently, complementarity is linked with horizontal accessibility where urban network develops from two-way flows between non-hierarchically organised localities.

Another approach that builds on central place theory was proposed by Peter Taylor, Michael Hoyler and Raf Verbruggen (2010). Although covering similar ground with Meijers (2007b) and other critics of central place theory, their approach differs as they do not wish to "dispatch central place theory to the dustbin of history" (p. 2804). Instead of abandoning or extending the central place thinking, they treat hierarchical and network approaches as representing two different processes of external urban relations. As Taylor *et al.* (2010, p. 2804) put it,

> As well as hierarchical structure postulated by central place theory, we argue that there is a network structure between cities. Whereas the former is a vertical spatial structure linking local scales of interaction (hinterlands), the latter is primarily a horizontal spatial structure linking non-local interactions. We treat both as generic urban processes and therefore both are required adequately to describe external urban relations now and in the past.

Informed by Castells' (1996) bipartite division of social space and work made on networked social organisation (Powell, 1990; Thomson, 2003), Taylor *et al.* (2010) introduced a central *flow* theory to accompany central *place* theory. While the latter is modelled as interlocking hierarchies, central flow theory postulates from interlocking set of networks. According to Taylor *et al.*, two processes of external urban relations – 'town-ness' and 'city-ness' – describe these theories. The former is defined as the process that links an urban place to its hinterland and is described by central place theory, while the latter represents inter-city relations that reach beyond the local hinterland and is described by central flow theory. Apart from the spatial construction, the key difference between the town-ness and the city-ness is the complexity of the processes. According to Taylor *et al.* (2010, p. 2811), "central place process is essentially simple in comparison with central flow theory."

3. Methodological considerations: the connectivity field method[9]

One of the central outputs of this dissertation is the contribution to the methodological basis of functional polycentricity research. This contribution takes shape particularly through the development of new method to analyse functional polycentricity: the connectivity field method. Functional polycentricity has typically been examined using measures that derive from the inter-nodal flows of people or information within the polycentric system. In the connectivity field method, however, functional polycentricity is approached as the connectivity of individual centres to the whole polycentric urban system. Instead of addressing directional flows between nodes, functional relations within the polycentric system are approached through the surfaces of interaction where the surface, or connectivity field, determines how intensely a particular centre is functionally connected to the rest of the polycentric system.

The advantage of the connectivity field approach over the inter-nodal approach is that it considers the totality of functional flows within the urban region, not only flows between the centres. In this regard, the connectivity field method resembles the bottom-up approach of identifying functional urban regions developed by Coombes *et al.* (1986). In the bottom-up approach, FURs are identified using an algorithm that optimises the regional boundaries on the basis of a full set of commuting data (Robson *et al.*, 2006; Davoudi, 2008). In contrast, the top-down approach uses predetermined core areas as a starting point in identifying FURs and certain commuting thresholds are applied to determine the FUR boundaries. As a whole, the bottom-up approach provides a more comprehensive way of analysing urban systems compared with the top-down approach, which focuses on flows between predefined nodes (Davoudi, 2008).

9 This chapter is slightly modified from the methodological sections of articles III and IV.

Connectivity fields are calculated using a flow attribute which may be any interaction data that have origin and destination locations, such as commuting, shopping trips, telephone and email traffic, business networks or international flights. The connectivity field of a particular centre is comprised of the distribution of origins of incoming flows to the centre. Similarly, it is possible to construct a connectivity field from the distribution of destinations of outgoing flows. Internal flows, which have both origin and destination in the same centre, are omitted from the analysis. Including the internal flows in the analysis would make the method sensitive to the size of a particular centre. Since larger centres have more internal flows than smaller centres, the internal flows would therefore determine the overall connectivity of larger centre more than the connectivity of smaller centre. Hence, the connectivity field reveals the degree to which each centre is functionally connected to the other parts of the urban system.

The level of connectivity is determined by comparing each connectivity field with a potential field, which is formed from the distribution of the total number of origin locations in the interaction data. The more the connectivity field of a particular centre resembles the potential field, the more connected the centre is with the rest of the region. The degree of connectivity is measured formally using the R squared statistic of ordinary least squares (OLS)[10]. In the case of a high R squared value, a linear relation exists between the connectivity field and the potential field thus suggesting that the centre in question has a more or less equal distribution with the potential field and, therefore, that the centre is functionally connected to the rest of the urban system. Consequently, as the connectivity measure reveals how integrated each centre is to the whole urban system, the overall level of spatial integration within the region can therefore be determined from the average R squared values of all centres in the region.

The connectivity field method can be illustrated through a simple example of commuting in a hypothetical urban region consisting of a core area and three employment sub-centres (Figure 1a–c). In Figure 1a, the connectivity field of sub-centre 1 (SC1) is shown. The darker the colour in the diagram, the more workers living in that particular location commute to the SC1. Similarly, the connectivity field of the sub-centre 2 (SC2) is illustrated in Figure 1b. Figure 1c shows the potential field for commuting, which is determined by the distribution of the places of residence for all employees in the region. It is clearly visible from Figure 1 that SC1 is more connected to the urban region as it attracts commuters, not only from nearby locations but evenly throughout the region. SC2, on the other hand, has a much more local labour market and thus

10 The R squared statistic of ordinary least squares gives practically identical results compared with the correlation coefficients. The correlation coefficients, however, yield somewhat higher connectivity measures, which decreases the variability of the measure. Therefore, the R squared statistic was chosen as an indicator of connectivity.

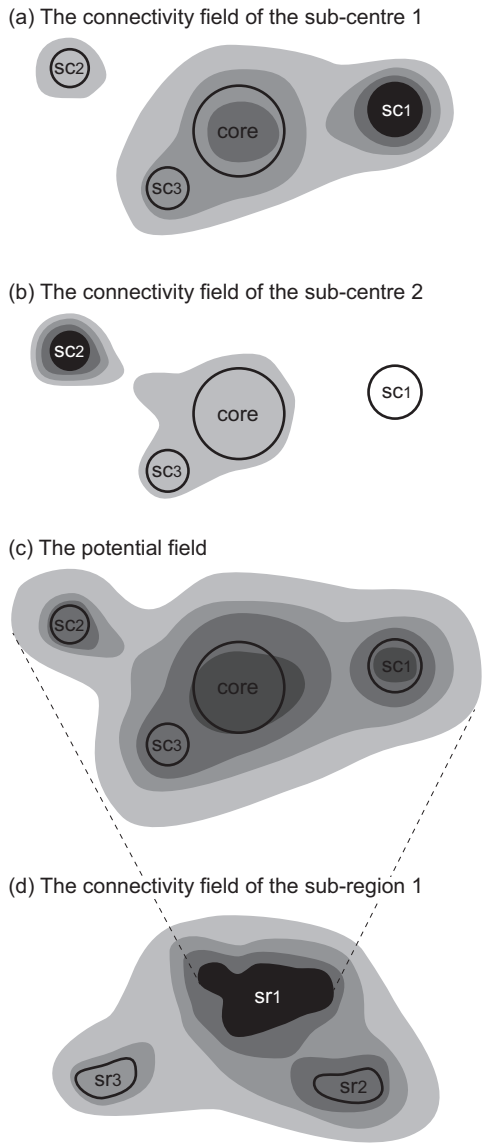

Figure 1 An illustrative example of the connectivity field method.

also lower connectivity to the region. In terms of formal measurement, the R squared value for SC1 would presumably be high, well above 0.5, whereas the same value for SC2 would be considerably lower.

In principle, the connectivity measures (R squares) are calculated for each region respectively. However, the connectivity field method is fully scalable and each region, for which connectivity measures have been calculated, can also function as a centre or sub-region in a higher scale polycentric system. Therefore, in addition to the internal measure of spatial integration which is determined for a given region, it is also possible

to determine a measure of external connectivity, which assesses the connectivity of that particular region in relation to a higher scale polycentric system (Figure 1d). Again, an internal spatial integration measure can be calculated for this system. Therefore, the connectivity field method enables a nested scalar approach where each region can function as part of a higher scale polycentric system.

As discussed in section 1.2., functional polycentricity is linked to two theoretically distinct concepts. The first concept, spatial integration, concentrates on the strength of the functional connections within an urban system while the other focuses on the balanced direction of functional linkages between the centres in a polycentric urban system. The fact that functional polycentricity has been associated with two such divergent concepts has generated fuzziness around the term. In general, the concept of functional polycentricity refers to a multi-nodal urban system, which has functional linkages between its centres. However, the same term has also been used to describe the balanced distribution of flows within an urban system. Although it is justifiable to call a functionally balanced multi-nodal urban system functionally polycentric, as an unbalanced urban system would by definition be functionally monocentric, the existence of parallel interpretations has created conceptual ambiguity and confusion around the term. Therefore, in the remainder of this dissertation, the term 'functional polycentricity' refers to the general interpretation of a networked multi-nodal urban system while the term 'functional balance' is used to describe the balanced distribution of flows within such a system.

The connectivity field method, as discussed above, can be used to calculate the degree of spatial integration for the whole region and for each centre separately. Therefore, borrowing from the spatial statistics lexicon, the former is a global whereas the latter is a local indicator of spatial integration. This is an important distinction because the two approaches of functional polycentricity – spatial integration and the balanced distribution of flows – follow the same spatial logic. As analytical measures, spatial integration and functional balance are both global indicators as they both describe certain quality – the overall connectedness or balanced distribution of flows – for the whole urban system. However, these measures, and functional balance particularly, are derived from local variables, in which the connectivity measures for each centre are determined individually.

Earlier approaches to functional balance have used centre-specific centrality scores to determine the degree of functional balance (Burger *et al.*, 2011; Burger and Meijers, 2012). In these approaches, the centrality of a given centre has been determined as the total number of incoming flows from other locations within the same urban system (Burger and Meijers, 2012). As such, this approach is markedly similar with the connectivity field method, which, in practice, measures the diversity of the directions of incoming flows. The advantage of the connectivity field method over the centrality

scores, however, is that it captures the diversity in the directions of incoming flows more precisely whereas the centrality approach measures merely the bulk of the incoming flows. Nonetheless, in addition to measuring overall level of spatial integration, the connectivity field method can also be used to determine the degree of functional balance within an urban system.

Two indicators have been used in recent empirical studies to measure the balanced distribution of centres in polycentric urban systems. The first one, a functional primacy index, is calculated from the ratio of incoming flows to the principal city to the total incoming flows in the urban system (Burger *et al.*, 2011). The larger the degree of primacy, the more functionally unbalanced (monocentric) the urban system in question is. The second indicator makes use of the slope of the linear regression line of rank-size distributions of centrality (or connectivity) values (Meijers and Burger, 2010; Burger and Meijers, 2012). In this approach, a flat slope suggests a high degree of functional balance whereas a steep slope is an indicator of unbalanced functional organisation. Figure 2 shows six hypothetical urban systems with different degrees of functional balance. The degree of functional balance is illustrated with the rank-size diagrams of connectivity values on the left together with the estimated measures of spatial integration and functional balance. On the right, the simplified sketch of the directions of flows for three centres in each urban system is illustrated. Figure 2 clearly shows that urban systems *c*, *e* and *f* are clearly functionally balanced whereas regions *a* and *b* are more or less functionally unbalanced.

In addition to the level of functional balance, Figure 2 also illustrates the relation between functional balance and spatial integration in different types of urban systems. As mentioned above, spatial integration can be measured as the average connectivity or centrality values of all centres within the system where a high average connectivity or centrality value indicates a high degree of spatial integration in the urban system. In Figure 2, major differences in spatial integration are visible between the urban systems *c*, *e* and *f* although they all are highly functionally balanced. Despite the balanced distribution of incoming flows between the centres, the centres in the urban system *f* are clearly more integrated to the whole system than the centres of the urban system *c*. Consequently, one could ask whether the functional structure of the urban system in Figure 2c is polycentric in the first place or whether it is merely a group of monocentric, non-integrated urban centres. Moreover, the slope of the regression line is a rather coarse measure of functional balance if the rank-size distribution is not linear. It is clearly visible from Figure 2 that, although urban systems *a* and *d* have the same slope coefficients, the urban system *a* is noticeably more functionally unbalanced than the urban system *d*.

The issues above have two implications. First, it is important to consider the overall degree of spatial integration when analysing the degree of functional balance in an urban system. This is because the balanced distribution of flows between the centres is

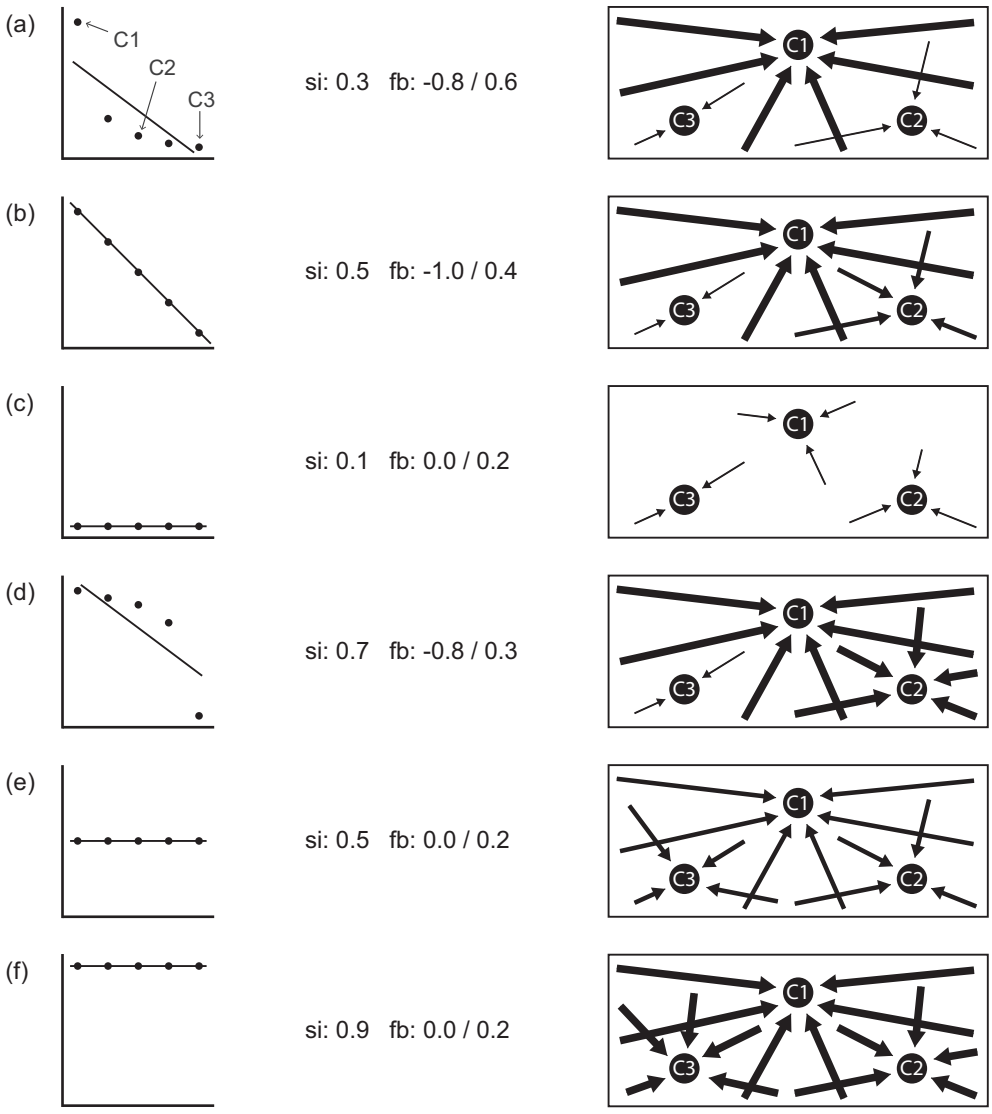

Figure 2 The degree of spatial integration and functional balance in different types of functional urban systems.

a rather poor indicator of functional spatial structure if the centres are not integrated into the surrounding region at all. Second, the slope of the regression line alone should not be used as an indicator of functional balance if the rank-size distribution of the connectivity or centrality of the centres is not linear. In such cases, the approach used by Meijers and Burger (2010), where an average value of slope coefficients for different number of centres is calculated, can obviously better perceive the diversity of different rank-size distributions.

The connectivity field method, as concluded in article III, has also shortcomings. The major limitation of the method is the poor availability of applicable data. The method requires large datasets, preferably covering the whole population under study, which limits the use of survey data, for instance, in the analysis. In urban or regional research settings, commuting data are widely used as they are often the only available high-quality interaction data (Parr, 2005; Burger *et al.*, 2011). However, at higher scales where commuting does not provide realistic information about daily mobility of people, similar interaction data are rarely readily available. The availability of applicable data is also linked with another shortcoming of the method. As available data are often economic in nature, the method effectively omits the socio-ecological spaces that shape the functional structure of the urban regions (Davoudi, 2008). Other interaction data, such as social visits, trips to cultural or leisure amenities and commodity or waste flows, for instance, might form completely different connectivity patterns within urban regions. Such data, however, are rarely available, at least at the required level of detail.

4. Empirical results

4.1. Dynamics of urban spatial structure in Turku urban region

In this section, the empirical findings of articles I and II are discussed. The general aim of these two research papers is to understand how different sociospatial processes shape the urban spatial structure at the regional scale and what kind of impact do residential preferences have on the development of urban structure. Both papers use the urban region of Turku as a case study. In general, the development of urban spatial structure is to a great extent conditional to the changes in population distribution. In the urban region of Turku, the total population in the region grew in the period of 1980–2010 from approximately 256,000 to 320,000. Figure 3, which illustrates the distribution of population change in different parts of the region, shows that the overall population growth has been distributed more or less evenly throughout the urbanised areas of the region. With an exception of the central city and older suburbs in the city of Turku, the number of inhabitants has increased in almost all residential built-up areas in the region.

There are, however, certain spatial patterns visible in the population structure in the region. As shown in article I, two distinctive trends characterise the development of population structure. First, while the overall population distribution in the region has become less concentrated, it is simultaneously getting increasingly spatially clustered. This is clearly visible in Figure 3. On the one hand, population growth has occurred in the outskirts of the region while population decrease has characterised the more densely populated central areas. On the other hand, population growth seems to have clustered around the central built-up areas of region's municipalities – a trend which was visible already in the 1970s (cf. Andersson, 1983). Second, as also noticeable in Figure 3, most of the absolute population growth has occurred in the core area of the region. In rela-

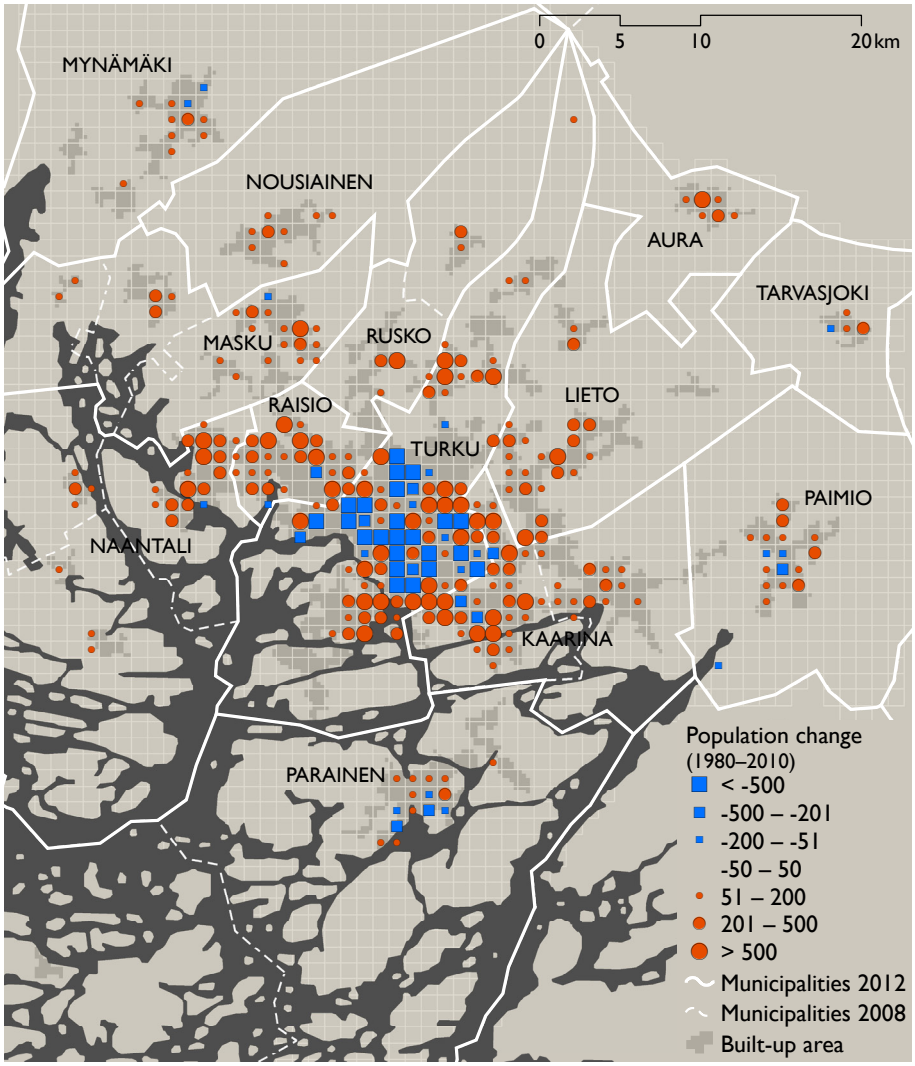

Figure 3 Changes in population distribution in the urban region of Turku from 1980 to 2010.

tive terms, however, the population growth has been the fastest in the inner commuting region (see Figures 1 and 2 in article I). As concluded in article I, it appears that the trend in population distribution in the urban region of Turku is the decentralisation of population clusters which has led to an increasingly polycentric urban form.

The influence of different sociospatial processes on the urban spatial structure was further considered in article I. The purpose of this analysis was to examine the role of general demographic trends (such as increased number of the elderly and decreased household sizes) and land use planning (examined indirectly through housing construction) on the population distribution. As emphasised in article I, the overall socio-demographic trend in the urban region of Turku has been decreasing household size and

the proportion of families with children together with the increasing proportions of small households and per capita housing space. However, this trend appeared opposite in those areas where population growth occurred (cf. Figure 3). The average household size and the proportion of families with children increased whereas the share of one person households and aged people decreased. In the population loss areas, the socio-demographic trends were parallel with the overall development although the changes were much more extreme. Moreover, population growth occurred predominantly in the areas where new housing was constructed. Although this finding is self-evident, it emphasises the importance of housing construction in regional population dynamics.

As suggested in article I, the results from the analysis of socio-demographic variables are related to two wider societal phenomena. First, the overall trend of declining household size is associated with the broad demographic development known as the second demographic transition (e.g. Van de Kaa, 1987; Champion, 1992). This phenomenon has evidently influenced in the process of population deconcentration as, in the circumstances of declining household sizes, the population decrease is an inevitable outcome unless new housing is made available. Hence, as concluded in article I, the decrease of population in existing urban structure is a natural outcome of the trend where smaller families tend to live more spaciously. Second, the increasing household size and proportion of families with children observed in the areas where population growth occurred can be interpreted through the concept of housing career (e.g. Feijten, 2005). With the general trend being an increasing number of small households, the opposite trend evidently points towards young parents seeking homes for their growing families. Although natural population growth is one obvious factor which results in increasing number of inhabitants in a given area, the residential mobility of families according to their residential preferences is also likely to cause population growth in an area, as suggested in article I.

The interpretation of relation between residential preference and intra-regional mobility was supported by the results of article II. The paper showed that the distribution of stated residential preference follow a clear spatial pattern. Those who reside on the urban fringe had a stronger preference for low-density detached housing and a lower preference for an urban environment whereas urban dwellers had more or less the opposite residential preferences. However, although clear congruence was found between stated residential preferences and individual housing choices, the influence of residential preferences on residential mobility was not found to be straightforward. On the one hand, preference for low-density detached housing seemed to be the most important factor describing population decentralisation in urban regions. On the other hand, moving towards the core urban area was associated with demographic determinants rather than residential preferences. The results indicated that the central city attracts young movers whatever their residential preference may be. As concluded in

article II, those living in an urban environment regardless of their residential preference are prone to adjust their housing situation by seeking a preferred residence on the outskirts of the urban region. This preference adjustment process creates a cycle of intra-regional residential mobility in which the population shift towards the central city creates a starting point for later centrifugal mobility.

In sum, there are two key processes which influence urban spatial structure at the regional scale. On the one hand, second demographic transition is linked with population decline in existing urban fabric. On the other hand, housing construction is self-evidently associated with population growth in a given area. The relation of these population growth/decline inducing processes on urban morphology is, however, less straightforward. Since urban structure is an accumulation of past construction, which has typically been heavily concentrated around the urban centres, the population decline is therefore likely to take place in the central parts of the urban areas, whether large or small. This is clearly visible in Figure 3 where population decline occurs, not only in the central parts of Turku, but also in smaller towns such as Paimio or Parainen. In contrast, and linked to the same accumulation process of urban structure, housing construction is likely to take place in the fringes of urbanised areas where vacant land is more abundant and presumably less expensive. This argument is independent of spatial scale. The land for housing purposes is more abundant and inexpensive in the outskirts of built up areas at the municipal scale but also in the remoter municipalities at the regional scale. However, also central locations are highly valued in European cities, which is clearly visible from the general property price distribution in urban areas. Therefore, a complimentary building to central cities, in the case there is vacant land available, is potentially attractive as well. This is also visible in Figure 3 where population growth has occurred in the most central parts of Turku as well. Moreover, in Finland, housing construction is strictly regulated by land use planning legislation. Municipalities have monopolistic power to compile their own land use plans and, although initiative to start a planning process may also come from construction firms, in general, major housing construction does not take place without a thorough planning process controlled by municipal decision-making process.

Municipal land use planners and construction firms, however, do not operate in a societal vacuum. The central aim of municipal land use planning is to provide housing and infrastructure for the citizens and a key motivation of construction firms is to make profit by selling homes to their future residents. Hence, the role of the residential preference of potential homebuyer is (or should be, at least) in the interest of both actors. However, residential preferences are manifold and, as shown in article II, their influence on the development of urban spatial structure become concrete only through residential mobility oriented towards the urban fringe and motivated by preference for detached housing. When compared to detached housing areas in the urban fringe, central cities

has to offer numerous urban amenities and, consequently, urban housing can be associated with countless different preferences. Therefore, it may be that urban dwellers do not prefer central city as a residential environment but have other preferences which override the residential aspiration. On the whole, although the influence of residential preferences on the development of urban spatial structure cannot be generalised in any simple argument, the most visible outcome of them is the increasing residential mobility towards the growing detached house areas in the outskirts of the urban regions.

As mentioned above, it seems that the population distribution in the urban region of Turku is characterised by decentralisation of population clusters. This trend can also be interpreted as concentration of population at the municipal scale and deconcentration at the regional scale. Indeed, this scalar division appears to be in the very core of the development of urban spatial structure in the region. The urban region of Turku is historically comprised of numerous small municipalities (see Figure 3) which all control land use planning within their own territories. However, as Kimmo Ylä-Anttila (2010, p. 173) has shown in his study concerning urban networks in the Tampere region, there has been a scalar shift in the region in recent decades where different parts of the region are increasingly accessible for daily private car based mobility. Following this line of reasoning, the everyday life of people living in the urban regions is increasingly taking place at the regional scale while most of the operations of local governance are bound to the municipal scale. Given these conditions, it is not surprising to come across the above mentioned spatial development. While municipalities keep operating mainly within their territories, hence at the municipal scale, the residents have extended their daily activity to the regional scale. As concluded in article I, the conflict between these scalar levels, can therefore be seen as central factor influencing recent population dynamics in the urban region of Turku.

4.2. Functional polycentricity in the urban regions of southern Finland

One of the findings of previous chapter was that Turku urban region seems to have developed towards increasingly polycentric urban spatial structure. In this section, the emphasis is on the examination of this polycentric development in wider geographical context. Drawing on the empirical results of articles III and IV, this section aims at analysing on what degree the spatial structure of the urban regions in southern Finland is structured in polycentric terms. Here, particular emphasis is on functional polycentricity, which is analysed using the connectivity field method, as introduced in Chapter 3. In article III, the focus is on the functional and morphological polycentric development in the urban regions of Turku, Helsinki and Tampere whereas article IV concentrates on functional organisation of altogether fifteen urban regions in southern Finland.

It was shown in article III that, when polycentricity is approached in terms of urban form as in article I, the spatial structure of Finnish urban regions has indeed become more polycentric. This polycentric development, however, was more apparent in terms of employment distribution, while population distribution did not show such a clear tendency towards increasingly polycentric urban form. Nonetheless, in the urban region of Turku, where the municipal structure has traditionally been more fragmented compared to the Helsinki and Tampere regions, increasing polycentricity was found also in strictly morphological terms, thus supporting the findings in article I. In recent polycentricity debate, however, the importance of the balanced distribution of population and workplaces between centres has been stressed in polycentric urban regions. In these terms, Finnish urban regions appear to be more or less morphologically monocentric. As suggested in article III, the urban regions of Helsinki, Turku and Tampere seem to be strongly dominated by their central city areas, whether considering by population or employment distribution. A clear shift towards a more polycentric urban spatial structure was evident only in employment distribution in the Helsinki region where the number of workplaces has increased notably in the sub-centres locating along the ring roads.

In terms of functional polycentricity, the examined urban regions appeared to be notably more polycentric. Although the connectivity levels of the urban core areas were still higher than those of the sub-centres, the functional spatial structure of the regions is clearly less dominated by the core areas. Moreover, the growth of the connectivity levels occurred predominantly in the sub-centres, which indeed suggest a development towards increasingly balanced functional urban structure in the examined urban regions. The joint comparison of functional and morphological polycentricity in article III further underpinned these findings (see Figure 4 in article III). On the one hand, the morphological spatial structure of the urban regions was noticeably monocentric in terms of both population and employment distribution. On the other hand, the functional spatial structure of the regions showed a clearly more polycentric pattern, induced particularly by the increasing connectivity levels of the sub-centres. Furthermore, it was shown in article III that the most significant growth in connectivity took place in the inner sub-centres, thus suggesting that functional polycentric urban development, characterised by intensive criss-cross commuting flows, has been restricted to rather small central areas within the urban regions.

The above findings gained support from the empirical results of article IV, in which the two aspects associated with functional polycentricity, spatial integration and functional balance[11], were examined separately across different scalar levels. As suggested in article IV, the urban regions in southern Finland are clearly more spatially integrated

11 See Chapter 3 for a detailed discussion about these two concepts.

and functionally balanced at the intra-urban scale compared to the intra-regional scale. It therefore appears that, in the urban regions of southern Finland, the core urban area is evidently more functionally polycentric than the whole urban region. Moreover, at all scales, urban systems were more polycentric in functional than morphological terms, which is in line with the findings from article III and other similar studies (e.g. Burger and Meijers, 2012). When the development of spatial integration and functional balance were examined, a steady growth of both was evident at the intra-urban scale. However, at the intra-regional scale, the degree of functional balance seemed to have decreased from 1980 to 2007 while, at the same time, the level of spatial integration grew markedly. Although the urban regions were increasingly functionally integrated at both scales, the empirical results from article IV suggested bidirectional functional urban development. On the one hand, the development at the intra-urban scale has been towards increasing functional polycentricity while, on the other hand, the increased degree of spatial integration at the intra-regional scale has primarily been the outcome of monocentric functional development. This bidirectional process of functional development is presented as a generalised illustration in Figure 4. Accordingly, at least when the commuting flows are considered, the inner parts of urban regions appear to be increasingly characterised by a complex network of functional relations whereas, in the outer parts of the regions, traditional centre-oriented functional flows prevail.

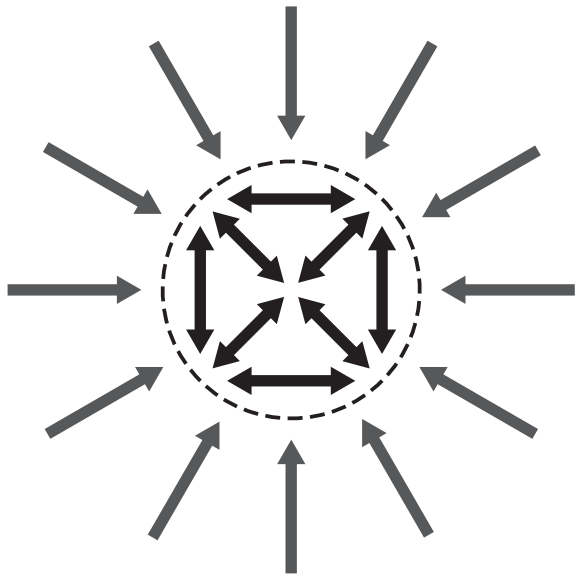

Figure 4 A generalised illustration of the functional spatial structure of the urban regions in southern Finland.

As concluded in article IV, the concept of functional polycentricity is clearly relational to scale: the higher the spatial scale, the lower level of functional polycentricity is apparent. Additionally, article IV showed that the size of the urban region is associated with the degree to which the urban regions are spatially integrated. The degree of spatial integration in larger regions, such as Helsinki, Turku and Tampere, was notably lower compared to many of the smaller regions. Such scale-dependence of commuting networks is not surprising as it is expected to find stronger spatial integration in smaller regions where commuting distances are shorter. Nonetheless, the results highlight the essentiality to acknowledge the influence of adopted scale in the analysis of urban functional structure. Since different urban regions are of different sizes, the geographical extent of their intra-urban scale, for instance, is prone to differ considerably. This distinction between absolute scale (size) and relative scale (level; such as urban or regional) has a significant influence on the analysis of the functional structure of urban regions.

The distinction between absolute and relative scales is illustrated in Figure 5, in which the connectivity levels of a representative large and small urban region are compared. Using the Tampere and Salo regions as an example (cf. Figure 5 in article IV), it is clearly visible that the absolute size of the intra-regional scale of the Salo region is roughly equal to the intra-urban scale of the Tampere region. Consequently, the highly connected intra-urban sub-centres of the Tampere region are located approximately at the same distance from the region's core than the corresponding highly connected intra-regional sub-centres in the Salo region. Figure 5 shows clearly that the increasingly complex functional network, which characterises the inner parts of the regions (cf. Figure 4), takes place at the intra-urban scale in the Tampere region and at the intra-regional scale in the Salo region. Therefore, it appears that the functional processes are apparently similar in the both regions at the absolute scale but, due to the different sizes of the regions, they occur at different relative scales. This divergence between absolute and relative scales largely explains the differences in the degrees of functional polycentricity between large and small urban regions. Since the functional structure at the absolute scale was found remarkably similar between two such a different urban regions as Tampere and Salo, there are good reasons to assume that these findings can be generalised to other urban regions at least in Finland, if not in wider geographical context.

The development of functional structure in urban regions is also closely connected with the physical infrastructure, particularly the road network. As concluded in article III, the inner sub-centres of larger urban regions, which are characterised by a high level of connectivity, are typically located along the ring roads. This finding is not surprising as it is expected that the centres which are easily reachable from every corner of the urban region are also functionally connected with the rest of the region.

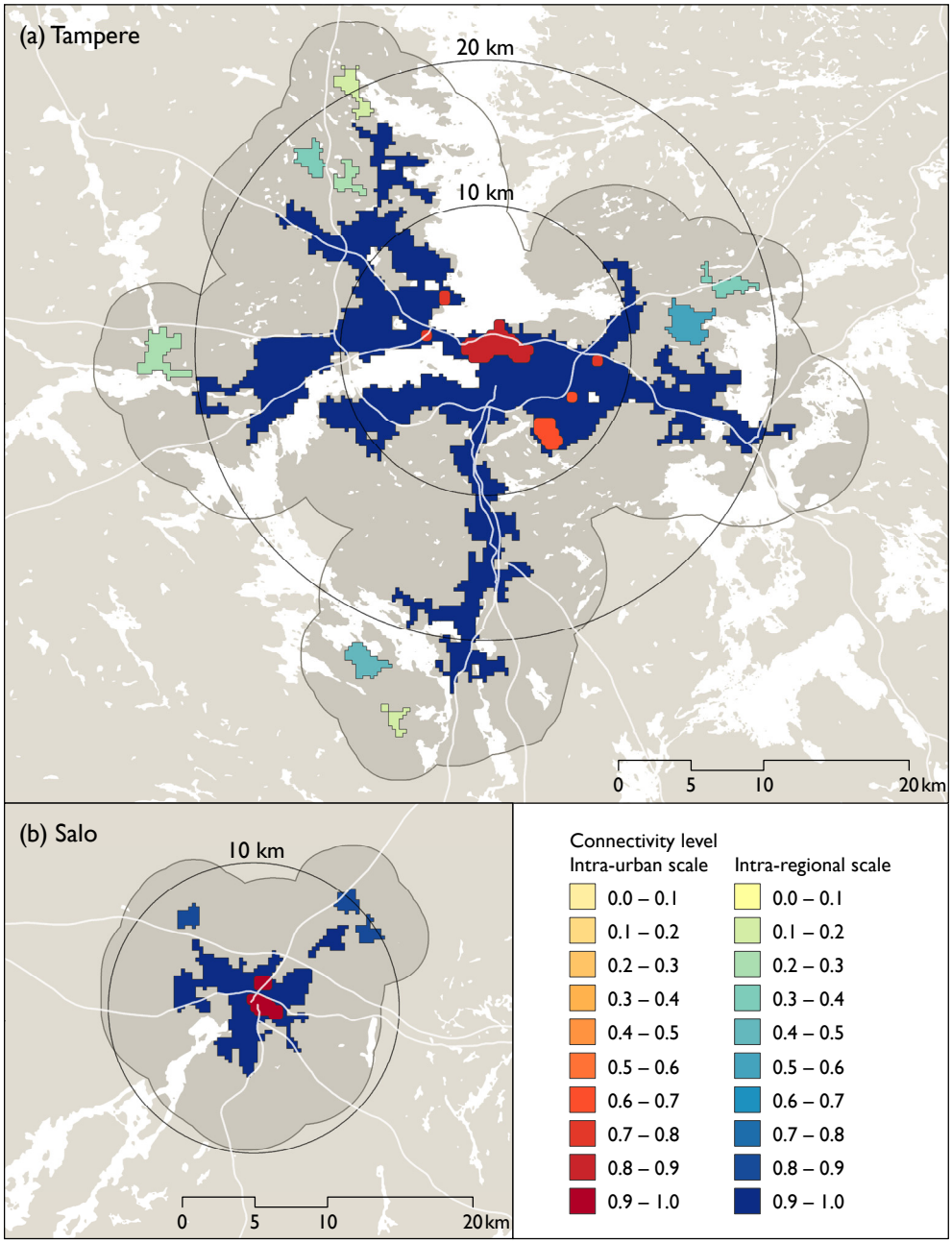

Figure 5 The connectivity levels of sub-centres at the intra-urban and intra-regional scales in the urban regions of Tampere and Salo.

The importance of ring roads for the functional structure of urban regions was also highlighted by another study on urban networks conducted in the Tampere University of Technology (Alppi and Ylä-Anttila, 2007; Joutsiniemi, 2010; Ylä-Anttila, 2010). Using a topomorphological approach to analyse the development of urban network in the Tampere region, Samuli Alppi and Kimmo Ylä-Anttila (2007; see also Ylä-Anttila, 2010) showed that the highest road network accessibility has shifted from the central city towards the southern ring road. Similar changes are evident in the logic of retail locations as shopping centres and other large scale retail units have relocated to the intersection of major urban highways, thus following closely the best accessibility in the road network. It seems that this accessibility shift has initiated the process where intra-urban sub-centres, particularly in the larger urban regions, form an increasingly functionally polycentric system characterised by dense network of criss-cross mobility. As Kimmo Ylä-Anttila crystallises, "[t]his change in the logic of retail location is the most notable single factor which influences in the development of urban spatial structure and, in general, one of the most significant aspect in this urban change where new polycentric structure emerges to the urban region" (Ylä-Anttila, 2010, p. 167, author's translation).

5. Concluding remarks

> There is a continuous tension between the 'scales of regulation' and 'scales of networks'. (Swyngedouw, 2004, p. 33)
>
> There is no doubt that networks do matter but so do 'geography', boundaries and scales as expressions of social practice, discourse and power. (Paasi, 2004, p. 541)

In the quotation above, Erik Swyngedouw emphasises the tension between two scalar configurations: the rhizomatic scales of economic networks on the one hand and territorial scales of governance on the other. Moreover, as Anssi Paasi's citation reminds, while relational spaces of economic networks may exist regardless of territorial boundaries, the bounded space "remain significant for the purposes of coordination and identification" (Paasi, 2004, p. 542). This juxtaposition between the two scalar constructs, whether conceptualised through networks and territories or spatial fixity and fluidity, are highly relevant when considering the development of urban spatial structure. On the one hand, as shown in this dissertation and other studies (e.g. Ylä-Anttila, 2010), the scales of urban networks, constructed from commuting and other forms of everyday mobility of people, has extended during recent decades and is increasingly taking place at the regional scale. On the other hand, most of the functions of local governance in the Finnish urban regions take place at the municipal (sub-regional) scale. Furthermore, it seems that the territorial spaces of municipal governance have created a 'scalar fix' (cf. Brenner, 1998) particularly in the largest urban regions. Despite recent legislative attempts to rescale the local governance in Finland to correspond better the daily activity patterns in the urban regions, these scalar fixes are seemingly almost impossible to deconstruct. The conflict between these two scalar constructs, as highlighted in this dissertation, plays an important role in the polycentric urban development where the urban regions have centralised at the municipal scale and decentralised at the regional scale.

One of the key issues in the recent theoretical debate about scale has been the ontological status of the concept. The central question here has been whether scales are tangible ontological constructs of socialspatial practices or whether they are mere epistemological devices that help researchers to understand different spatial phenomena (e.g. Jones, 1998; Marston, 2000; Marston *et* al., 2005; Jonas, 2006; Moore, 2008). Building on these discourses and based on the findings of this dissertation, I argue that both approaches to scale offer a fruitful viewpoint in analysing urban spatial structure. First, it is apparent that different scalar spatialities, both networked and territorial in nature, are constructed by various sociospatial processes in urban regions. As has been shown in this dissertation, the regional scale is largely constructed through the daily mobility patterns of people living in different parts of the regions, thus manifesting the network ontology of scale. Additionally, scale has a bounded or territorial ontology which is constructed through hierarchical power relation. As emphasised above, the bounded approach to scale is clearly visible in the territorial organisation of municipal governance. Similarly, although with much more flexible boundaries, bounded scales can be constructed thorough the process of identification and attachment to a place (Paasi, 2004; cf. Jauhiainen and Moilanen, 2011). Furthermore, the concept of scale has also an epistemological domain, which is rather obvious in geographical research. In this dissertation, different scalar levels were used to study functional polycentricity in urban regions (article IV). Although these scalar levels have also ontological content describing geographical extents of urban spatial structure, they were used here primarily as pre-given analytical tools rather than ontological social constructs.

As shown in this dissertation, the Finnish urban regions have developed towards increasingly polycentric spatial structure where physically separate urban localities are connected through complex network of commuting flows and other forms of daily mobility. As such, it is possible to conceptualise the spatial structure of urban regions through the theoretical thinking of Manuel Castells (1996). If we set aside the widely criticised information society thesis and concentrate on Castells' contribution on spatial theory, the concept 'space of flows' offers a seemingly noteworthy starting point for interpreting the structural development in urban regions. In Castells' thinking, space of flows, promoted by information technology and managerial elites, dominates the historically rooted space of places where majority of people lives. Similarly, albeit disregarding Castells' power structure between the two spatial configurations, the spatial structure of urban regions is characterised by both: physical places such as neighbourhoods, office areas or public parks, on the one hand, and complex network of flows comprised of daily mobility of people between these places, on the other. Based on the results from this dissertation, I argue that the latter has become increasingly important in characterising the spatial structure of urban regions. Hence, in Castells' terms, the physical space of places provides only a partial understanding about the spatial struc-

ture of contemporary urban regions which are increasingly being constructed through topological networks, or space of flows, that tie the urban region together as a coherent functional entity.

Furthermore, informed by Castells' spatial theory, Peter Taylor, Michael Hoyler and Raf Verbruggen (2010) offered an interesting approach on networked urban space by proposing a central flow theory to accompany central place theory. Although central place theory is burdened by the historical weight of positivism and a general shift towards relational spatial thinking, Taylor *et al.* argue that hierarchical relations described by the central place theory do indeed exist in urban systems. However, they continue that central place theory requires an accompanying relational theory, central flow theory, to treat the increasingly networked nature of contemporary urban systems. According to Taylor *et al.*, these urban processes operate at different scales: whereas central place theory links local scales of interactions, central flow theory operates at the intercity level. Although this interpretation is undoubtedly correct as it is, this dissertation has shown that networked relations are crucial also in understanding the development of urban spatial structure at the intra-regional scale. Therefore, whether conceptualised through Castellsian 'space of flows' or 'central flow theory' of Taylor *et al.*, I argue that relational space, formed of complex networks of commuting, but also information, commodity or waste flows, for instance, is highly important in order to understand the structural development of contemporary urban regions.

In this dissertation, the emphasis has been on economic networks, which have been approached through commuting flows. As suggested above, however, urban networks may constitute of number of different flows and the networks that these flows constitute may emerge at completely different spatial scales (cf. Burger *et al.*, 2013). Furthermore, as shown in this dissertation, the geographical extent of relative scales, such as 'the urban' or 'the regional', varies considerably between different sized urban regions. Therefore, as Andrew Herod (2011, p. 16) puts it, "it is important to distinguish between the geographical size of particular urban areas and how we might conceptualize the urban scale itself". Since different scalar constructs are "an outcome of perpetual movement of sociospatial dynamics", as pointed out by Erik Swyngedouw (2004, p. 33), it is essential that different urban processes are considered carefully when analysing the scalar dimensions that they produce. As a consequence, further research should concentrate on the multiplicity of spatial interaction in urban regions in order to reach a full picture of the complex functional networks that shape their urban spatial structure.

Lastly, the theoretical focus of this dissertation has been on the concepts of scale, network and, to a smaller extent, territory. However, following the multidimensional TPSN thinking of Bob Jessop, Neil Brenner and Martin Jones (2008), this dissertation has had little to say about place. This deficiency is perhaps one of the major limitations

of this dissertation. Since it is places where people live and attach emotionally, the subjective meanings given to place are bound to have a considerable influence on the sociospatial processes that shape the urban regions. However, as the focus of this dissertation has been on the structural development of urban space, there has been little room to consider the subjective views of people and the influence of these views on the urban development. In making this point, I call for a new research approach, which would add the subjective meanings attached to places to the research on development of urban spatial structure. In addition to quantitative analyses presented in this dissertation, such research approach would help to understand also the quality of networked spaces that emerge from the everyday mobility of people living in urban regions.

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