MARTIJN J. BURGER

Structure and Cooptition in Urban Networks

Structure and Cooptition in Urban Networks

Structure and Cooptition in Urban Networks

Structuur en coöpetitie in stedelijke netwerken

Thesis

to obtain the degree of Doctor from
the Erasmus University Rotterdam
by command of the rector magnificus

Prof.dr. H.G. Schmidt

and in accordance with the decision of the Doctorate Board.

The public defense shall be held on
Thursday, 22 September 2011 at 15.30 hours

by

Martijn Johan Burger
born in Groningen

ERASMUS UNIVERSITEIT ROTTERDAM

Doctoral Committee

Promotors:	Prof.dr. G.A. van der Knaap Prof.dr. H.R. Commandeur
Other members:	Prof.dr.ing. G.R. Teisman Prof.dr. P. McCann Prof.dr. F.G. van Oort

Erasmus Research Institute of Management – ERIM
The joint research institute of the Rotterdam School of Management (RSM)
and the Erasmus School of Economics (ESE) at the Erasmus University Rotterdam
Internet: http://www.erim.eur.nl

ERIM Electronic Series Portal: http://hdl.handle.net/1765/1

ERIM PhD Series in Research in Management, 243
ERIM reference number: EPS-2011-243-ORG
ISBN 978-90-5892-288-5

Design: B&T Ontwerp en advies www.b-en-t.nl
Cover Image: Yacintha van Zuidam
Lay-out: Jermaine van Laarhoven

This publication (cover and interior) is printed by haveka.nl on recycled paper, Revive®.
The ink used is produced from renewable resources and alcohol free fountain solution.
Certifications for the paper and the printing production process: Recycle, EU Flower, FSC, ISO14001.
More info: http://www.haveka.nl/greening

‘*Der Raum ist kein Zauberer, kein übersinnliches Wesen*’

- Walter Christaller

Preface

Let every man be master of his own time

-William Shakespeare, The Tragedy of Macbeth

A professor once taught me that it is not important to have free time, but to be free to plan your own time. Although I still presume he was referring to the benefits of academic life, I now also learned that it is often difficult to keep track of time. Indeed, it is remarkable how quickly time has passed since I started my PhD in urban and regional economics at the Erasmus University Rotterdam. Over the past four years, I had the opportunity to study many subject areas, ranging from polycentric urban systems, spatial competition, agglomeration economies, and strategic spatial planning to foreign direct investment, trade in services, housing bubbles, and strategic alliances in the biopharmaceutical industry. Yes, perhaps I took sometimes too many side roads, but, after all, joy is often found in the journey and not in the destination. Still, I am glad that the PhD project has now come to an end, something that would never have been possible without the support of my family, friends, colleagues, and supervisors. Therefore, I would like to express my profound gratitude to

Bert van der Knaap, for his input, coaching, and our lengthy discussions on the history of the spatial sciences as well as for giving me the opportunity to write a doctoral dissertation and to develop my own research agenda.

Harry Commandeur, for his continuous support and inspiration as well as for challenging me to put my research in a broader perspective by relating it to issues in industrial economics and management.

Frank van Oort – whom I not only highly regard as an additional mentor, but also as a friend – for his guidance, infinite enthusiasm and dedication, many e-mails at 2am, and outstanding company during conferences and dinners.

Evert Meijers, for exploring together the research agenda on spatial structure and regional performance, for our successful collaboration over the past years, and for greatly enhancing the time spent at several conferences.

Bas Karreman, not only for sharing ideas and frustrations, but also for introducing me to The Wire, decorating H13-11 on my birthday, bringing home-baked cookies to work, not bothering too much about the mess I make, and just for being the best roommate you can ever wish for.

Frank Neffke, for many memorable games of pool, theatre classes, evenings in the Muppet cafe, late night escapes from Rotterdam, and never-ending discussions about research and starting up a joint paper (which is after three years still on the Bucket list).

Ronald Wall, for our successful collaboration in joint research projects over the past years as well as for his enthusiasm and determination to explore the relationship between urban planning and economic geography.

Mark Thissen, not only for his hospitality at the time I was guest researcher at the Netherlands Institute for Spatial Research, but also for the many pleasant dinners and visits to the theatre and cinema.

Matthias Brienen, Vincent Buskens, Bastiaan de Goei, Dario Diodato, Koen Frenken, Jarno Hoekman, Gert-Jan Linders, Roderik Ponds, Otto Raspe, Lambert van der Laan, and many other co-authors within and beyond my own department for the fruitful cooperation within joint research projects over the past years.

Kirsten Rohde, Aurélien Baillon and Enrico Pennings, for their research support and enjoyable company during countless coffee breaks, lunches and dinners.

Sandra Phlippen, for her creativity, original ideas, and ability to make even a boring day at work a lot of fun.

Nita Ramsaransing and Gerda de Rave, for the administrative support and trying to keep me healthy.

All my other colleagues at the 13th floor, Italo, Ronald Huisman, Pilar, Teresa, Jan, Hans, Esen, Justus, Han, Anka, Ramona, and Eddy for creating together a stimulating work environment.

Annemieke, Bas, Bob, Kristel, and Youri, for our long-lasting friendship which dates back to high school and University College. Even though I don't see some of you as often as I would wish for, many things never change. When we meet, it is as we have never been really apart.

My former classmates from the Sociology and Social Research Master, Agnieszka, Andrea, Claartje, Gwen, Jara, Jelmer, Joris, Jornt, Katrin for the enjoyable gatherings and outstanding trips to Texel, Poznan and Nürnberg.

Jermaine, Jeroen, Karolinka, Lieke, Matti, Tessa, Thijske, Vera, Yacintha, and other members of my theatre groups at Parnassos for the very welcome distraction during the work week, the hilarious moments on and off stage. Special thanks go to Jermaine and Yacintha, who helped me in preparing this publication.

Last, but certainly not least, I would like to express my gratitude and appreciation to my family, especially my grandmother Carla, sister, brother-in-law, and parents for their unprecedented love and support. Evita and Anne-Guus, you are the best sister and brother-in-law you can ever wish for. Carina and Matthé, I can't thank you enough for your continuous interest, care and support – I know your door is always open, which is extremely valuable to me

Martijn Burger
Utrecht, June 2011

Table of Contents

Chapter 1:

Dreaming of Megalopolis: From Hierarchy to Network

1.1 Polycentric Urban Networks in the Making?

Fifty years ago, the French geographer Jean Gottmann (1961) envisioned the rise of a super-metropolitan region along the northeastern seaboard of the United States, stretching from just north of Boston all the way to Washington DC (see Figure 1.1). Gottmann named this new urban form after the Peloponnesian city *Megalopolis*, founded by Epaminondas of Thebes as the seat of the Arcadian league in an attempt to form a political counterweight to Sparta. According to Gottmann (1961, p. 4), "*the name applied to* [this area] *should ... be new as a place name but old as a symbol of the long tradition of human aspirations and endeavour*". Indeed, the Greek Megalopolis was planned on an enormous scale; the city was populated through the enforced transfer of inhabitants from 40 local villages and was encompassed by 9 km in circumference of strong walls (see also Baigant, 2004). Although Epaminondas' Megalopolis did not succeed as hoped and although it gradually faded into oblivion, Gottmann was optimistic about the future of the new Boston-Washington corridor Megalopolis. He felt the region could function effectively as an inter-regional polycentric urbanised system that still had many characteristics of a single city. Gottmann (1961, p. 5) argued that:

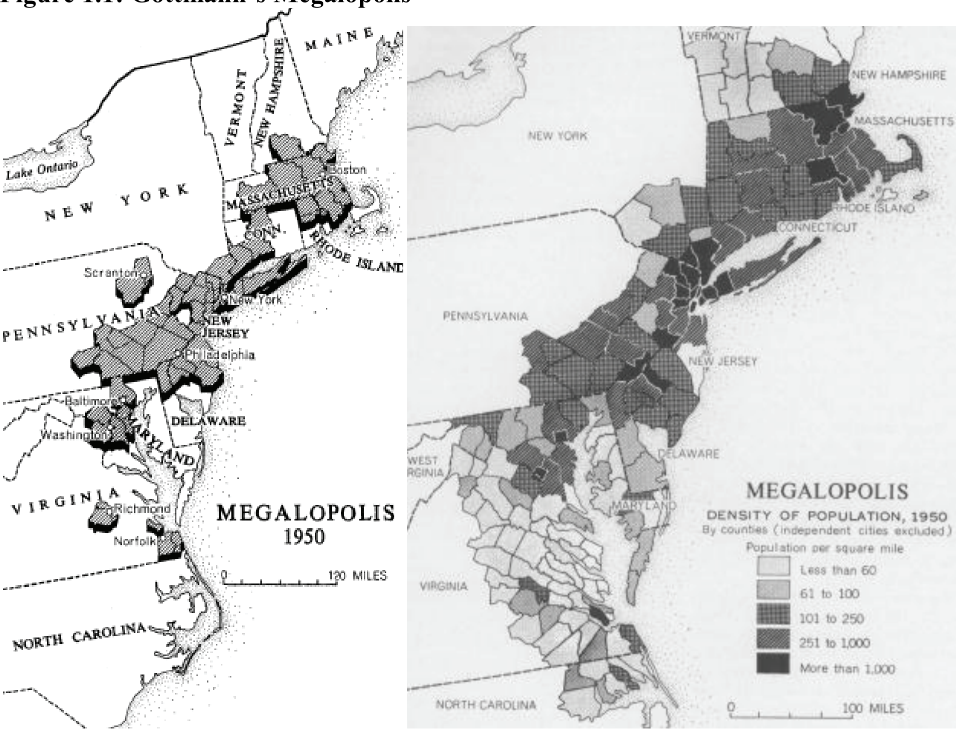
"*We must abandon the idea of the city as a tightly settled and organized unit in which people, activities, and riches are crowded into a very small area clearly separated from its nonurban surroundings. Every city in this region spreads out far and wide around its original nucleus; it grows amidst an irregularly colloidal mixture of rural and suburban landscapes; it melts on broad fronts with other mixtures, of somewhat similar though different texture, belonging to the suburban neighborhoods of other cities.*"

Gottmann considered the Megalopolis to be the emergent form of spatial organisation, characterised by high average population densities and the flow of high volumes of people, goods, capital and information. Functional relationships between the different parts of the Megalopolis would be of the utmost importance for its ability to function as single city.[1] The Megalopolis reflected the enlarged scale of urban life and the shift from a single metropolis with a principal centre to an urban network with multiple centres. Gottmann

[1] However, it should be acknowledged here that Gottmann's original concept was predominantly morphological. Only later (in response to critiques) would he stress the functional aspects of the Megalopolis (Hall, 1997).

also emphasised the importance in the Megalopolis of inter-state cooperation and governance organised on greater geographical scales than the local scale. He claimed local governments would inadequately fulfil the needs of these large cities and their ever-expanding suburbs. The Megalopolis would be characterised by a marriage of urban and rural modes of life, leading to maximum freedom of movement and a perfection of the modern urban lifestyle, one that would remedy the problems of the congested city and the backward village. Visions for the city similar to Gottmann's were also expressed in (earlier) planning concepts such as the Garden City (Howard, 1902), Broadacre City (Wright, 1935), and the Regional City (Stein, 1964).

Figure 1.1: Gottmann's Megalopolis



Source: Gottmann (1957)

Gottmann's vision of the Boston-Washington corridor as a polycentric urban network were radical in the 1950s and broke with the conventional conceptualisations of cities as local hierarchical urban systems[2], as popularised by Christaller (1933) and Lösch (1941) in Europe and the Chicago School (McKenzie, 1933; Bogue, 1949; Hawley, 1950) in the United States. Overall, Gottmann's work received positive reviews (Pawson, 2008), and in the wake of his book on the northeastern seaboard of the United States, related concepts such as the 'dispersed city' (Gainsburg, 1959; Burton, 1963), 'non-place urban realms' (Webber, 1964), 'urban fields' (Friedmann and Miller, 1965) and 'ecumenopolis' (Doxiadis, 1968) were developed. All these concepts analysed the rise of borderless cities and the increasing interdependencies between regions as a result of technological change.

Despite this increasing awareness in the spatial sciences that the hierarchical model did not represent the spatial reality of post-war urbanised areas well, applying more to rural areas of the 1930s (e.g., Vining, 1955; Burton, 1963; Wurster, 1963; Vance Jr., 1964; Berry, 1967; Allpass, 1968), most researchers in planning, geography and regional economics remained consumed with hierarchical urban systems. For example, the main themes in analytical work on urban systems in the 1960s and 1970s focused on theoretical extensions and modifications of Christaller's and Lösch's central place theory and explorations of the nature of city-hinterland relationships. In addition, delimitations of functional urban regions and metropolitan regions remained very much based on the model of a dominant urban core with a surrounding territory (Gober, 1997), and normative planning concepts that viewed the hierarchical urban system as planning ideal stayed very popular (Low, 1975; Hall, 1997).

From the mid-1970s onwards, urban systems theory slowly but surely faded to the background of the spatial sciences. Research on the spatial structure of urban systems was replaced by case studies on individual regions and micro-level approaches that focused on the spatial behaviour of households and firms. These developments were spurred by criticism that the modelling of urban systems was too concerned with theory and not enough with the policy problems that needed to be solved (Harvey, 1972; Lee, 1973; King, 1976) and that it lacked real world data to test its hypotheses (Coffey *et al.*, 1998). Similar developments took place in planning, which abandoned the systems approach as being a pseudo-science, too probabilistic and only able to generate general goals (Hall, 2003). At the same time, attention shifted from the wider urban region to the city as planning unit, stimulated by the urban problems related to urban decline and ongoing deindustrialisation in the late 1970s and 1980s. This period is also marked by the rise of Marxist thinkers such

[2] Yet Harris and Ullman (1945) had already proposed a polycentric model of spatial organisation at the city level.

as David Harvey and Manuel Castells, who developed strictly sociologically based theories that critiqued spatial plans as being subordinate to and even destructive towards social development because they reinforced existing class relations.

From the 1990s onwards, there has been renewed interest in the spatial organisation of urban systems at higher spatial scales, exemplified by the discourses on urban networks and, more recently, the Polycentric Urban Region (PUR) in planning and geography. The PUR can best be represented as a set of historically and spatially separate city-regions seen to comprise a larger functional urban region (Champion, 2001; Kloosterman and Musterd, 2001; Parr, 2004) and to share many characteristics with Gottmann's Megalopolis. Gottmann's Megalopolis emphasised a suburbanisation inspired by the rise of the telephone and automobile. In contemporary studies, globalisation, the internet and the increasing importance of the service economy are the main drivers of the increasing geographical scope of economic and social processes and the growing importance of external urban relations (Camagni and Salone, 1993; Batten, 1995). In contrast to research in the 1960s, it is now argued that the traditional Christallerian central place conceptualisation of urban systems, which is characterised by a strict urban hierarchy, is outdated. This conceptualisation can, at best, be replaced by a network view of urban systems characterised by the absence of urban hierarchy and a considerable degree of spatial integration between formerly independently functioning urban regions. Polycentricity and urban networks have become catchphrases in spatial planning in particular, where polycentric development policies have been introduced to support territorial cohesion and higher levels of urban and regional competitiveness (Meijers and Romein, 2003).

However, the shift from local hierarchical urban systems to inter-urban and inter-regional polycentric urban systems can be seen to occur on a continuum; the extent to which the network model has completely replaced the hierarchical model remains unclear. PURs and, to a lesser extent, urban networks have mainly evolved as normative planning concepts (Van Houtum and Lagendijk, 2001; Davoudi, 2003), while less attention has been paid to the development of theoretical models and empirical testing. Polycentricity and urban networks are currently among the most versatile and fuzzy concepts in use. Some progress has been made with to clarify the concept of polycentric spatial constellations (e.g., Champion, 2001; Kloosterman and Musterd, 2001; Parr, 2004; Lambregts, 2009) and urban networks (e.g., Camagni, 1993; Camagni and Salone, 1993; Batten, 1995; Capello, 2000). However, we still find greatly diverging interpretations of what makes territories polycentric and networked, as well as diverging approaches to measuring polycentricity and urban network formation.

Table 1.1: Characteristics of Urban Systems in Hierarchical Versus Network Models

Characteristic	Network System	Hierarchical System
Morphological structure	Multinodal; several centres in close proximity to each other; centres of relatively similar importance.	Uninodal; one principal centre; relatively significant separation between city and countryside.
Orientation of functional linkages and spatial integration	Multidirectional; two-way core-periphery/periphery-core linkages and criss-cross linkages between centres of similar size.	Unidirectional; linkages directed at the principal centre; no relationships between centres of similar size.
Type of spatial constellation	Network city or polycentric urban region (PUR).	Monocentric metropolitan area
Relationship between spatial units	Tendency towards complementarities and regional cooperation.	Tendency towards competition, local orientation and dependence.
Economic specialisation	Function of centres independent of centre size but dependent on urban-network position; spatial division of labour between centres.	Economic function of centres dependent on centre size, with higher-order functions concentrated in larger centres.
Economic externalities	Agglomeration economies shared among groups of cities of similar size; no agglomeration disadvantages.	Agglomeration economies restricted to the urban core.

Along these lines, there is a need for an overarching conceptual framework of polycentricity and urban networks that would unify (1) the normative planning discourse on the spatial organisation of urban systems, providing handles for planners and policymakers on appropriate levels for spatial planning and governance and (2) previous analytical work on spatial structure found in urban systems research. Such a framework should be able to assess whether polycentric and networked regions are indeed a good reflection of contemporary spatial organisation and whether network cities and PURs actually outperform hierarchical spatial constellations. In addition, this framework should incorporate information on the spatial structure, the functional interdependencies between cities and the nature of agglomeration externalities within a network system. It should also indicate how it differs from a hierarchical system. An overview of the important characteristics of the hierarchical versus network urban systems that will be discussed in this dissertation is provided in Table 1.1.

The goal of this introductory chapter is to gain a better understanding of why geography, regional economics and planning have relied on hierarchical urban systems for so long when researchers such as Gottmann (1961) and Friedmann and Miller (1965) were already noting the development of polycentric urban networks 50 years ago. We show that the literature on urban systems as used in quantitative planning and geography, and neoclassical approaches that developed from the end of the 1950s onwards, gradually ended up in a Catch-22. On the one hand, researchers were aware that the theoretical urban models largely inspired by the work of Christaller and Lösch did not adequately represent empirical reality. On the other hand, good alternative theoretical urban models in geography or regional economics that enabled researchers to better understand contemporary spatial constellations were also lacking. There was also a widespread belief among planners and policymakers that urban hierarchies were the most efficient form of spatial organisation from an economic perspective.[3]

The remainder of this chapter is organised as follows. Section 1.2 discusses early urban systems theories, focusing mainly on the idea of urban hierarchies in the traditions of central place theory and the Chicago School of Urban Ecology. The next two sections focus on applications of central place theory and the development of systems theory in the light of the scientific turn in the planning profession (1.3) and the theoretical and quantitative revolution in geography (1.4). We also elaborate here on the fields' preoccupation with hierarchical urban systems. This results in a discussion in Sections 1.5 and 1.6 of the erosion of the hierarchical model in the spatial sciences and the rise of the network model of spatial organisation. We pay attention not only to the shift from an intra-urban hierarchical urban model to an inter-urban polycentric urban model but also to the interplay between the analytical models of spatial organisation and normative planning. This discussion resulted in the number of lacunas in the present literature on polycentricity and urban networks, which will be detailed in Section 1.7 and addressed in the remainder this dissertation. Section 1.8 concludes with an overview of the organisation of the dissertation.

[3] In addition, there was also a countermovement led by Mumford that opposed the idea of extended urbanisation as represented in Gottmann's Megalopolis, as it would destroy idyllic rural life. For a more extensive discussion, see Baigent (2004).

1.2 Urban Hierarchies and Systems of Cities

Prior to the Industrial Revolution, it was relatively easy to define a city. As a general rule, a city could be identified as an agglomeration of people and businesses, separated from the countryside by fortifications, gates, and towers. This characterisation is not only reflected in the Greek term polis ('surrounding wall') and the Latin word 'urbs' ('walled city') but also in the English 'town' ('circular palisade'), the German 'Zaun' ('hedge'), and the Spanish 'ciudad' ('stronghold') (Kerbat, 1995). However, what primarily distinguished cities from rural areas in medieval times were their specific legal status (notably 'city rights') and their political identity. Medieval towns were usually autonomous, being free from feudal bondage and having their own jurisdiction (Hohenberg and Lees, 1985). More specifically, Frug (1980, p. 1083) points out that the European medieval city was foremost '*an economic association of merchants who created the town as a means of seeking relief from the multiplicity of jurisdictional claims to which they, and their land, were subject*'. However, cities also offered traders protection from violence and regulations against fraud, which was needed to secure the functioning of these markets. For this reason, the legal status of medieval cities cannot be understood separately from their economic function as marketplace for surrounding areas. In this fashion, markets and places of administration gradually '*crystallized as central places for their surrounding areas ... in which each center approximated the center of gravity of its service area in order to minimize transportation costs*' (Hohenberg and Lees, 1985, p. 49). Yet, the city in the pre-industrial era was very concentrated and centralised, as physical distance often encumbered interactions between different cities. Although functional relationships with other cities certainly existed (mainly through trade networks), they were not very intense; most movements, activity patterns and business relations were restricted to the urban core. Accordingly, the medieval city was relatively closed and independent (Hohenberg and Lees, 1985).

The city could shift its functional borders as mobility steadily increased and communication technology further developed. Tram, train, and telegraph technology in the nineteenth century, and telephone and automobile in the twentieth century, are examples of technology that considerably affected the organisation of urban systems (Anas *et al.*, 1998). Local economic growth and prosperity were now contingent not only on the urban core but also on economic development in the suburbs. Nevertheless, the relationship between the urban core and its suburbs remained hierarchical-nodal. The most important economic activities were based in the urban core, flows were directed towards the central cities, and the suburbs merely fulfilled a residential function.

Paralleling the ever-growing suburbanisation in the early twentieth century, the focus in urban research gradually shifted from the internal structure of cities ('city as a system') to the external relations of cities, as it sought to explain the distribution of urban centres across space ('systems of cities' or 'urban system') (see Ullman, 1941). In this research, urban systems can be defined as a set of regionally, nationally or globally linked and interdependent urban areas (Pred, 1977; Bourne and Simmons, 1978). The notion of urban systems would be formalised in the interbellum in the following two strands of literature (see also Aiken *et al.* 1987; Ross, 1992; Neal, 2011): central place theory (Christaller, 1933; Lösch, 1941) and the urban ecology of the Chicago School (McKenzie, 1933; Bogue, 1949; Hawley, 1950).[4] The study of the organisation of urban systems in geography and economics originates from urban location theory (Von Thünen, 1826; Weber, 1909) and can be traced back to the work of Christaller (1933) and Lösch (1944) on central place theory. Christaller (1933) was predominantly interested in explaining the distribution, size and number of cities and towns, while Lösch (1941) was concerned with explaining the location of economic activities and the creation of regions. Christaller and Lösch nonetheless arrived at the same conclusion: not every place can be self-sufficient. Hence, a division of labour occurs in which small villages and hamlets provide basic needs for their own inhabitants, and larger towns and cities specialise as central places providing higher-order goods and services to their surrounding areas. In a central place system, there is a *hierarchy* of central places, where the centrality of a settlement and the variety of goods and services it provides are thought to correlate perfectly. Accordingly, lower-order

[4] However, it should be noted that the analysis of urban systems in planning, geography and economics dates back to the work of Von Thünen (1826) on the location of agricultural activity and urban-rural relationships, Kohl (1841) on geometric models for optimising flows of circulation between places and Reynaud (1841) on the role of cities carrying out central functions for its surrounding territories. Subsequent contributions included the work of Galpin (1915) and Gradmann (1916).

central places are dependent on higher-order central places for the provision of goods and services; only a small proportion of the central places will be self-sufficient, in that they can provide the full range of goods. In other words, each place produces the majority of goods and services that can found further down in the hierarchy, plus an additional range of higher-order goods and services. An important difference between Christaller's and Lösch's work is that Lösch's central place theory allows for complementarities between comparably sized places that provide functions for one another and smaller settlements that provide some lower-order functions to larger centres (Pred, 1977; Van der Knaap, 1980). However, hierarchical relationships also dominate in Lösch's view, with the largest centre still presented as being self-sufficient.

Concurrent with developments in central place theory, urban historians and sociologists of the Chicago School of Urban Ecology, such as Gras (1922), McKenzie (1933), Bogue (1949) and Hawley (1950), were focusing on the division of labour between cities within metropolitan areas. In an analogy with biological ecology, metropolitan regions were treated as organisms or communities, discernible by commuting patterns and other socio-economic interactions. Accordingly, urban ecology perceived cities not as self-contained forms of social organisation but as inherently interdependent, where the larger cities would carry out the most important service functions for their surrounding areas. Like Christaller (1933), McKenzie (1933) identified an urban hierarchy based on the economic influence of a settlement in its surrounding territory. The most important centres are those with the headquarters of the largest commercial organisations and the higher-level administrative centres (Hawley, 1950). However, this theory is less rigid and formal than central place theory, as it allowed each urban centre and sub-centre to fulfil its own specialised role. Hence, the relationship between settlements need not necessarily be competitive; it can also be complementary.

Competition in urban systems would long continue to dictate the urban systems discourses; urban complementarities would first be explicitly incorporated in the work of Pred (1977) on city systems in advanced societies, in which channels of interdependencies between cities were seen as much more complex than in Christaller and Lösch's model. Currently, urban complementarities have become an important element of the network model developed in the 1990s (Camagni and Salone, 1993; Batten, 1995). Indeed, as indicated by Van der Knaap (1980), the Christaller model would be more applicable to rural societies, the Lösch model to industrial societies and the Pred model to post-industrial societies. Nevertheless, urban models based on central place theory, hierarchy and competition would be part of mainstream urban geography and economics until the end of the 1970s. These issues will be further discussed in the following sections.

Although ideas from both central place theory and urban ecology would be incorporated into urban systems research, central place theory would become the dominant paradigm for the study of urban hierarchies. Most important, central place theory was a more formal theory in that it focused on the economic aspects of regions rather than the more eclectic and population-oriented focus of urban ecology (Mayer, 1980). Central place theory was thus a more attractive starting point for formal theory construction in economics and geography.[5]

1.3 Central Place Theory and Urban Hierarchies in Planning

Although it would be the end of the 1950s before central place theory would take root in geography and regional economics (see section 1.4), Christaller's work quickly became popular in German planning as the new spatial planning theory and model for the country's reorganisation (Rössler, 1989). After publishing his seminal work *Die zentralen Orte in Süddeutschland* [Central places in southern Germany] in 1933, Christaller started researching the regional planning implications of his work, which resulted in his habilitation dissertation entitled *Die ländliche Siedlungsweise im Deutschen Reich und ihre Beziehungen zur Germeindeorganisation* [Rural settlements in Germany in their relation to community Administration], which he finished in 1937. In his habilitation dissertation,

[5] At the same time, sociologists gradually withdrew from urban systems research. As indicated by Berry and Kasarda (1977), this withdrawal was the result of a strong socio-psychological movement in sociology that focused on the interpersonal dynamics of small groups and that advocated a micro-social approach with the individual as smallest unit of analysis. In this movement, urban ecology was seen as a form of spatial fetishism.

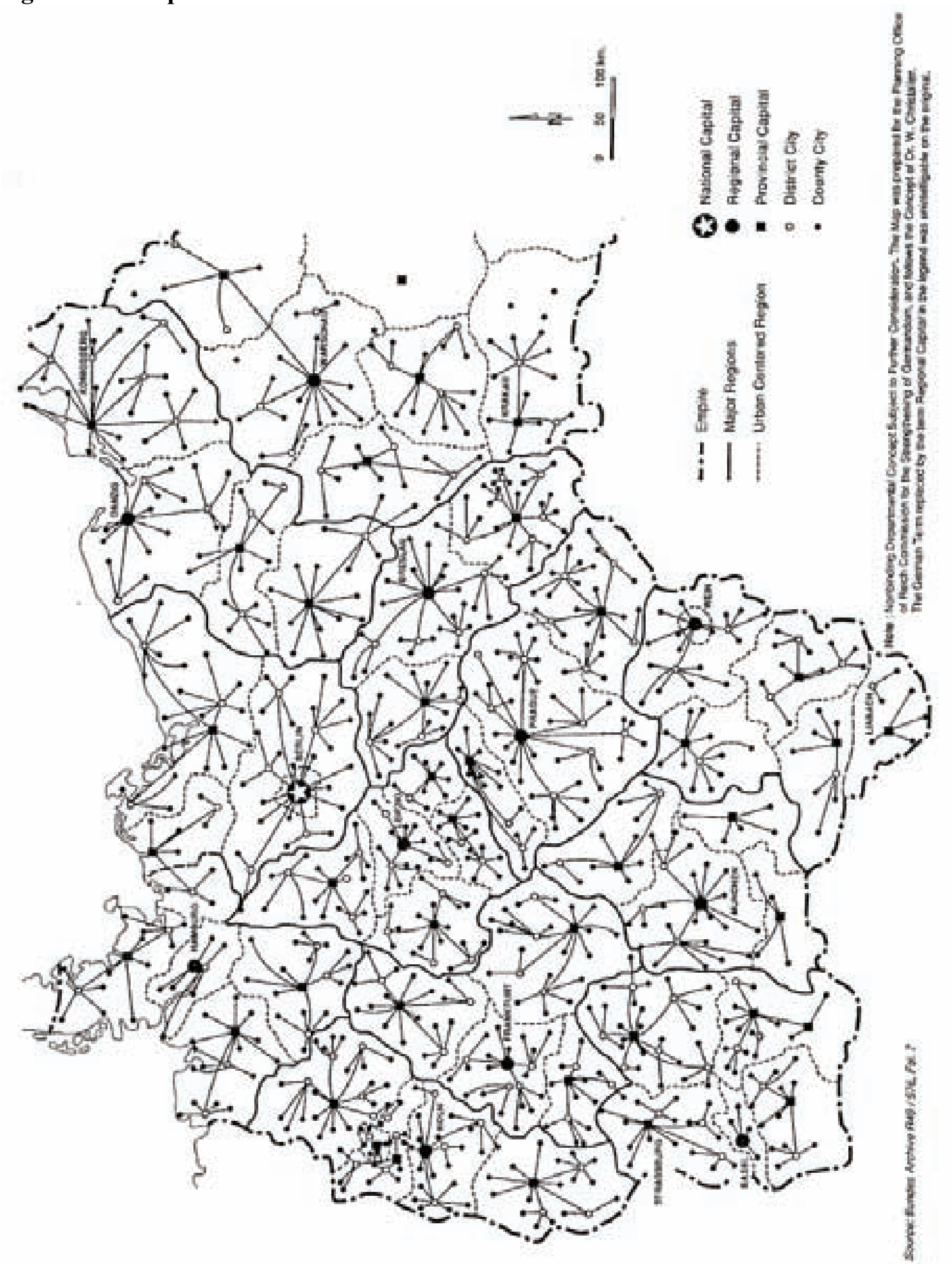
Christaller (1937) combined insights from central place theory with theories of local governance and the political organisation of towns, villages and hamlets.

Christaller perceived spatial planning to be a natural extension of geography and argued that geographers could contribute to the resolution of problems related to the delimitation of administrative regions. He was convinced that a good state administrative division should fulfil two requirements (Preston, 1992). First, it should be efficient (rational) in its spatial organisation of the economy. Second, it should strengthen the administrative structure of the state by facilitating the provision of public goods. Christaller's model of a hierarchically structured network of settlements offered the possibility of planning the distribution of (public) goods and services in an economic manner and creating an efficient and economically viable administrative system. According to Christaller (1934; 1937), the best administrative organisation would be hierarchically structured around the most important central places; suburban areas could be included in the urban-centred administrative region to which they were most connected by journey-to-work travel and shopping. Accordingly, Christaller was well ahead of his time in that he used flows of people and goods to organise settlement systems (Preston, 2009).

In his work, Christaller focused both on a new administrative organisation for Germany and on general planning aspects of community organisation. During World War II, Christaller became involved in planning the occupied territories in the East (i.e., *Generalplan Ost*). His central place model was used to develop a settlement policy and administration (see Figure 1.2 for his ideas on the administrative division of the Third Reich) that facilitated both central political administrative control and regional planning (Kamenetsky, 1961; Rössler, 1989) within the context of the *Lebensraum* policy. Although the overall planning objective of the National Socialist regime was to stimulate spatial efficiency, the political objective was to concentrate control functions in Berlin and strengthen national identity. These spatial planning projects were never carried out, however.[6]

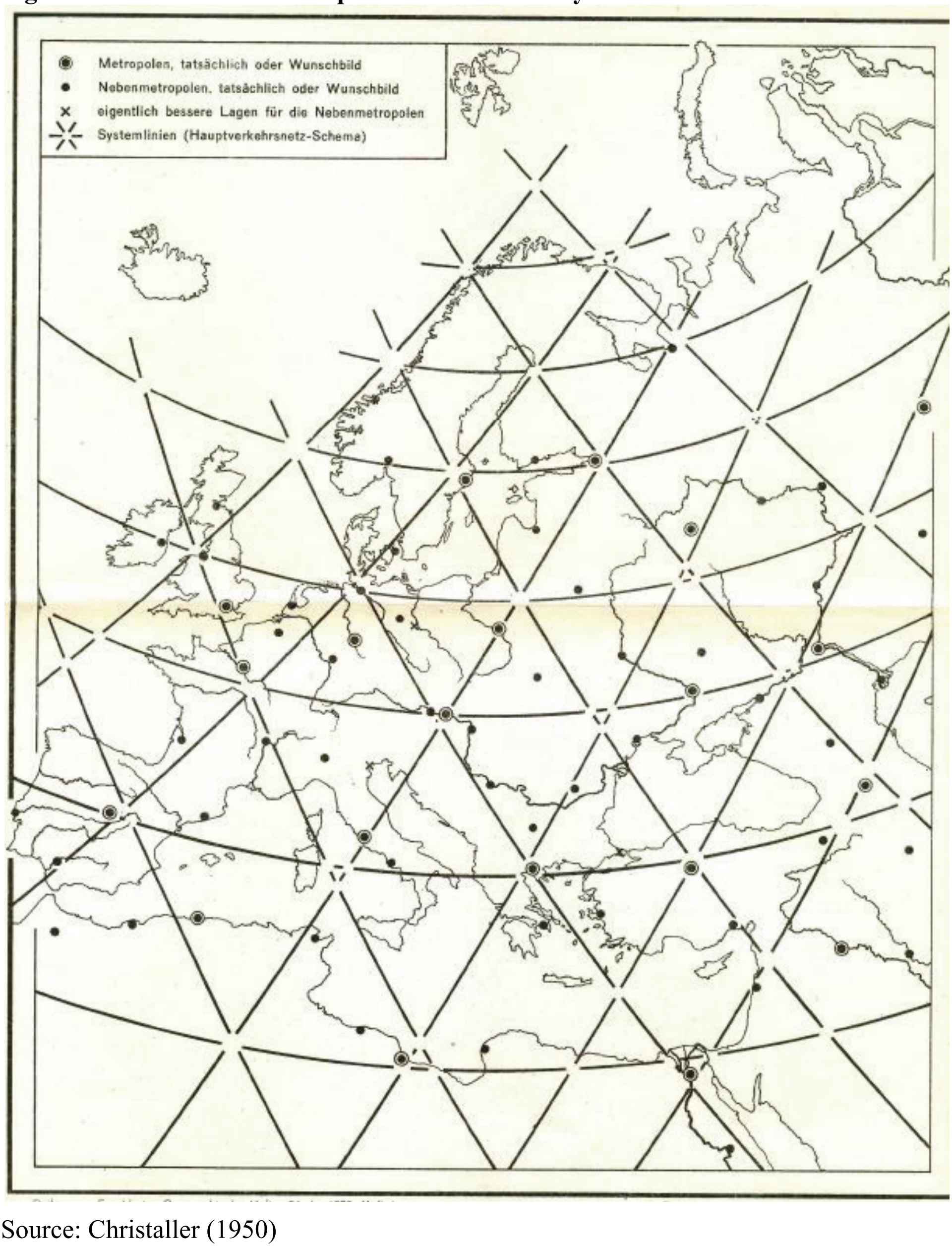
[6] An exception is the central place theory-based Dutch Noordoostpolder, which was developed by Dutch planners collaborating with the Nazis during the war (Constandse, 1972; Derks, 2001). However, Christaller himself never directly participated in the development of the Noordoostpolder.

Figure 1.2: Proposal for New Administrative Division of the German Realm



Adapted from: Preston (2009)

Figure 1.3: Christaller’s European Central Place System



Source: Christaller (1950)

After World War II, Christaller focused (once again) on a (never to be implemented) new administrative division for Germany (e.g., Christaller, 1947) and normatively argued for a hierarchy of European cities (Christaller, 1950, see Figure 1.3). This period can be considered to be the beginning of spatial planning, in European terms (Kunzmann, 2006). Central place theory also began to be extensively used in regional planning outside of Germany. Ideas of hierarchical urban systems were incorporated by Dickinson (1947) in the United Kingdom and Bogue (1949) in the United States for the delimitation of urban regions.[7] This resulted in a shift from population-based urban regions to functional urban regions.

Gradually, planning changed from a craft dominated by landscape architects and urban designers into a scientific discipline increasingly dominated by geographers and economists (Hall, 2003). Spurred by developments in computing and the rise of logical positivism in economics and geography, it was argued that planners should use quantitative and exact methodologies to plan urban transportation, the location of economic activities and even the distribution of settlements. According to this line of thought, "*cities and regions were viewed as complex systems...while planning was seen as a continuous process of control and monitoring of these systems*" (Hall, 2003, p. 347). Blueprints were replaced by process planning, in which programmes were continuously adapted when new information required such changes (Webber, 1964). In his theory on planning, Von Böventer (1964) goes so far as to argue that the tasks of planning entail identifying the activities in which a region should specialise, specifying the industry and occupation mix and deciding the optimal distribution of the economic activities. He argued that it is of utmost importance "*to determine where additional growth poles are needed, in which centers economic growth should be stimulated, and in which parts of the region the pull of the agglomeration forces should be reduced*" (Von Böventer, 1964, p. 98). Von Böventer's view, which was very much based on environmental determinism, is exemplary for planning in the 1960s and 1970s: the environment shapes human life and not the other way around.

The idea that a system of centres arranged hierarchically presents an efficient way of organising economic activities and administration within regions became widespread in international planning practice (Boyce, 1963; Krakover, 1987; Berry and Parr, 1988). In

[7] Bogue's (1949) delimitation of metropolitan regions also drew on McKenzie's concept of metropolitan communities (Mc Kenzie, 1933).

particular, it was expected that such a hierarchical urban system would be able to solve rising urban and regional problems resulting from elevated growth patterns and urbanisation (Hall, 1974). Amongst others, it was believed that decentralization and urban sprawl would result in traffic congestion, the viability of public transportation, and the decline of the central business district (Boyce, 1963). Along these lines, planning practice at lower spatial scales focused on the location of economic activities (most notably, retail), where the identification of a network of centres and the geographical scope of activities would make it possible to find the appropriate location for new facilities. In particular, planning became linked to land use planning and zoning; planners believed that functions should be organised in centres and that these centres should be arranged hierarchically according to their level of importance, in terms of the size of the population they serve (Low, 1975). Models such as the gravity-based Lowry-Garin model were used to develop interactive systems of transportation-land-use planning for metropolitan areas, where information on employment and transportation links was used to spatially allocate economic activities and determine land uses. However, centrism in planning could also be found at higher spatial scales. Exemplary of this period is the use of the concept of growth poles by Friedmann and colleagues[8] in relation to hierarchical models of diffusion (Friedmann, 1966a, 1966b; Berry, 1973). It was believed that economic development spreads from the core (pole) to the periphery (Rodwin, 1961) and that economic impulses in large centres would be critical for growth in the entire urban system because of the presence of localisation and urbanisation economies in these centres (Friedmann, 196a). Economic development would therefore depend on the spatial organisation of the economy, with an urban hierarchy representing a favourable condition for economic growth.

1.4 Central Place Theory in Geography and Regional Economics

The initial reaction to Christaller's work by geographers was that it was too theoretical and too based on economic theory (Berry and Harris, 1970). Several reviewers pointed to the overreliance on formulas, the negligence of politics, history and culture and the fact that it was too abstract to appeal to geographers. Although some reviewers recognised the quality

[8] Yet growth poles and growth centers have been used in many ways in the literature (Darwent, 1969). The approach of Friedmann was very much based on central place theory and differed from the growth pole concept of Boudeville (1966). See Darwent (1969) and Hansen (1971) for a discussion of these issues.

of Christaller's work, none of them "*foresaw the tremendous impact the work would ultimately have in stimulating a whole new school of geography devoted to precise and mathematical formation of general principles in urban geography and regional science*" (Berry and Harris, 1970, p. 118). The reaction was not surprising, as most work in the field of geography was based on the conceptualisation of geographical space as a physical or ecological space instead of a geometrical space. Although Christaller's work would be introduced in the Anglo-Saxon world through German speaking scholars, such as in the work of Ullman (1941) and Wehrwein (1942), it was not until the late 1950s that the work of Christaller (1933) and Lösch (1941) would become popular in analytical work on urban systems by Anglo-Saxon geographers and regional economists. However, by the mid-1960s, central place theory had become the bible of the theoretical and quantitative revolution in geography, a movement spurred by the rapidly evolving analytic capabilities of the scientific computer, and with it a general desire to go beyond mere descriptions by seeking explanations for spatial economic phenomena (see also Section 1.3).

The literature that has built on central place theory has followed two different paths (McPherson, 1981). On the one hand, a number of studies rooted in regional science have extended and modified the central place model, to arrive at a more general and realistic model of hierarchical urban systems (e.g., Beckmann, 1958; Tinbergen, 1960; Dacey, 1966; Woldenberg, 1968; Beckmann and McPherson, 1970; Parr, 1970, 1978; Rushton, 1971; Saey, 1973).[9] The regional science movement, starting with Isard's seminal work *Location and the Space Economy* (1956), combined the work of Christaller and Lösch with insights about empirical regularities in spatial distributions. These insights included the rank-size rule (e.g., Gibrat, 1931; Zipf, 1949), the distance-decay functions and gravity models (Ravenstein, 1885; Stewart, 1948; Bogue, 1949) and rational choice theory and equilibrium models. These developments initiated a theoretical revolution in the spatial sciences, characterised by a shift from descriptions of cities and regions to the development of general hypotheses about spatial distributions that could be tested empirically. The power of regional science was its epistemological theorising; it was able express spatial economic phenomena that could be found in the real world in an abstract, formal and rationalist way.

On the other hand, the empirical research that originated primarily in the urban systems school (Bourne and Simmons, 1978) has approached central place studies more

[9] A good overview of these models can be found in Berry and Parr (1988).

analytically, without the restrictions of formal theory. Its goal was to explore the organisation of urban systems in order to understand the nature of city-hinterland relationships (Berry, 1964; Berry and Pred, 1965; Haggett, 1965; Berry and Horton, 1970). Drawing on general systems theory (Von Bertalanffy, 1950), it was argued that any urban system can be thought to consist of a set of interdependent nodes (for example, centres) and the patterns of interaction that occurs between these nodes (for example, commuting, investments, shopping, trade) (Berry, 1964; Simmons, 1978). Along these lines, central place theory predicted that all urban systems are by definition monocentric (Haggett, 1965). The monocentric urban system is characterised by a hierarchy of centres rank-ordered on the basis of the size of their market areas and the complexity of the functions they provide (Berry and Garrison, 1958a; Davies, 1967). From a network point of view, such a monocentric urban system is best represented by a star-shaped pattern of interactions, where flows of goods, services, and people between centres of different hierarchical orders are one-sided and centralised (Nystuen and Dacey, 1961; Haggett and Chorley, 1967).[10]

1.5 Erosion of the Hierarchical Model and Urban Systems Research

The early literature on urban systems generalised the idea of a hierarchal urban system in both theory and application. However, spatial theory and empirical reality progressively grew apart. The first empirical applications of central place theory to predominantly rural regions such as Southern Germany (Christaller, 1933), Estonia (Kant, 1935), Scania (Godlund, 1951), Southwestern Wisconsin (Brush, 1953), Somerset (Bracey, 1953) and Snohomish County (Berry and Garrison, 1958a) were broadly in line with the theoretical predictions. Its application to industrialised urban regions appeared to be less successful, however (e.g., Wurster, 1963). Although this problem was already recognised by the mid-1960s (Burton, 1963; Berry, 1967), most theoretical urban models long remained concerned with hierarchical urban systems. Although researchers made generalisations about central place model of several kinds (e.g., more general geometries and placement within general systems theory), researchers still adapted the hierarchical model to the reality of a polycentric urban system. Indeed, as noted by Hall (1997, p. 316):

[10] Similar conceptualisations can be found in studies on metropolitan dominance, corporate networks and administrative hierarchies in urban ecology (e.g., Winsborough, 1960; Duncan *et al.*, 1960), and studies on the structure of physical transport and communication networks in regional economics and quantitative planning (e.g., Isard, 1960; Kansky, 1963).

“*The classical urban models, then, were developed in the late 1950s and the 1960s on the basis of much older urban theory developed in the United States and Germany between the mid 1920s and the mid 1940s. They faithfully reflected the world of that time: at a broader, inter-urban or regional scale, a world of relatively self-contained agrarian regions, in which central urban places exchanged goods and services with their rural hinterlands*”

When suburbanisation began, the population decentralised but most employment was still concentrated in the urban core. By the early 1970s, when economic activities decentralised because of advances in transport, information and communication technology, urban models and spatial reality became even more disconnected. One of the main problems was that Isard’s regional science tended to be treated as a theoretical social science that established concepts for geographers to use in empirical studies (Berry, 1995). Hence, theories and models came first, followed by empirical applications and social and policy relevance. Paradoxically, this order of preferences resulted in a situation whereby urban model builders completely withdrew into theory formation, disconnecting themselves from the practical applications that had once been their justification. Lacking a better formal theoretical model and unable to explain changes in urban systems, theorists stuck to the simple and elegant idea of urban hierarchies. Empirical deviations from the hierarchical model were treated as a nuisance; few polycentric urban models (intra-urban level) that appeared from the 1970s onwards reworked versions of the hierarchical urban model (e.g., White, 1976; Sullivan, 1986). As noted by Golledge (2008, p. 244), “[this] *mismatch between empirical reality and theory lay largely in the nature of the simplifying and constraining assumptions that had been imported into the fundamental theories*”. Eventually, this estranged many applied geographers from applying these models.

Understandably, in the 1960s and early 1970s, two strands of empirical literature developed. One the one hand, empirical studies increasingly focused on those issues where urban hierarchies could be found, such as retail geography and rural geography. On the other hand, studies that developed outside the paradigm of hierarchical urban systems increasingly described the emergent reality of urban systems in the form of the coalescence of formerly independent metropolitan areas. Exemplary of this period is the work of Gottmann (1961) on the megalopolis and Friedmann and Miller (1965) on the urban fields discussed in the first section. In the 1970s, increasing attention was paid to the complexity of urban systems, where it was believed that “*an urban place plays many roles* *simultaneously and operates under a wide variety of interwoven forces*" (Simmons, 1978, p. 67). Gradually, the notion of hierarchies in empirical work on urban systems would become less important, as signified by the work on the spatial organisation of large metropolitan complexes of, for example, Duncan and Lieberson (1971), Borchert (1972) and Simmons (1978) in which hierarchical and vertical relations between cities coexist. Although these concepts mirrored the emerging spatial reality, no formal theoretical model was the basis for these alternative spatial organisations of urban systems.

From the mid-1970s onward, the analysis of urban systems became less popular as researchers shifted their focus to individual cities and regions and micro-level approaches to the spatial behaviour of households and firms. According to Berry (2002), a paradigm was lost. Apart from the aforementioned problems, modelling of urban systems was criticised as being too concerned with theory and not enough with the real world and policy problems that need to be solved (Lee, 1973; King, 1976). Indeed, as noted by Harvey (1972, p. 6):

"[Geography's] *quantitative revolution has run its course and diminishing marginal returns are apparently setting in as* … [it] *serve*[s] *to tell us less and less about anything of great relevance…. There is a clear disparity between the sophisticated theoretical and methodological framework which we are using and our ability to say anything really meaningful about events as they unfold around us*. … *In short, our paradigm is not coping well*'.

The 1970s were characterised by discussions of urban poverty, environmental problems, civil rights, and the growing unemployment in cities due to deindustrialisation. The unwillingness, or inability, of systems theory to deal with these issues led to a gradual loss of interest in it among geographers. The gap in theory was filled by what would become known as radical geography, which was inspired by Marxist studies and which had the goal not only of analysis but also of advocating change.[11] Concurrently, behavioural approaches were growing strong in geography (e.g, Golledge and Rushton, 1976; King and Golledge, 1978). Behavioural geography saw cities and regions as inappropriate units of analysis because urban systems were instead shaped by the decisions made by firms, households

[11] An elaborate treatment of the clash between positivism and Marxist school in geography is beyond the scope of this chapter. See e.g., Barnes (2001) and Goheen and for a discussion of these competing visions.

and governments. Hence, the actions of individuals were shaped by how they perceive the environment and are not predetermined by the environment. The view that geography should focus on the independent role of space as influencing on human behaviour gradually grew more popular in geography. However, differences between behavioural geography and the urban systems school eventually appeared to be relatively minor (Golledge, 1981; Berry, 2002)

Similar developments could be observed in the field of scientific and rational planning, where planners and policymakers had long believed in the economic efficiency of the hierarchical model (Low, 1975; Hall, 1997). By the 1970s, however, it became clear this model could not fulfil the claims of scientific objectivity; systems analysis would need to be subordinate to intuition and judgement (Hall, 2003). As indicated by Hall (2003), it proved to be difficult for systems planners to move from general goals to operational ones, as real world information was lacking so it was impossible to make a proper cost-benefit analysis. According to Cooke (1983, p. 17),

"*The worst … has developed by inducing the assumption that planning solutions should give primacy to the achievement of certain ideal principles rather than being based on thorough knowledge of the mechanisms giving rise to the surface problems, which can be empirically identified*".

Accordingly, it was believed that positivist and quantitatively oriented planning did not improve practice. The planning doctrine based on system theory lost its hegemonic position, to be replaced by a multiplicity of postmodern approaches. During the 1980s, planning would become less technocratic and more of an interactive process.

1.6 The Rise of Polycentricity and Urban Networks

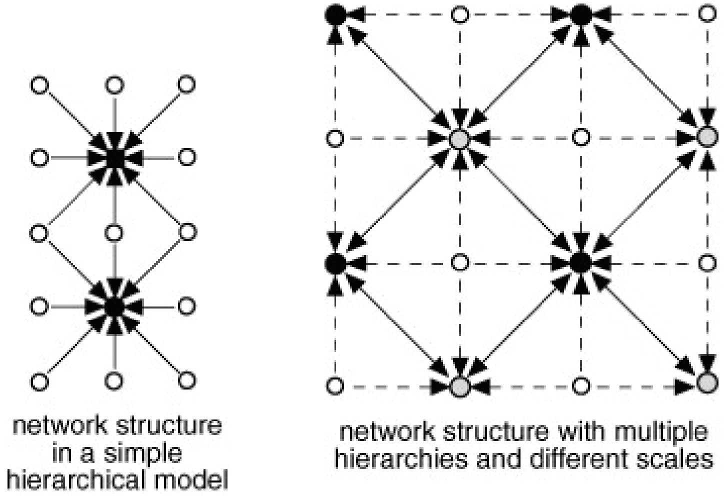
City-Systems in Advanced Societies and Urban Networks

The 1980s and early 1990s were marked by relatively little interest in urban systems (Coffey *et al.*, 1998). Most urban systems literature was concerned with either the local (daily urban systems) or the global scale (Chase-Dunn, 1985; Friedmann, 1986; Meyer, 1985; Sassen, 1991), herewith ignoring the geographical scales in between (Coffey *et al.*, 1998). This trend can also be seen in planning, where attention shifted to urban problems related to unemployment and deindustrialisation. Yet the remaining urban systems literature increasingly departs from the hierarchical model and we can see a rise in research on the decentralisation of employment, polycentricity ('multinucleation') and subcentre formation at the intra-urban scale in this period (e.g., Greene, 1980; Erickson, 1983; Richardson, 1988; Champion, 1989; Berry and Kim, 1993; Clark and Kuijpers-Linde, 1994). In addition, new concepts such as edge cities – large concentrations of office and retail space at the nodes of major transport networks – are introduced (Garreau, 1991). In regional science and urban economics, formal theoretical models of polycentric cities and suburbanization (Fujita and Ogawa, 1982; Fujita, 1988) are further developed. In the new economic geography that emerged in the 1990s (Krugman, 1991), attention is drawn to general equilibrium models that include centripetal (aggregative) and centrifugal (dispersive) forces. These formal models would be extended to the evolution of city-systems (Krugman, 1996; fujita and Krugman, 1995; Fujita *et al.*, 1999), such as the formation of megalopoli (Mori, 1997), they remain based on the monocentric (core-periphery) model.[12]

During this period, alternative theories about the spatial organisation of urban systems were also developed, which would pave the way for research on urban networks and polycentric urban systems on larger spatial scales in the 1990s. The work of Pred (1977) on city-systems in advanced economies can be seen as a landmark in urban systems theory. Pred (1977) showed that functional relationships in the form of innovative linkages were directed not only from large cities to small cities but also from small cities to large cities and between cities of comparable size. In fact, the most important linkages would be between large metropolitan complexes at the inter-urban scale. Although Pred acknowledged the existence of hierarchical relations, this polycentric network model contrasted with the central place idea of urban hierarchies. Moreover, the model added two-sided and criss-cross linkages, disrupting the correlation between urban size and urban functions. In his model, relationships between cities were no longer seen solely as competitive (as an urban hierarchy), but they could also be complementary.[13]

[12] See Fujita (2010) for an overview.
[13] It should be acknowledged that this was also possbile in a limited way in a Löschian central place system.

Figure 1.4: Inter-Urban Linkages in Hierarchical and Network Model



Source: Van der Knaap and Wall (2003)

Hence, the situation in such urban system is one of competitive and cooperative relationships (*cooptition*). In an economic sense, this meant that urban centres making up an urban network could be specialised in different economic sectors, hereby fulfilling different economic roles (Meijers, 2005). For example, a city specialising in business services could provide these services to a city specialising in labour-intensive industry, and vice versa. A schematic representation of these changes is depicted in Figure 1.4. Although Pred's urban system has no underlying mathematical model, urban economists such as Fujita and Thisse (2002) would arrive at similar spatial structures using formal theoretical models based on neoclassical economics.

Where Christaller's and Lösch model would be especially applicable to rural and industrial society, respectively, the Pred urban system would be exemplary for a post-industrial economy (Van der Knaap, 1980). It stressed the importance of knowledge and information flows for the development of urban systems. Although Pred's work did not receive the attention it deserved, some of his ideas would be further developed in the work of Camagni and Salone (1993), Batten (1995) and Cappello (2000) on urban networks, which also stressed horizontal linkages, complementary assets and cooperation between cities.

Like Pred, proponents of the network paradigm argued that the central place conceptualisation of urban systems was outdated and could at best be replaced by a network view (Meijers, 2007). Camagni's criticism of the hierarchical model was that it exaggerated the role of transport costs, neglected input-output relationships resulting in linkages among specialised centres of similar size and neglected network externalities resulting from similar, cooperating centres (Camagni, 1993). Along these lines, Camagni (1993) distinguished between two types of non-hierarchical network that stressed cooperative relationships. On the one hand, 'complementarity' networks consist of specialised centres that are interlined through input-output relationships, resulting in economies of specialisation and division of labour. On the other hand, cooperative relationships between cities specialised in similar economic activities result in market integration and economies of scale. According to Camagni (2007), an example of the former type is the Randstad, Holland, while an example of the latter type is the network of financial cities. Drawing a parallel with business networks, Batten (1995, p. 313) notes:

"*The cooperative mechanisms may resemble those of inter-firm networks in the sense that each urban player stands to benefits from the synergies of interactive growth via reciprocity knowledge exchange and unexpected creativity*".

This discourse on urban networks was fuelled by advances in transport and communication technology, globalisation, and the individualisation of production, which fuelled the belief that the geographical scope of social and economic processes is continuously increasing. At the super-regional scale, these developments would cause cities and regions to become increasingly interconnected, ultimately forming a fully integrated economy. As such, metropolitan areas would lose significance as independent 'daily urban systems' and would instead form part of a polycentric urban network, looking very much like Gottmann's Megalopolis. However, attention was given not only to innovation networks à la Pred but also to physical infrastructure and communication networks, as reflected in the development of concepts such as the corridor city and network city (Batten, 1995).

The empirical literature on spatial networks has developed along two promising strands, which both stress the complex nature of urban networks. On the one hand, researchers have combined network modelling approaches to the analysis of spatial flows (Reggiani and Nijkamp, 2007). Using methods from social physics, spatial economics, Geographic Information Systems (GIS) and graph theory, this interdisciplinary literature has sought primarily to unravel the complexity of spatial networks by developing appropriate network structure measures. Others have focused on analysing infrastructure networks (Schintler and Kulkarni, 2000; Reggiani and Schintler, 2005) and commuting patterns (Patuelli *et al.*, 2010; Reggiani *et al.*, 2011). On the other hand, a number of studies predominantly originating from the Globalisation and World Cities (GaWC) group have focused on global external relations, stressing the increasing importance of 'space of flows' (Castells, 1996) for the functioning of cities. This research has studied corporate connections and office networks (Taylor, 2004; Taylor and Aranya, 2008; Derudder *et al.*, 2010; Wall and Van der Knaap, 2011), as well as airline and sea transportation networks (Smith and Timberlake, 2001; Derudder and Witlox, 2005; Derudder *et al.*, 2007; Ducruet *et al.*, 2010). The idea of horizontal linkages and cooperation between cities has been further developed especially within the context of corporate linkages (Taylor, 2009; Taylor *et al.*, 2010).

Polycentric Urban Region

Yet, despite the renewed interest in urban systems and eclectic theory in the work of Camagni, urban networks have been mainly used as a policy concept and not as an analytical concept (Van Nuffel and Saey, 2005). This usage becomes especially evident in the concept of the polycentric urban region (PUR) (Dieleman and Faludi, 1998), sometimes referred to as the mega-city region (Hall and Pain, 2006). In planning, polycentric development policies have been mainly introduced to support a more balanced spatial distribution of economic activities between spatial units (cities, regions) across the territory, and higher levels of urban and regional competitiveness (Meijers and Romein, 2003). At the regional level, planners have developed the concept of the Polycentric Urban Region, which is a set of historically and spatially separate city-regions comprising a larger functional urban region. Functional linkages between cities and towns within a PUR are promoted to achieve complementarities and synergies between the different parts of the region (Camagni, 1993; Meijers, 2005). The spatial integration of formerly independently functioning urban regions is supposed to create a favourable setting for economic growth, especially when the cities and towns in such an urban network complement each other's economic specialisations. As indicated by Faludi (2004), such polycentric spatial constellations are supposed to be more competitive than their monocentric counterparts because they provide opportunities to benefit from large agglomerations, such as through access to broader labour markets, luxury goods and services and airports, while avoiding some of the negative factors associated with such agglomerations, such as pollution, crime and congestion. In the planning literature, the Randstad, Flemish Diamond and Rhine-Ruhr area are often seen as prime examples of PURs.

Although the PUR is predominantly a normative planning concept (Van Houtum and Lagendijk, 2001; Davoudi, 2003), a number of scholars have tried to provide more formal conditions for the existence of such spatial constellations (Champion, 2001; Kloosterman and Musterd, 2001; Parr, 2004). For a region to be designated as a PUR, it should consist of a number of historically distinct cities. There should also be no obvious leading city, a considerable spatial interaction between the cities and, preferably, each city should specialise in different economic activities.

1.7 Research Objectives

In the midst of all of the enthusiasm about polycentricity and urban networks among planners and policymakers, the conceptualisation and empirical assessments of these concepts falls short in at least four respects. First, polycentricity, spatial integration and urban networks all rank among those key terms in the spatial sciences that are employed loosely and in a variety of ways, despite widespread calls for further clarification (Kloosterman and Musterd, 2001; Davoudi, 2003; Turok and Bailey, 2004; Hoyler *et al.*, 2008). In the literature, we find greatly diverging interpretations of what makes such territories polycentric and networked. The vagueness of these concepts may explain their popularity, as they appeal widely. The Babel-like confusion surrounding these concepts nonetheless impedes the much needed and often called for progress in research on the actual merits of urban networks and in the establishment of polycentric- and network-based development policies.

Second, and related to the previous point, there are diverging approaches to measuring polycentricity and urban network formation. Three issues that deserve attention in this respect are the spatial, temporal and functional heterogeneity of the spatial organisation of regions. Although it is often assumed that all regions become more polycentric and spatially integrated, the development of spatial organisation can differ considerably across regions. Likewise, information is needed on whether we are indeed moving from a monocentric and non-networked urban system to a polycentric and networked urban system. If such tendencies did not exist, the many planning and policy attempts to stimulate polycentric and networked regions in Europe would be called into question. However, polycentricity and urban networks can be studied by examining different types of functional linkages between cities and regions. Along these lines, the degree of polycentricity and urban network formation in a particular territory is typically dependent on the indicator used. Yet, such information would be important data for planners and policymakers and would allow them to understand what polycentricity and urban network development really amounts to and to select those key strategic issues for which regional coordination and cooperation would be most relevant.

Third, there seems to be considerable confusion in the literature on the extent to which relationships between cities in a region are competitive or complementary. Most studies on PURs assume that relationships between centres within such a region are predominantly complementary, in that cities within a PUR have different specialisations and, hence, serve different markets. Exemplary is the situation of two cities within the same urban system that each produce different goods or services for which the other has an effective demand, which can lead to an exchange between the two places. For example, a city specialised in financial services can provide these services to a city specialised in manufacturing, and vice versa. As such, cities do not have to produce all of the types of goods demanded in the city; rather, they can benefit from specialisations elsewhere in the urban network (Meijers, 2005). However, few studies have empirically addressed the degree of urban complementarities within PURs. At the same time, a large body of literature on territorial competitiveness has stressed increased competition between cities and regions over product markets, inward investments, firm establishments, tourists, hallmark events and government funding (Lever and Turok, 1999). Yet, it can be argued that a basic understanding of cooptition (i.e., the degree (intensity, functions) to which cities cooperate or compete within an urban system) is nonetheless pivotal with regard to polycentric and urban network development policies.

Fourth, many territorial development strategies suggest that polycentric development is instrumental in increasing territorial competitiveness and reducing spatial disparities. Although urban network development may result in the pooling of resources and the development of complementarities between the cities, it is unclear to what extent polycentric and networked regions really outperform monocentric and non-networked regions. For example, it is evident that agglomeration economies are not restricted to the urban core anymore but are increasingly shared among a group of functionally linked settlements (Capello, 2000; Phelps and Ozawa, 2003). It is nonetheless unknown to what extent a collection of proximate cities provide a substitute for the urbanisation externalities of a single larger city. Indeed, as indicated by Davoudi (2003, p. 72), a polycentric and networked regional structure "*now appears to be cropping up everywhere as an ideal type regional spatial structure, despite a lack of common definition and empirical evidence about its desirability, effectiveness, or the potential for its alleged success being replaced elsewhere by policy intervention*. Accordingly, there is a need again for insights from urban systems theory to support spatial planning.

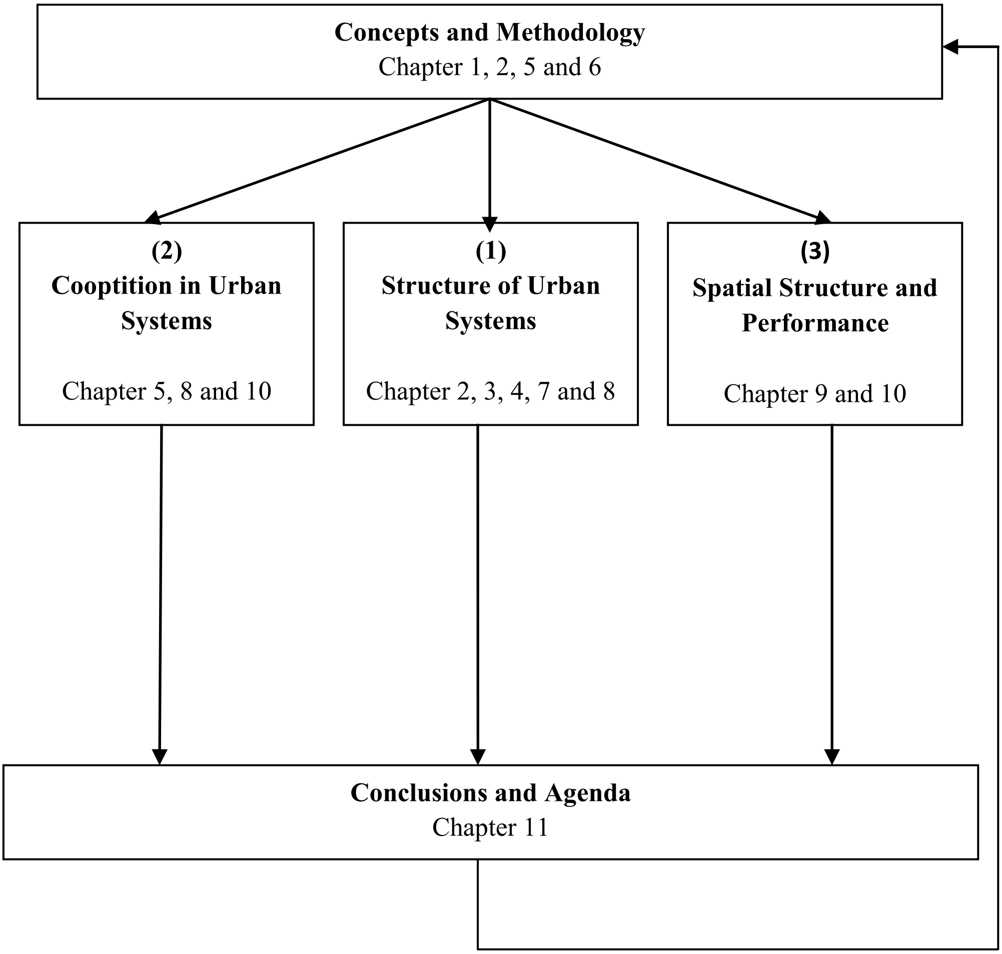
1.8 Organisation of this Dissertation

In sum, whereas the network paradigm has become popular primarily in planning, the theoretical and empirical literature on the spatial organisation of urban systems is lagging behind. Because of this mismatch, we find ourselves a cacophony of research activities, in which concepts such as urban networks, polycentricity and spatial integration remain versatile and vague. Second, there is still a lot to learn with respect to the functioning of contemporary spatial constellations. It remains especially unclear to what extent (1) the structure of urban systems are polycentric and spatially integrated, (2) relationships between cities in polycentric, spatially integrated urban systems are complementary and not competitive, and (3) polycentric, spatially integrated urban systems are more economically efficient than their monocentric and non-integrated counterparts. Within the context of (1), the spatial, temporal, and functional heterogeneity of the spatial organisation of urban systems need further examination.

In the remainder of this dissertation, we will address the aforementioned issues. We clarify concepts such as polycentricity, spatial integration and cooptition, and we empirically test the relationship between spatial structure and regional performance and the spatial reality of the PUR. However, we emphasise empirical testing. A schematic overview of the organisation of this dissertation, related to the aforementioned lacunas in the literature (see Section 1.7), is provided in Figure 1.5.

It should be noted that not all chapters focus on the spatial organisation of PURs, but some also examine the spatial organisation of urban systems at the level of the city-region (intra-urban) and the European (inter-regional) scale, and spatial interdependence between countries. However, the presented conceptual framework and measurement of polycentricity, spatial integration and cooptition are quintessentially scale-free and, without making major modifications, can be applied to spatial entities ranging from individual cities to continents. The reader should nonetheless bear in mind that the *interpretation* of these concepts in normative planning strategies *is* scale-dependent and that urban systems can be dominated by a polycentric structure at the inter-urban level and a monocentric structure at the intra-urban level, and vice versa.

Figure 1.5: Overview of the Dissertation



Chapter 2:

Linking Morphological and Functional Polycentricity

Abstract[1]

Empirical research establishing the costs and benefits that can be associated with polycentric urban systems is often called for but rather thin on the ground. In part, this is due to the persistence of what appear to be two analytically distinct approaches in understanding and measuring polycentricity: a morphological approach centring on nodal features and a functional approach focused on the relations between centres. Informed by the oft-overlooked but rich heritage of urban systems research, this chapter presents a general theoretical framework that links both approaches and discusses the way both can be measured and compared in a coherent manner. Using the Netherlands as a test case, it is demonstrated that most regions tend to be more morphologically polycentric than functionally polycentric. The difference is largely explained by the size, external connectivity and degree of self-sufficiency of a region's principal centre.

---

[1] This chapter is accepted and forthcoming in *Urban Studies* as "Form follows function? Linking morphological and functional polycentricity" (with Evert Meijers) and has been slightly edited to fit the format of this book.

2.1 The Many Faces of Polycentricity

Over the past 15 years, a vast academic and policy literature has emerged focusing on the concepts of 'polycentrism' and 'polycentric development'. Nevertheless, polycentric development remains one of the most versatile and 'fuzzy' concepts around (see Markusen, 2003), despite widespread calls for further conceptual clarification (Kloosterman and Musterd, 2001; Davoudi, 2003; Hague and Kirk, 2003; Turok and Bailey, 2004; Hoyler *et al.*, 2008; Lambregts, 2009). Polycentricity definitely ranks among those key terms that are employed loosely and in a variety of ways and, as Parr (2008) warns, this inevitably leads to imprecision and a loss of meaning. While the versatility of the concept may partly explain its persisting prominence – as it seems to hold something for everyone (Waterhout, 2002; Davoudi, 2007) – at the same time the Babel-like confusion surrounding the concept impedes academic progress. As regards polycentric development, progress would mean empirically establishing the actual merits of polycentric development as a strategy, and establishing the environmental, economic and social consequences of a move towards polycentric urban systems (see for example, Kloosterman and Musterd, 2001; Parr, 2004; Turok and Bailey, 2004; Davoudi, 2007; Meijers, 2008a; Hoyler *et al.*, 2008; Vandermotten *et al.*, 2008; Lambregts, 2009; Meijers and Burger, 2010).

However, the calls for further clarification of the concept of polycentricity may give the wrong impression that conceptual and analytical clarification of the concept has not progressed over the last years. The contrary holds and those calling for clarification can be partly credited for this. For instance, Lambregts (2009) makes a useful distinction between three related but yet distinct approaches to polycentricity. The first sees polycentric development as a normative planning strategy applied at metropolitan, national and transnational scales (see for instance Albrechts, 2001; Davoudi, 2003; Waterhout *et al.*, 2005). The second considers polycentric development as a spatial process, resulting from the outward diffusion of (often higher-order) urban functions from major centres to smaller nearby centres (Kloosterman and Musterd, 2001; Hall and Pain, 2006). A third approach considers the spatial outcome of this process and in the literature we find a plethora of concepts describing the resulting spatial configuration of contemporary urban areas (see Meijers, 2005, for an overview). Although the labels of these concepts nearly all contain the word ‘polycentric’ in various connections to such territorial concepts as ‘city’, ‘urban region’, ‘mega-city-region’, ‘metropolitan area’, and ‘global city region’, in practice we find greatly diverging interpretations of what makes such territories polycentric, as well as diverging approaches to measuring polycentricity.

The most considerable difference of opinion in the debate rests on the question of whether polycentricity refers just to morphological aspects of the urban system or whether it should also incorporate relational aspects between the centres making up the urban system in question (Green, 2007; Meijers, 2008b). The morphological dimension, referred to as morphological polycentricity, basically addresses the size distribution of the urban centres across the territory, and equates more balanced distributions with polycentricity (see e.g., Kloosterman and Lambregts, 2001; Parr, 2004; Meijers and Burger, 2010). The relational dimension, referred to as functional polycentricity, takes the functional connections between the settlements into account, and considers a balanced, multi-directional set of relations to be more polycentric (ESPON 1.1.1, 2004; Green, 2007; De Goei *et al.*, 2010). Proponents of the functional polycentricity approach generally claim that nodes without balanced relations would not form a polycentric system (ESPON 1.1.1, 2004). In fact, the strength and orientation of linkages between centres or cities could well be a major explanation of the performance of the urban system as a whole.

However, according to Hoyler *et al.* (2008, p. 1058), combining morphological characteristics and functional relations in one approach “*contributes to a conflation of two analytically distinct dimensions of polycentricity*”. Naturally, a balance in the size distribution of centres does not necessarily imply that there are functional linkages between the different centres, let alone an equal distribution of these linkages and the existence of multi-directional flow patterns. Accordingly, in the contemporary literature on urban systems, morphological polycentricity and functional polycentricity are considered to be two different analytical concepts and relatively little effort has been made to connect these two trains of thought. In addition, it remains unclear why some systems are morphologically polycentric and not functionally polycentric, or vice versa (see for example, Hall and Pain, 2006).

In this chapter, we explore the relationship between morphological and functional polycentricity. We present a general theoretical framework rooted in urban systems research which indicates the interdependency between the degree of *morphological polycentricity* (balance in the size distribution or absolute importance of centres) and *functional polycentricity* (balance in the distribution of functional linkages or relative importance across centres). To do so, we need to take into account a number of related features of urban systems, which include the network density and openness of urban systems. In this, we build on other analytical approaches to functional polycentricity by disentangling the directionality of the functional linkages between centres from the degree of network formation between centres (i.e., *network density*). As well as examining the rather unknown relationship between morphological and functional polycentricity, this chapter also links these concepts of polycentricity to the literature on central places and urban systems. This literature has faded somewhat into the background the last two decades (Coffey *et al.*, 1998), but still has great relevance for understanding the concept of polycentricity. Using the Netherlands as a test subject, we show how the degree of morphological polycentricity and functional polycentricity within territorial units can be jointly evaluated. We will also explain why the degree of morphological polycentricity and functional polycentricity differs within territories.

The remainder of this chapter is organised as follows. Given that morphological polycentricity can be linked to the balance in the distribution of the absolute importance of centres and functional polycentricity to the balance in the distribution of relative importance across centres, how the importance of centres is conceptualised and measured is a crucial question. This has been a core issue in classical central place studies and urban systems theory and section 2.2 discusses this literature. This discussion results in a theoretical model for studying morphological and functional polycentricity that will be applied in the case study presented in this chapter. However, first, section 2.3 synthesises the literature on both approaches to polycentricity. Section 2.4 presents the research approach adopted in our empirical analysis, which itself is presented in section 2.5. This section compares morphological and functional polycentricity and explains the differences found using our theoretical model. Section 2.6 concludes with a discussion of the findings.

2.2 Conceptualising the Importance of Centres

Central Place Theory and the Importance of Centres

The study of the organisation of urban systems in urban geography, regional science, urban economics, and spatial planning originates from urban location theory and can be traced back to the work of Christaller (1933) and Lösch (1944) on central place systems. Central place theory is occupied with the study of the distribution, size and number of cities and towns (Berry and Parr, 1988), and originally focused on urban-rural relationships, where the scope of interactions was most often confined to consumer-oriented trade (Berry and Pred, 1965). In a central place system, there is a hierarchy of central places, where the centrality of a settlement and the variety of goods and services it provides are thought to be perfectly correlated. Accordingly, lower-order central places are dependent on higher-order central places for the provision of goods and services and only a small proportion of the central places will be self-sufficient in that they offer the full range of goods. In this, lower-order centres do not provide goods and services to the highest-order central place and trade between centres of similar size is considered redundant as these centres provide the same goods and services. Although the central place model does not officially say anything about journey-to-work flows as it was originally concerned with trade between centres, it can be expected that in a central place system the centre is characterized by an excess labour demand and the small places by an excess labour supply (Parr, 1987).

The central place model focuses on rural areas in general and city-hinterland relationships in particular and is, above all, a very specific theory about the spatial organisation of the local economy. However, the idea of a hierarchical urban system can be made more general in both theory and application and translated to higher spatial scales. In this, the literature that has built on central place theory has followed two different paths (McPherson, 1981). On the one hand, a number of economic studies have extended and modified the formal model, to arrive at a more general and realistic model of a hierarchical urban system (cf. Berry and Parr, 1988).[2] On the other hand, empirical research, mostly originating from the urban systems school (see Bourne and Simmons, 1978), has viewed central place studies in a more analytical way, without the restrictions of formal theory. In this, the goal was to explore the organisation of urban systems and try to understand the nature of city-hinterland relationships (Berry, 1964; Berry and Pred, 1965; Haggett, 1965). Drawing on general systems theory (Von Bertalanffy, 1950), any urban system can be thought of to consist of a set of interdependent nodes (for example, centres) and the patterns of interaction between these nodes (for example, commuting, investments, shopping, trade) (Berry, 1964; Simmons, 1978). Central place theory predicts that all urban systems are by definition rather monocentric, given the emphasis put on the hierarchy, and not balance, of the importance of centres. Such a monocentric urban system can be perceived as a nodal area containing a principal centre and several surrounding subordinate centres of different hierarchical orders that are part of the principal centre's market area (Haggett, 1965). Such an urban system is characterized by a hierarchy of centres that is rank-ordered on the basis of the size of their market areas and their complexity in terms of the number of functions provided (Berry and Garrison, 1958; Davies, 1967). From a network point of view, such a monocentric urban system is best represented by a star-shaped pattern of interactions, where the flows of goods, services, and commuters between centres of different hierarchical orders are one-sided and centralized (Nystuen and Dacey, 1961; Haggett and Chorley, 1967).[3]

However, the hierarchical central place model, with its emphasis on monocentricity, has increasing difficulty explaining spatial reality (Batten, 1995; Coffey *et al.*, 1998; Meijers, 2007). One of the reasons is its inability to deal with the more polycentric spatial organisation of metropolitan areas that appears to be inherent to the post-industrial era and that is fuelled by globalization (Kloosterman and Musterd, 2001; Scott *et al.*, 2001; Phelps

---

[2] A good overview of these models can be found in Berry and Parr (1988).

[3] This does not mean that the study of spatial structure has been limited to central place based studies. Similarly, interrelated conceptualisations of hierarchical spatial structures can be found in other fields of research. Most notably, studies on metropolitan dominance (McKenzie, 1933; Duncan *et al.*, 1960), focused mainly on the structure of corporate networks and administrative hierarchies (see Ross, 1992, for an overview), while studies drawing on graph theory and spatial interaction models –rooted in quantitative planning studies and regional science – have explicitly focused on the structure of the physical transport and communication networks, commuting, and migration networks as well as intraregional trade (Isard, 1960; Kansky, 1963; Griffith, 1976).

and Ozawa, 2003). In other words, hierarchy appears to be a less dominant feature of many urban systems at all spatial scales.

Nodality versus Centrality in Urban Systems

Following Preston (1971; 1975), it is possible to distinguish between the absolute importance of a centre or its *nodality* and the relative importance of a centre or its *centrality*. Whereas the nodality of a centre can be expressed by its size and the range of functions it offers (Lukermann, 1966), the centrality of a centre is typically defined as the part of its importance that can be ascribed to the provision of goods, services, and jobs in excess of those demanded by the centre's own inhabitants (Ullman, 1941; Preston, 1971; Barton, 1978; Marshall, 1989). This distinction goes back to the work by Christaller (1933). In his seminal work *Die Zentralen Orte in Süddeutschland*, it is argued that if the importance of a centre is only based on its size, then part of its importance must be ascribed to the settlement itself as an agglomeration and another part to the settlement as a central place, providing goods, services and jobs to surrounding places. Hence, it is desirable to separate the external importance from the local importance of a centre. The centrality of a centre *c* in a closed system of cities can then be defined as follows:

$\mathbf{C_c = N_c - L_c}$, in which

$\mathbf{C_c}$ = the surplus of importance of a centre based on incoming flows from other places, i.e. the relative importance of a centre, its *centrality*
$\mathbf{N_c}$ = the absolute importance of a centre based on internal and incoming external flows, i.e. its *nodality*
$\mathbf{L_c}$ = the local importance of a centre based on *internal flows*.

To illustrate, when examining the importance of a centre as a job provider, it can be argued that $\mathbf{N_c}$ represents total employment in centre *c*, $\mathbf{C_c}$ represents the number of incoming commuters in centre *c*, and $\mathbf{L_c}$ represents the number of employees in centre *c* that also live there (see also Burger *et al.*, 2011a). In a similar fashion, it is possible to look at shopping and producer-oriented trade.

Christaller's and Preston's distinction between nodality and centrality is entrenched in a much broader discussion in urban research that dates back to the 1950s and 1960s, which dealt with the question of whether the configuration of urban systems in general and the importance of central places in particular should be evaluated on the basis of the internal characteristics of centres or the external relations of centres.[4] Although Christaller (1933) originally rank-ordered central places based on the external relations of centres, this practice was replaced by more broad and less restrictive characterizations of functional aggregate importance – internal characteristics of centres – in post-war extensions and modifications of classical central place theory. In this, the explicit distinction between the local and extra-local importance of a settlement gradually got lost (Preston, 1971, 1975).

The motivation for this shift in focus came from both a theoretical and an empirical point of view. On the one hand, formal theoretical accounts of hierarchical spatial structure now related central place and market hierarchies to the distributions of city size (Beckmann, 1958; Parr, 1969; Beckmann and McPherson, 1970). On the other hand, there was a lack of data regarding the functional interaction between centres based on consumer, firm and commuting behaviour (Thompson, 1974). Hence, the number of studies that have measured the importance of cities on the basis of spatial interaction between centres has been, up until the end of the 1990s, relatively limited (Coffey *et al.*, 1998). Nevertheless, the question as to whether the most populous centres are also the most central centres in a system of cities continued to be challenged (see for example, Preston (1975); and more recently, by Short, 2004; and Limtanakool *et al.*, 2007).

It is not difficult to draw parallels between this debate and the contemporary debate on morphological versus functional polycentricity. The discussion in this contemporary debate is also about measuring the importance of centres on either internal characteristics or on the basis of flows. Furthermore, good data on flows are still difficult to obtain. Exemplary is for instance that the ESPON 1.1.1 project (ESPON 1.1.1, 2004) approximates functional polycentricity by using an internal characteristic of cities – namely, their accessibility.

[4] See also Ross (1992), for a discussion of this issue in the field of urban sociology.

Importance of Centres, Openness and the Spatial Scope of Activities

So far, we have considered the importance of centres in a closed or isolated urban system. Accordingly, the centrality of a centre is determined on the basis of the surplus of importance within an urban system (e.g., city-region or metropolitan region), where the surplus of importance derived from linkages with centres outside this system is ignored. This is at least to some extent problematic as contemporary urban systems are not entities that operate on their own and certainly in the present day economy, most urban systems interact at least to some extent. In this, it can be expected that centres at the top of the urban hierarchy in an urban system are disproportionally connected to this 'outside world' because of better accessibility and the higher order functions they provide. Indeed, some centres fulfil a global or national function, while other centres fulfil a more regional or local function (Lambregts, 2009; Wall, 2009).

Extending Christaller's definition of centrality[5], the surplus of importance of a centre $\mathbf{C_c}$ within an urban system –for example a city-region or metropolitan region – can be thought to consist of a within-system component $\mathbf{C_{ci}}$ and an outside-system component $\mathbf{C_{ce}}$:

$\mathbf{C_{ci} = N_c - C_{ce} - L_c}$, where

$\mathbf{C_{ci}}$ = the surplus of importance of a centre based on incoming flows from other places within the same urban system; its *internal centrality*.

$\mathbf{N_c}$ = the absolute importance of a centre; its *nodality*

$\mathbf{C_{ce}}$ = the surplus of importance of a centre based on incoming flows from other places outside the urban system; its *external centrality*.

$\mathbf{L_c}$ = the local importance of a centre based on internal flows.

To illustrate, when examining the importance of a centre as a provider of employment in a

[5] Yet, Preston (1971) already considered the centrality based on the consumption of people that neither live in the centre nor in the complementary region, which he labelled 'irregular consumption'. The reason why Christaller (1933) only focused on centrality based on consumption of people living in the complementary region was the lack of mobility of people back in the 1930s.

city-region, it can be argued that $\mathbf{N_c}$ represents the total employment in centre *c*, $\mathbf{C_{ci}}$ represents the incoming commuting in centre *c* from places situated within the city-region, $\mathbf{C_{ce}}$ represents the incoming commuting in centre *c* from places situated outside the city-region, and $\mathbf{L_c}$ represents the number of employees in centre *c* that also live there. In this, $\mathbf{C_{ci}}$ and $\mathbf{C_{ce}}$ add up to the total centrality of a centre (see also Preston, 1971; 1975).

In the remainder of this chapter, we make use of this extended model when analysing the relationship between morphological and functional polycentricity. In this, we will look at spatial structure at the intra-urban or supra-local scale (cf. Kloosterman and Musterd, 2001) based on journey-to-work and consumer travel flows.

2.3 The Morphological and Functional Approaches to Polycentricity

In analogy with the distinction between nodality and centrality discussed in the previous section, two main approaches to measuring the spatial structure of systems can be distinguished: the morphological approach and the functional approach (Green, 2007; Meijers, 2008b).

Morphological Polycentricity

As exponents of the morphological approach to polycentricity assert, the term polycentricity basically refers to the plurality of urban centres in a given territory. However, polycentricity tends to be more closely associated with the *balanced distribution* with respect to the importance of these urban centres (see e.g. Kloosterman and Lambregts, 2001; Parr, 2004; Meijers, 2008b). This interpretation is most probably inspired by existing policy debates on the national and the European scale, in which polycentricity is linked to the rise in importance of metropolitan areas relative to one or two existing core metropolitan areas. As such, the main promise of the concept of polycentric development appears to be its ability to link the seemingly conflicting objectives of cohesion and competitiveness (Waterhout, 2002), a combination that is, however, far from evident (Krätke, 2001; Meijers and Sandberg, 2008; Vandermotten *et al.*, 2008). Having studied the interpretation of polycentric development in policy strategies in European countries, Meijers *et al.*, (2007, p. 7) define polycentric development policies as "*a policy that addresses the distribution of economic and/or economically relevant functions over the [spatial] system in such a way that the urban hierarchy is flattened in a territorially balanced way*." This lack of hierarchy in terms of size or absolute importance among the larger centres is also stressed by Parr (2004) and Kloosterman and Lambregts (2001) as defining characteristic of a polycentric system at the regional scale. In other words, we have to distinguish 'polycentric' from concepts such as 'multicentric' or 'multinuclear', the difference being that polycentricity puts more emphasis on the balanced distribution in size of the multiple centres in an urban system.

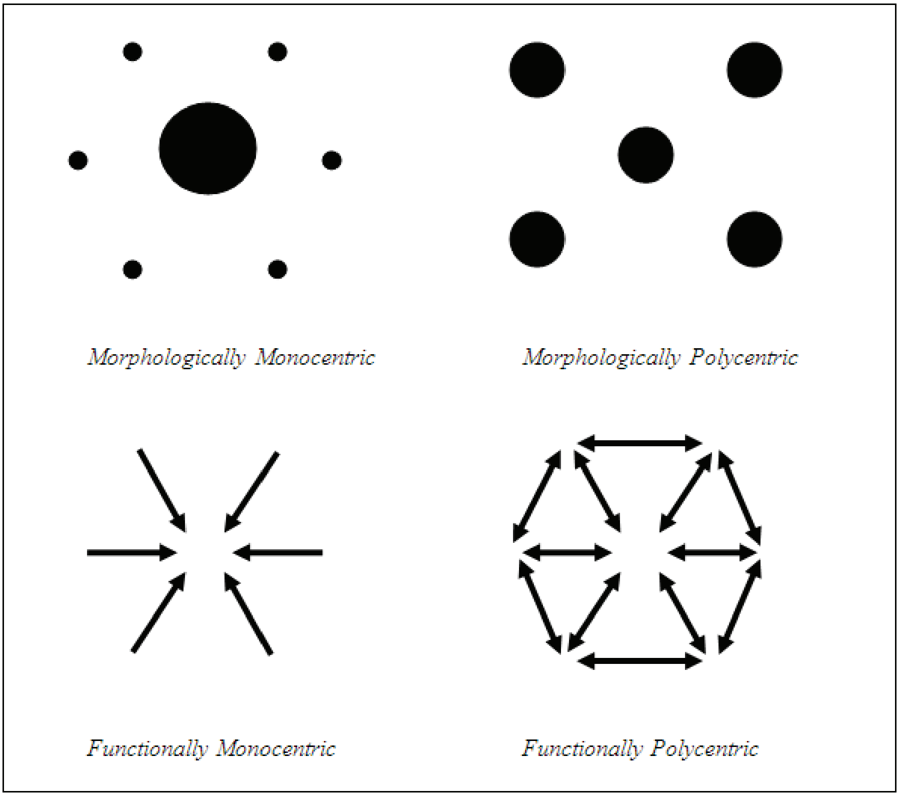
Functional Polycentricity

Those that adhere to the relational or functional dimension of polycentricity do not dismiss the morphological approach, but rather, extend it to include also the pattern of functional interaction between the urban centres. The approach generally taken has many similarities with the morphological approach. Again, it is not so much about the existence or strength of functional relationships between centres, but rather about the balance in the distribution of the functional relationships. The more evenly flows are distributed between the centres, or in other words, the more multi-directional rather than mono-directional (ESPON 1.1.1, 2004) the flows are, the more polycentric. Such an equal balance in the distribution of inflows can be found in an urban system in which functional relationships are not directed at one centre, but two-sided (reciprocal) and criss-cross (also existing between smaller centres) (Van der Laan, 1998; De Goei *et al.*, 2010; Burger *et al.*, 2011a).[6] In a recent, seminal contribution on functional polycentricity, Green (2007; 2008) adds another dimension, which is network density. The degree of network density reflects the extent to which centres in a region are functionally interdependent (that is open or not self-sufficient) and can be conceptualised as the ratio of the actual connections between centres to the total of potential connections between centres (Green, 2007). In our case, the total potential connections between the centres within a region can be defined as the sum of the

[6] This definition comes close to what Green (2007) labels 'Ordinary Functional Polycentricity'

absolute importance of the centres within a region, or alternatively, the sum of people working/shopping within a region. A generally low ratio of the sum of internal centrality scores of centres within a region to the sum of the absolute importance of centres within a region indicates a low level of network density.

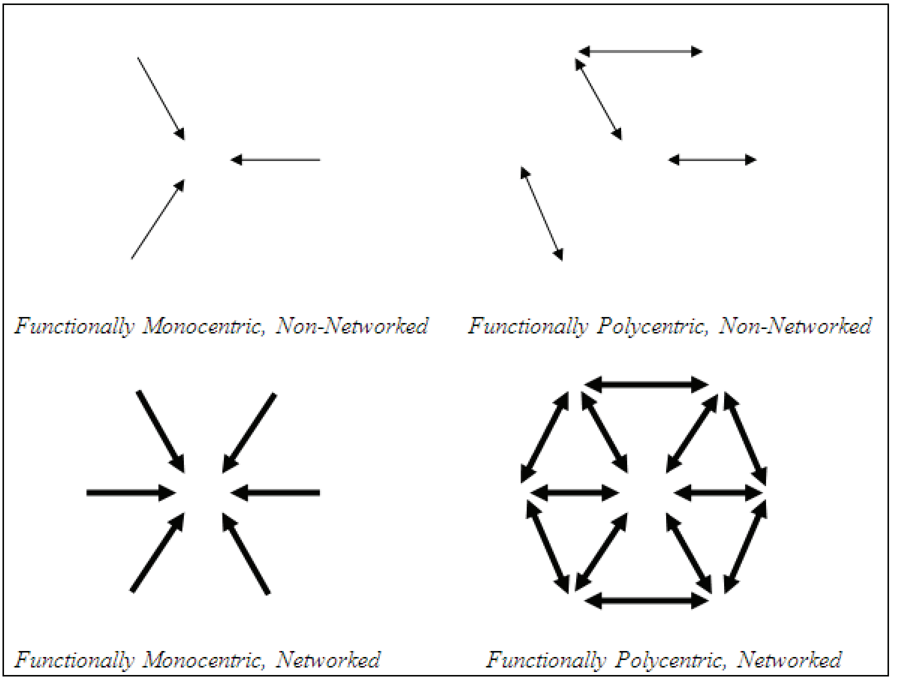
Figure 2.1: Morphological Polycentricity versus Functional Polycentricity



Polycentricity, Nodality and Centrality

Important to note here is the link between nodality, centrality and both forms of polycentricity. As nodality and centrality reflect the *absolute* and *relative* importance of centres in an urban system, then morphological polycentricity and functional polycentricity should be about the balance in the *absolute* and *relative* importance of these centres. Hence, it can be argued that in a morphologically polycentric system there is no dominant centre, or alternatively, that centres are relatively equal in terms of nodality or their absolute importance. In a functional polycentric system there is no dominant city, in other words the relationships have no obvious orientation towards a particular centre; centres are relatively equal in terms of centrality or their relative importance (see Figure 2.1). Consequently, nodality provides the basis for measuring morphological polycentricity, whereas the measurement of functional polycentricity is to be based on centrality. In existing analyses, most often attention is paid to the distribution of intra-regional flows, and hence *internal centrality* scores (Hall and Pain, 2006; Green, 2007; Burger *et al.*, 2011a).

Figure 2.2: Functional mono/polycentric systems versus networked systems



Note that we explicitly disentangle the degree of functional polycentricity (balance in the distribution of functional linkages) from the degree of *network density* (extent to which the centres are functionally linked). Not including network density in our measure of functional polycentricity (based on centrality) is necessary as it is possible to come across urban systems with a high network density, but hierarchically organised and urban systems with a low network density, but in which centres are relatively equal in terms of their connectivity to other centres (see Figure 2.2). If both centralization and network density scores are combined, we may find that urban systems with a highly unbalanced distribution of functional linkages but a high network density would receive a similar score to those urban systems with a highly balanced distribution of functional linkages but a low network density. In fact, the perhaps remarkable finding in the POLYNET study (Hall and Pain, 2006) that a morphologically monocentric region such as Greater London is more functionally polycentric than morphologically polycentric regions such as Central Belgium and Northern Switzerland can probably be mainly ascribed to the lack of network formation between the centres in the latter regions. Hence, we argue that for conceptual clarification, and in conformity with common practice in network analysis (Wasserman and Faust, 1994)[7], it is better to not equate a functionally polycentric urban system with a networked urban system. This does not mean that the degree of network density is not an important aspect of the organisation of a spatial system. In actual fact, synergies between the centres in an urban system will not be achieved without linkages between them (Meijers, 2005) and within a policy context one cannot speak of a functionally integrated urban region without linkages resulting from economic complementarities between the different centres (Van Oort *et al.*, 2010). Finally, separating functional polycentricity and network density also facilitates comparison with morphological polycentricity. Obviously, the distribution of local importance and external centrality provide starting points to explain the difference between morphological and functional polycentricity. In the next sections we present our empirical assessment of the relationship between both forms of polycentricity. Section 2.4 presents the case study regions, the research approach and the data. Section 2.5 presents the analysis.

2.4 Case Study: Polycentricity in Dutch WGR Regions

WGR Regions in the Netherlands

The framework developed in the previous section will be applied to the Netherlands. While we could have taken any country, the Netherlands is of particular interest as it is widely known that polycentricity is a key characteristic of its spatial organisation (Lambregts,

---

[7] Similar approaches can be found in Limtanakool *et al.* (2007), De Goei *et al.* (2010) and Burger *et al.* (2011).

2009). The conceptual framework we presented is quintessentially scale-free and hence can be applied to any spatial entity ranging from individual cities to continents. Here, we decided to apply the model to 42 functionally coherent regions that together cover the entire Netherlands. These regions are referred to as 'WGR'-regions, and they get their name from the Inter-municipal Statutory Regulations Act ('Wet Gemeenschappelijke Regelingen' - WGR) that enables municipalities to jointly work on issues that need to be addressed on a higher spatial scale than the municipal scale by means of issue-based common agreements. The Act does not specify which issues should be jointly addressed, but in practice these often concern regional aspects of economic development, tourism, recreation, housing, employment, traffic and transport, spatial development, nature and environmental affairs, welfare and social affairs. As the delimitation of WGR-regions is based on municipal and provincial administrators' and councillors' perceptions of the scale on which issues in need of a regionally coordinated approach arise, these regions provide an indirect proxy of functionally coherent regions. Despite the 'professional' definition of this region, the outcome appears generally well defendable, coinciding fairly well with what are believed to be travel to work areas, and consequently has not led to a great debate on its rationality.[8] Figure 2.3 presents these 42 regions. We refer to these regions by the name of their largest centre. Note that we collected data on the nodality and centrality of the four largest cities or towns in these regions.

Quantifying Spatial Structure

As explained in the previous sections, polycentricity is all about the balance in importance of urban centres. The more even the importance in terms of nodality and centrality of urban centres, and hence the less hierarchy, the more morphologically and functionally polycentric the system is. The rank-size distribution with regards to the importance of cities provide information on this hierarchy of centres and is therefore a good measure of the degree of mono- or polycentricity (Parr, 2004; Spiekermann and Wegener in ESPON 1.1.1, 2004; Meijers, 2008b; Adolphson, 2009). We adhere to this view and use the rank-size distribution of the nodality scores in an urban system to assess the degree of morphological polycentricity and the rank-size distribution of the centrality scores in an urban system to assess the degree of functional polycentricity. The major indicator is the

---

[8] It is in fact the only official recent delimitation of functionally coherent regions in the Netherlands and one of its advantages is that it is not by definition confined to traditional administrative borders.

slope of the regression line that best fits these rank-size distributions. The flatter the slope of this line is, the more polycentric the region. Conversely, the steeper the slope of this line is, the more monocentric the region.

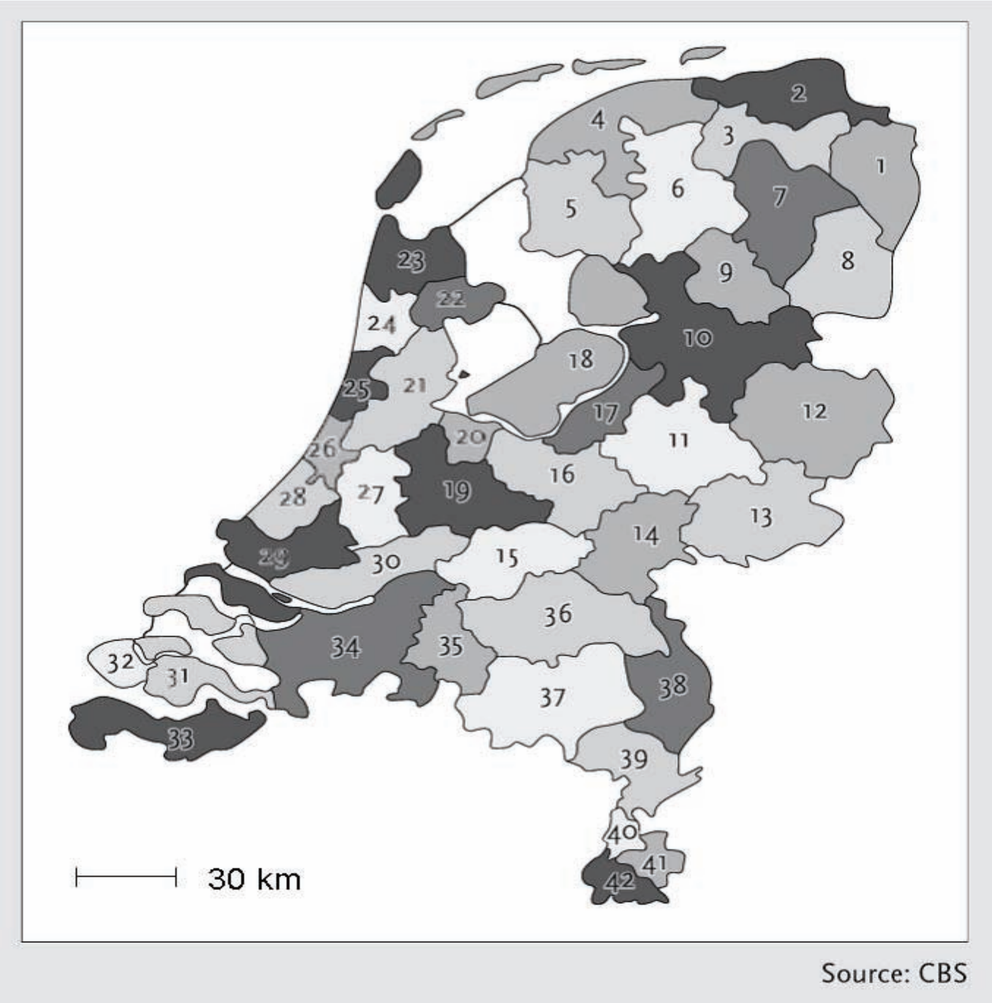
As Meijers (2008b) points out, a crucial question concerns the number of urban centres ranked in the rank-size distributions. The extent of mono- or polycentricity is generally judged on the basis of the nodality and internal centrality of just the handful of largest cities. In general, sample size can be based on a fixed number of cities, a fixed size threshold, or a size above which the sample accounts for some given proportion of a region's total nodality or internal centrality (Cheshire, 1999). The latter method has disadvantages, as it is apparent that the number of centres included in the analysis is large for polycentric systems and small for monocentric systems. Hence, the number of centres including some given proportion of the nodality or centrality is in itself an indicator of mono- or polycentricity and applying such a measure twice would distort the picture. A fixed size threshold is equally less appropriate, as in large and more densely populated urban systems a centre of say 5,000 inhabitants may be insignificant, while it could be of considerable absolute and relative importance in small or less populated systems. Hence, when measuring morphological and functional polycentricity on the basis of the rank-size distribution, the sample size could best be based on a fixed number of centres. In line with Meijers and Burger (2010), we used different numbers of places per region (2, 3 and 4 largest places) and then calculated the average of these three scores.

Figure 2.4 presents the four largest places (in terms of employment) in two Dutch regions (Maastricht and Sittard-Geleen) including the regression line that fits the rank-size distribution best.[9] In this example, Maastricht is obviously a morphologically monocentric region, while Sittard-Geleen is a clear example of a morphologically polycentric region. This brings us to an important issue that needs to be taken into account when analysing the results and figures provided below. This is that in our texts and figures we refer to the degree of polycentricity. However, as can also be seen in Figure 2.4, our measure based on the rank-size distribution positions regions on a scale ranging from very monocentric to very polycentric. So, regions with a low level of polycentricity are actually monocentric, and only regions with a high level of morphological polycentricity can be truly considered polycentric urban regions as addressed by authors such as Champion (2001), Kloosterman

[9] The parameter values have been estimated using the rank-size regression approach by Gabaix and Ibragimov (2011), which corrects for small sample bias.

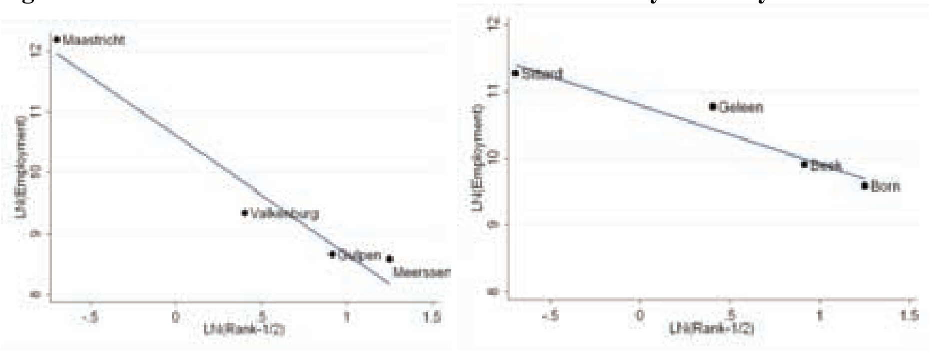
and Musterd (2001), Parr (2004), Van Oort *et al.* (2010) and Cowell (2010).

Figure 2.3: WGR Regions in the Netherlands



1 Veendam	10 Zwolle	19 Utrecht	28 ’s-Gravenhage	37 Eindhoven
2 Delfzijl	11 Apeldoorn	20 Hilversum	29 Rotterdam	38 Venlo
3 Groningen	12 Enschede	21 Amsterdam	30 Dordrecht	39 Roermond
4 Leeuwarden	13 Doetinchem	22 Hoorn	31 Goes	40 Sittard
5 Sneek	14 Nijmegen	23 Den Helder	32 Middelburg	41 Heerlen
6 Drachten	15 Tiel	24 Alkmaar	33 Terneuzen	42 Maastricht
7 Assen	16 Amersfoort	25 Haarlem	34 Breda	
8 Emmen	17 Harderwijk	26 Leiden	35 Tilburg	
9 Hoogeveen	18 Almere	27 Gouda	36’s-Hertogenbosch	

Figure 2.4: Rank-size Distributions to Measure Mono/Polycentricity.



Data

To examine the relationship between morphological and functional polycentricity, we estimated the slope of the regression line of the rank-size distribution of the nodality and internal centrality scores of the largest places in all 42 WGR regions (see Figure 2.3). More specifically, the nodality scores are used to assess the degree of morphological polycentricity and the internal centrality scores are used to assess the degree of functional polycentricity. We performed two analyses, one on the basis of commuting and one on the basis of shopping trips. We based both the nodality and the internal centrality scores on these trips. This flow-data is drawn from the *Dutch National Travel Survey 2004-2008* (Mobiliteitsonderzoek Nederland).[10] As indicated in the previous sections, the degree of nodality of a place is determined on the basis of employment (i.e. total incoming journey-to-work flows, including those flows originating from its own centre as well as the places situated outside the WGR region) and the total number of shoppers. Likewise, the internal centrality of a place is determined on the basis of the total incoming journey-to-work and shopping flows from places situated within the same WGR region.

[10] In this, we calculated the yearly average scores. In addition, scores were weighted so that they are representative for the whole Dutch population.

Table 2.1: Morphological Polycentricy (MP) versus Functional Polycentricity (FP)

	Employment			Shopping		
Region	**MP**	**FP**	**MP-FP**	**MP**	**FP**	**MP-FP**
Veendam	-0.31	-0.47	0.16	-0.22	-0.53	0.31
Delfzijl	-0.28	-0.24	-0.03	-0.36	-0.29	-0.07
Groningen	-1.95	-1.13	-0.82	-1.70	-0.76	-0.93
Leeuwarden	-1.60	-1.34	-0.26	-1.22	-0.67	-0.55
Sneek	-0.91	-1.02	0.10	-0.76	-0.70	-0.06
Drachten	-0.73	-0.63	-0.10	-0.56	-0.50	-0.05
Assen	-1.13	-1.04	-0.09	-1.10	-0.71	-0.39
Emmen	-1.42	-1.23	-0.18	-1.22	-1.06	-0.15
Hoogeveen	-1.09	-0.71	-0.38	-0.89	-0.88	-0.01
Zwolle	-1.35	-1.24	-0.10	-1.08	-0.44	-0.64
Apeldoorn	-0.84	-0.58	-0.27	-0.80	-0.48	-0.32
Enschede	-0.45	-0.21	-0.23	-0.48	-0.11	-0.37
Doetinchem	-0.87	-0.85	-0.01	-0.73	-0.56	-0.16
Nijmegen	-0.61	-0.79	0.17	-0.54	-0.36	-0.18
Tiel	-0.42	-0.28	-0.14	-0.57	-0.44	-0.13
Amersfoort	-0.76	-0.75	-0.02	-0.71	-0.64	-0.07
Harderwijk	-0.39	-0.28	-0.11	-0.39	-0.21	-0.18
Almere	-0.87	-0.74	-0.13	-0.94	-0.46	-0.49
Utrecht	-1.30	-1.17	-0.13	-1.13	-0.90	-0.23
Hilversum	-0.96	-0.66	-0.30	-0.73	-0.58	-0.14
Amsterdam	-1.51	-1.04	-0.47	-1.46	-0.72	-0.74
Hoorn	-0.94	-0.72	-0.22	-1.05	-0.62	-0.43
Den Helder	-1.21	-0.46	-0.75	-0.94	-0.91	-0.03
Alkmaar	-1.15	-1.12	-0.02	-0.83	-1.18	0.35
Haarlem	-1.00	-0.51	-0.49	-0.87	-0.32	-0.55
Leiden	-1.08	-0.69	-0.40	-0.79	-0.59	-0.20
Gouda	-0.52	-0.55	0.04	-0.49	-0.25	-0.24
's-Gravenhage	-1.27	-0.80	-0.47	-1.08	-0.25	-0.83
Rotterdam	-1.69	-1.40	-0.29	-1.47	-1.00	-0.47
Dordrecht	-0.88	-0.67	-0.21	-0.69	-0.29	-0.40
Goes	-1.12	-0.96	-0.16	-1.08	-1.04	-0.04
Middelburg	-0.99	-0.64	-0.34	-0.98	-0.75	-0.24
Terneuzen	-1.30	-1.07	-0.24	-0.80	-0.36	-0.44
Breda	-0.78	-0.48	-0.31	-0.64	-0.52	-0.12
Tilburg	-1.41	-1.09	-0.32	-1.28	-0.72	-0.55
's-Hertogenbosch	-0.78	-0.76	-0.03	-0.67	-0.67	0.00
Eindhoven	-1.19	-1.02	-0.16	-1.05	-0.96	-0.09
Venlo	-1.04	-1.03	-0.01	-0.75	-0.17	-0.59
Roermond	-0.73	-0.90	0.17	-0.66	-0.83	0.16
Sittard	-0.70	-0.62	-0.08	-0.38	-0.38	0.00
Heerlen	-1.12	-0.99	-0.13	-0.74	-0.80	0.06
Maastricht	-2.27	-1.60	-0.67	-1.85	-0.99	-0.86

2.5 Empirical Analysis of Polycentricity in Dutch WGR Regions

Comparing Morphological and Functional Polycentricity

Table 2.1 shows the difference between the degree of morphological and functional polycentricity in Dutch WGR regions based on commuting and shopping respectively. A number of conclusions can be drawn. First, spatial structure differs across regions. Some regions are predominantly monocentric while other WGR regions are predominantly polycentric and most city-regions are somewhere in between. Overall, similar patterns can be observed for commuting and shopping.

Second, although there is a considerable correlation between the degree of morphological and functional polycentricity (0.84 for commuting, and 0.57 for shopping; Table 2.2A and 2.2B), almost all regions are relatively more functionally polycentric than morphologically polycentric. For both commuting and shopping, the distribution of incoming flows from places located within the WGR region is more equal than the size distribution of centres.

Table 2.2A: Correlation matrix of the different dimensions of the spatial organisation of WGR regions - Employment

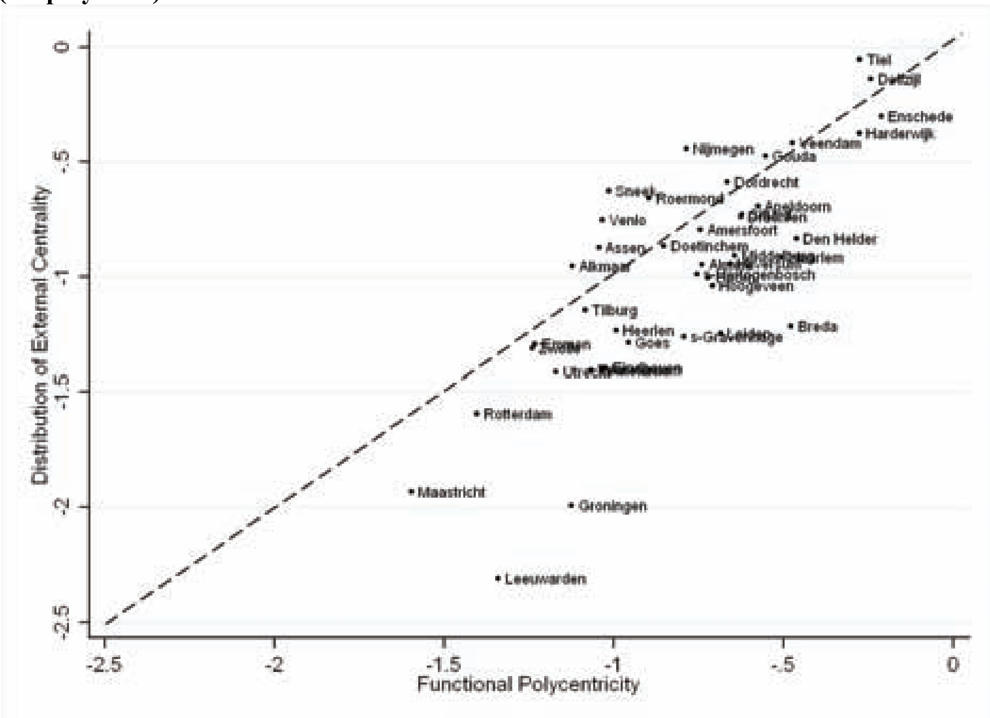
	(1)	(2)	(3)	(4)
Morphological polycentricity (1)	1.00			
Functional polycentricity (2)	0.84	1.00		
Network Density (3)	0.30	0.10	1.00	
Distribution of External Centrality (4)	0.90	0.78	0.18	1.00

Table 2.2B: Correlation matrix of the different dimensions of the spatial organisation of WGR regions - Shopping

	(1)	(2)	(3)	(4)
Morphological polycentricity (1)	1.00			
Functional polycentricity (2)	0.57	1.00		
Network Density (3)	0.41	-0.01	1.00	
Distribution of External Centrality (4)	0.55	0.47	0.14	1.00

These results differ somewhat from the POLYNET study (Hall and Pain, 2006), in which it was found that morphologically polycentric regions are not necessarily functionally polycentric and the degree of morphological polycentricity is generally stronger than the degree of functional polycentricity. However, in the POLYNET study functional polycentricity was measured by an index containing both the balance in the distribution of linkages and network density.

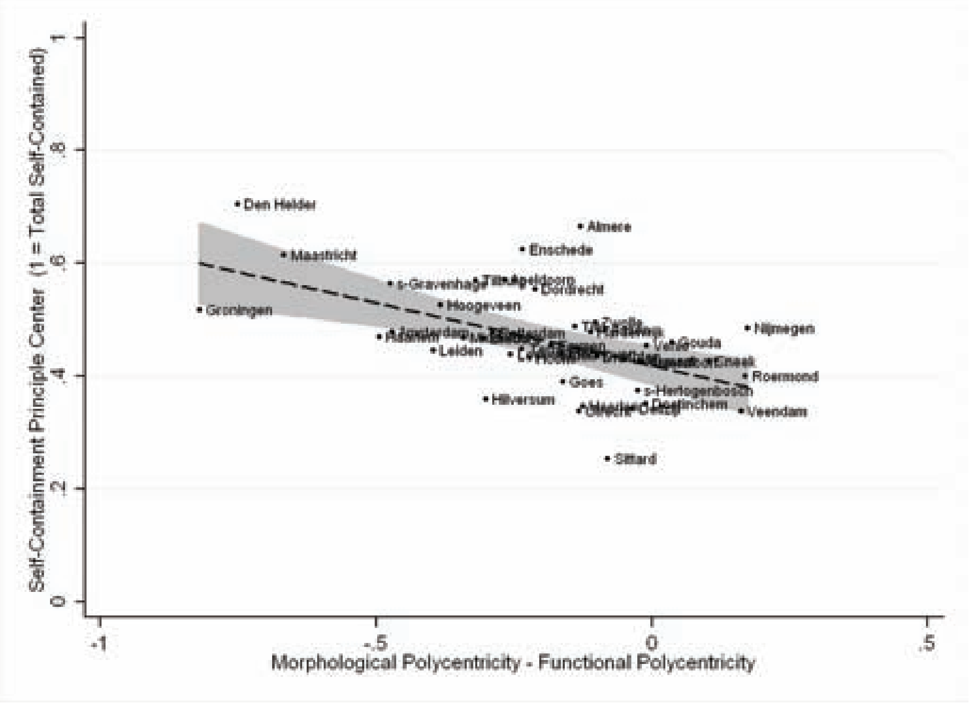
Figure 2.5: External centrality and functional polycentricity in WGR-Regions (Employment).



Tables 2.2A (employment) and 2.2B (shopping) indicate the relationship between the different aspects of the organisation of spatial systems. From these tables, it can be obtained that the more morphologically polycentric a region is the higher the network density, although this relationship is not very strong. Network density here is measured as the ratio between internal centrality and nodality, in other words, the ratio between flows in the region and total employment. The higher this ratio, the more strongly networked the cities in the region. Hence, the more morphologically polycentric a region is, the higher the degree of network formation between the cities. However, network density is not related to the balance in the directions of commuting flows (functional polycentricity), which

provides support for our viewpoint that both should be disentangled. Finally, a POLYNET finding is that intra-regional connectivity is often less hierarchical than external connectivity (Hall and Pain, 2006; Lambregts, 2009). This is confirmed by our findings, as the intra-regional distribution of commuting flows (functional polycentricity) tends to be more balanced than the distribution of external centrality (see Figure 2.5).[11]

Figure 2.6: Local Orientation Principal Centre and the Difference between Morphological and Functional Polycentricity – Employment



The Difference between Morphological and Functional Polycentricity

Recall that the nodality of a centre is the sum of its internal centrality, external centrality and local importance (section 2.3), or, in other words, the total of flows (commuting or shopping) directed at this centre. Consequently, the difference between the degree of morphological and functional polycentricity can be explained by two factors: the

[11] In the remainder, we focus predominantly on employment and commuting flows. Results for shopping are available on request.

distribution of local importance (extent to which flows remain within the same city) and the distribution of external centrality (extent to which the cities receive flows from outside the WGR-region). Figures 2.6 and 2.7 show these relationships for employment. The X-axis in these figures presents the difference between morphological and functional polycentricity expressed in percentage point differences. In other words, those regions that are positioned to the right, with a score greater than zero, are more morphologically polycentric than functionally polycentric. The opposite holds for most regions. Their negative score indicates that these are more functionally polycentric than morphologically polycentric. The further to the left the score is, the larger this discrepancy is.

Figure 2.7: External Orientation Principal Centre and the Difference between Morphological and Functional Polycentricity – Employment

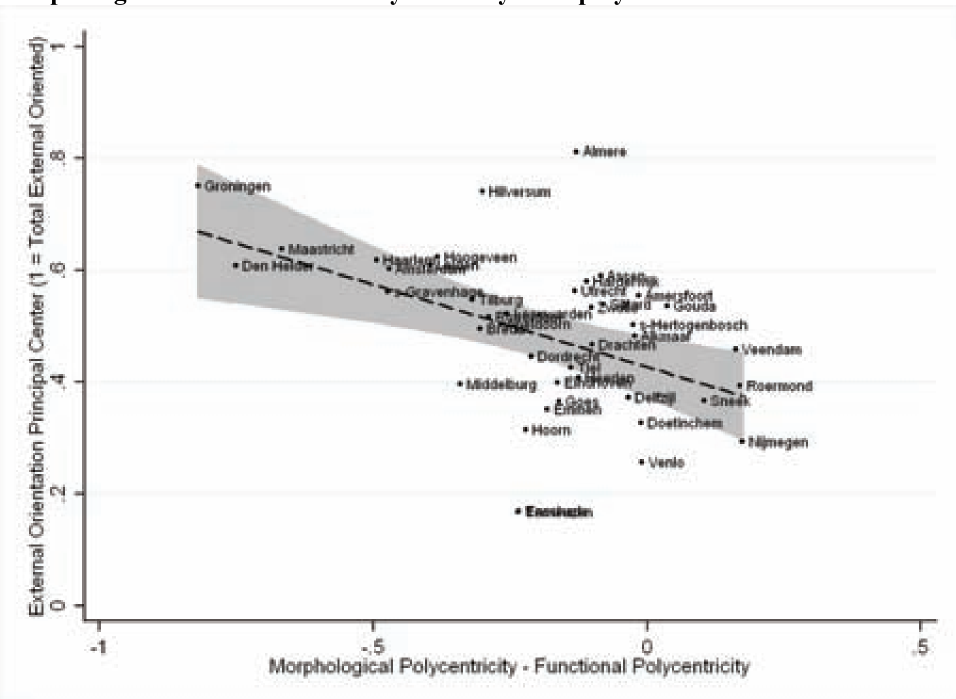


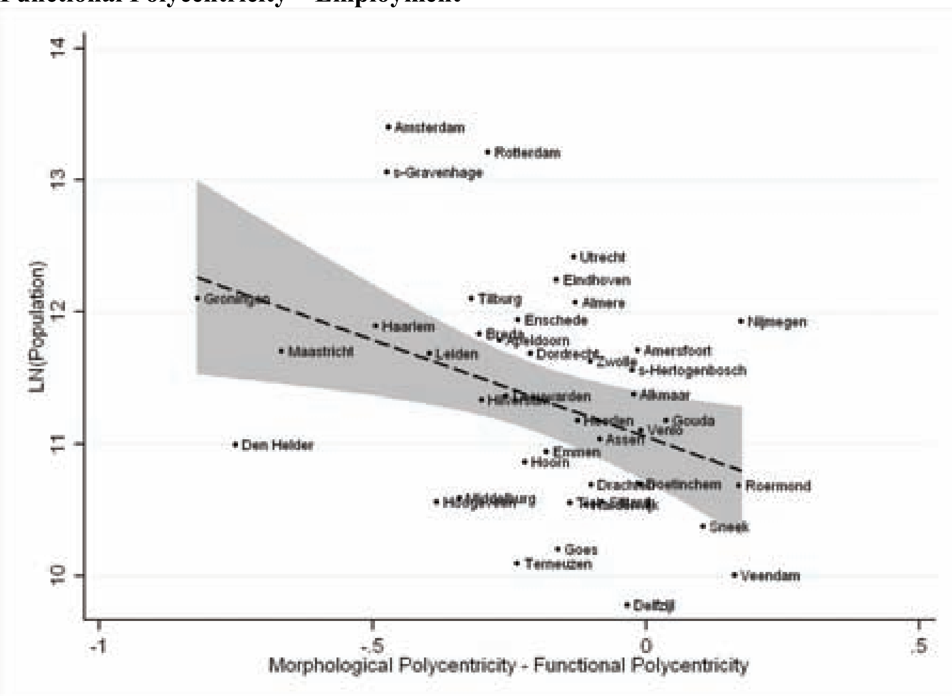
Figure 2.6 shows that regions that are more functionally polycentric than morphologically polycentric tend to have a principal city that draws more heavily on the local population, in our case the local labour market. Obviously it is easier to match labour demand and supply

locally when the local labour market is larger.

Figure 2.7 shows that when the principal city in a region has stronger external linkages with places outside the region, it is likely to be more functionally polycentric than morphologically polycentric. In our case, principal cities that draw more commuters from outside the WGR-region tend to be located in regions that are more functionally polycentric than morphologically polycentric.

Concerning differences between the regions, regions that are substantially more functionally polycentric than morphologically polycentric have principal centres that are large in absolute terms (e.g., Amsterdam, ‘s-Gravenhage (The Hague), Groningen, Maastricht). Conversely, regions that are relatively more morphologically polycentric than functionally polycentric (e.g., Roermond and Veendam) have a relatively small primary centre that is subordinate in the supra-regional urban system (Figure 2.8).

Figure 2.8: Principal Centre Size and the Difference between Morphological and Functional Polycentricity – Employment

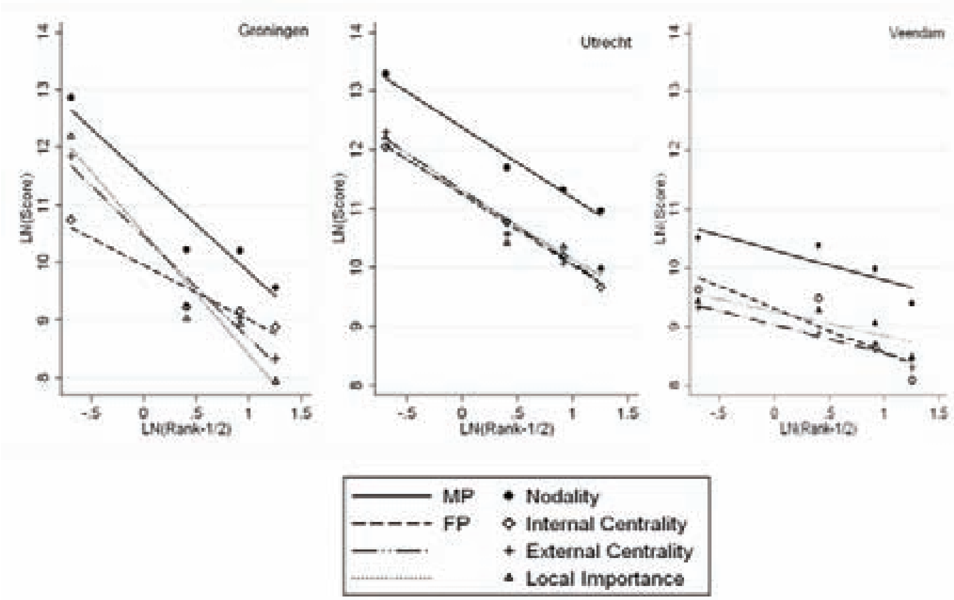


Regional Variations

Finally, we want to show how our four measures (nodality, internal centrality, external centrality and local importance) relate to each other at the scale of individual WGR regions. In this, we focus again on employment. We present the WGR regions Groningen, Utrecht and Veendam in Figure 2.9. Groningen is an example of a region that is much more morphologically polycentric than functionally polycentric. On the contrary, Veendam is one of the few regions that is more functionally polycentric than morphologically polycentric, whereas for Utrecht there is hardly any difference between the degree of morphological and functional polycentricity. For Groningen, it is obvious that nodality scores (related to morphological polycentricity) are distributed in a less balanced way than the centrality scores of the four largest places in the region (related to functional polycentricity). External centrality, however, has a slightly more skewed distribution than morphological polycentricity. In other words, the largest city, Groningen, maintains relatively more relations (flows) with places from outside the region than we would expect given the size (nodality) distribution, whereas the lower ranked cities in this region are more oriented towards other places within the region.

It is also clearly visible that local importance is distributed more unevenly than nodality and centrality. A much larger percentage of jobs (54%) in the city of Groningen is filled by workers who also live in the city than is the case with the other, lower-ranked cities in the Groningen region (24%). These are less able to draw workers from their own local labour market. Utrecht is hardly more functionally polycentric than morphologically polycentric. This tends to come coupled with reasonably similar distributions of local importance, internal centrality and external centrality. Comparing the Utrecht and Groningen WGR-regions, it can be seen from the less steep slopes for Utrecht, that Groningen is in all respects more monocentric than Utrecht. The latter does not hold for the region in which Veendam is the largest centre. This region is one of the most morphologically polycentric regions in the Netherlands. Yet, this does not automatically imply that internal commuting flows are evenly distributed to the same extent.

Figure 2.9: Morphological Polycentricity (MP), Functional Polycentricity (FP), Distribution of External Centrality and Distribution of Local Importance in 3 Prototypical WGR Regions - Employment



2.6 Discussion and Conclusions

The lack of conceptual clarity surrounding the fuzzy concept of polycentricity has long impeded the much needed and often called for progress in our knowledge of the actual merits of polycentricity and the need for polycentric development policies. However, many of the contributions to the debate on polycentricity over the last years have highlighted the variety of interpretations and approaches towards the concept of polycentricity (e.g. Lambregts, 2009 provides an excellent overview), and, therefore, this chapter aims to shed light on what can be considered as the next step in this debate: the measurement of polycentricity. Not surprising given the variety in approaches to polycentricity, there is no consensus on what to measure. We identified, in the literature, two dominant but analytically distinct approaches. The first one, often referred to as morphological polycentricity, basically addresses the size of the urban centres across the territory, and equates more balanced distributions with polycentricity. The second approach takes relations between the centres into account and is referred to as functional polycentricity. A balanced, multi-directional set of relations between urban centres is considered more polycentric. Rather than taking a normative stance towards one approach or the other, we show that both approaches share the same basic principle in that both are concerned with the balance in importance of urban centres in a given area. This enables a similar method of measurement to be used and hence enables a comparison of morphological and functional polycentricity. Informed by the rich heritage of central place and urban systems research, this chapter presents a model that links both approaches and discusses the way both can be measured and compared. We provide this comparison for 42 functionally coherent regions in the Netherlands. To enhance robustness, we did these analyses using employment (commuting) and shopping data. The following conclusions can be drawn:

- There is no dominant type of spatial organisation in the regions. Some are monocentric, some polycentric and most are somewhere in between.
- Despite a considerable correlation between the degree of morphological and functional polycentricity of the regions, almost all the regions are relatively more functionally polycentric than morphologically polycentric.
- The greater this dominance of functional polycentricity over morphological polycentricity, the greater:
    - the degree to which the principal city is self-sufficient, building on its own local labour and consumer market;
    - the more flows the principal city attracts from places from outside their own region;
    - the larger the size of the principal city.

Hence, large differences between the degree of morphological and functional polycentricity of regions come coupled with a relatively large principal centre that has both a stronger local *and* external orientation. This can be explained by the fact that this difference also increases the larger the principal city is. Centre size is positively associated with sectoral diversity and a diverse occupational mix (Jacobs, 1969; Duranton and Puga, 2000). Size also brings with it a larger local labour force, enabling a better match between labour supply and demand. Moreover, higher-order functions (including specialized retail establishments) are still more often found in larger cities (Ross, 1992; Glaeser *et al.*, 2001; Markusen and Schrock, 2006). This makes principal centres more self-sufficient than the lower-order centres. In addition, the over-representation of higher-order functions in the principal centres may also attract a disproportionate number of people from outside the region. In this, it is well known that higher-ranked employees (in terms of education and income) are willing to commute longer distances to work (Schwanen and Dijst, 2002) and consumers are willing to travel longer distances to purchase specialized goods and services (Dijst and Vidakovic, 2000). As these explanations also hold outside the Netherlands, it is likely that we find similar results for regions in other countries or at different scales, such as countries or cross-border macroregions. Yet, one has to be aware that the Netherlands is a comparatively densely populated country and most of its cities are small or medium-sized, which might imply that general levels of polycentricity are relatively high, while it could be assumed that the external centrality of a region's principal city remains relatively low. Therefore, explorations for other countries will reveal whether these results can be generalized.

This chapter has taken commuting and shopping as primary features to build our analysis on. We may reflect on the consequences of taking other flow data. Although the effect of the distribution of external centrality on the difference between morphological and functional polycentricity is rather limited, it can be expected that when assessing the spatial structure of territories on the basis of inter-firm trade or shareholder relations, the external centrality of centres would play a more important role as the geographical scope of these functional linkages is usually also larger.

It is our hope that this contribution opens up a research agenda on polycentricity that is no longer dominated by conceptual issues, but that focuses on whether the alleged benefits of polycentricity and polycentric development hold true or not. Such an evidence base is necessary to determine whether polycentric development as a policy concept is sustainable. In actual fact, such research on the relationship between polycentricity and regional performance is of pivotal importance, given that polycentric development is a key policy concept in discussions of territorial cohesion (a potential third pillar of cohesion policy next to economic and social cohesion) and considerable amounts of public investments can accordingly be spend in suboptimal ways. This chapter suggests that in carrying out this research it is essential to distinguish between morphological and functional polycentricity, and that any associated benefits of these may be related to other characteristics of the urban system, such as the degree of network density or a region's capacity to draw in flows from further away.

Chapter 3:

Heterogeneous Development of Metropolitan Spatial Structure: Evidence from Commuting Patterns

Abstract[1]

In the contemporary literature on urban systems, it is often suggested that the conceptualisation of urban systems as monocentric spatial entities has become increasingly problematic. However, by analyzing employment and commuting patterns in English and Welsh city-regions between 1981 and 2001, it can be shown that not all city-regions are experiencing a shift toward a polycentric spatial structure. Although most city-regions in Southeast England and the Midlands are becoming more polycentric, the spatial structures of many city-regions in the North have not shown significant change. In fact, some are becoming more monocentric. In addition, polycentricity takes different forms, which indicates that the development of metropolitan spatial structure can be characterized as a heterogeneous spatial process.

[1] This chapter has been published in *Cities*, 28(2), pp. 160-170 as "Heterogeneous development of metropolitan spatial structure: evidence from commuting patterns in English and Welsh city-regions, 1981-2001" (with Bastiaan de Goei, Lambert van der Laan and Fieke Huisman). It has been slightly edited to fit the format of this book.

3.1 Polycentric City-Regions

The contemporary literature on urban systems often argues that polycentricity has become the dominant metropolitan form in Western-Europe. The literature claims that the monocentric model, in which a principal city offers labour demand and the surrounding territory labour supply, is increasingly inaccurate (Meijers, 2007). Indeed, it is hypothesised that firms and households increasingly locate outside the principal city create new centres while maintaining significant linkages with the original core. In addition, past studies have conjectured that proximate but historically autonomous urban centres within the same city-region are undergoing a spatial and functional integration.[2] The outcome of these developments is hypothesised as a spatially and functionally integrated city-region with multiple centres at the supra-local scale.

Therefore, it is argued that modern urban life is taking place in a *polycentric city-region*, not a monocentric city. In this, the emphasis on polycentricity reflects the move from territories dominated by a principal centre to territories in which no centre predominates (Kloosterman and Musterd, 2001; Meijers, 2007). The city-region indicates a shift in emphasis from the principal city and its suburbs as the unit of analysis to the principal city and its wider, surrounding territory (Parr, 2005; Davoudi, 2008).

Changes in the relationship between cities and surrounding territories are often seen as consequences of economic and socio-cultural developments. Examples of such developments include changes in the demography of Western populations, the change of Western economies from manufacturing economies to services economies, and an increased demand for customised products and services (Champion, 2001; De Goei *et al.*, 2010). At the same time, increasing urban diseconomies, such as congestion, high land prices and pollution, have made the principal city increasingly unattractive (Richardson, 1995). These developments have resulted in complex and interlinked processes of deconcentration and restructuring (Champion, 2001).

Some scholars have argued that the size of the population and businesses residing in the core is dependent on the stage of urban development (Van der Berg *et al.*, 1982; Tosics, 2004). Others perceive the development of spatial structure as a path-dependent process in which the initial shape of cities and urban subsystems determines spatial structure (see e.g., Nitsch, 2003; Kloosterman and Lambregts, 2007). The focal point of these discussions

[2] For example, city-regions characterised by the historical co-location of multiple smaller centres (i.e., conurbations), such as the area around Middlesbrough.

provides a clear view of the *development* of spatial structures. Many past empirical studies on urban systems have been cross-sectional in assessing spatial structure at only one specific point in time. More recently, scholars have focussed on modelling the dynamics of metropolitan spatial structures (see e.g., Aguilera and Mignot, 2004; Nielsen and Hovgesen, 2005; Green, 2008; Guth *et al.*, 2009; De Goei *et al.*, 2010).

There is a large amount of literature on the emergence of the polycentric city-region (e.g. Kloosterman and Musterd, 2001; Parr, 2005), including an increasing number of empirical studies on polycentric development. However, two elements in this field of research remain unexamined. First, with regard to spatial heterogeneity in urban development processes, many studies assume, often implicitly, that urban systems evolve from a monocentric spatial structure toward some form of polycentric spatial structure. However, the original state differs between city-regions. Some city-regions are predominantly monocentric; others are predominantly polycentric. In reality, most city-regions fall somewhere between those poles (De Goei *et al.*, 2010). As such, the spatial structure of city-regions does not necessarily have to change in the same direction.[3] Second, previous studies have often neglected that polycentricity may take different forms. Patterns of deconcentration can differ across urban systems, ranging from the presence of exchange commuting between the original centre and the surrounding territory to a fully networked city-region. In the fully networked city-region, the original centre and surrounding territory become indistinct (Van der Laan, 1998; Schwanen *et al.*, 2003).

This chapter aims to contribute to the existing literature on metropolitan spatial structure by analysing the development of city-regions at the intra-urban scale. Metropolitan spatial structure has traditionally been assessed by examining the distribution of internal characteristics of cities, such as the number of residents or jobs. However, many of the theoretical foundations for the polycentric model are based on flows linked to the physical movement of goods, people and services (Hall, 2001; De Goei *et al.*, 2010). Also, the position of centres within a network of cities increasingly determines the importance of centres (Batten, 1995; Hall, 2001). Hence, the metropolitan spatial structure is not only assessed by examining the distribution of population or employment within a city-region, but by assessing the distribution of flows between the different parts of the city-region. As such, a typology of city-regions has been developed based on the spatial configuration of

[3] In this, it should be acknowledged that Hall and Pain (2006) specifically reported on differences between European mega-city regions in relation to their degree of polycentricity at the *inter-regional* scale.

commuting networks (Van der Laan, 1998; Schwanen *et al.*, 2003). To accomplish this, a number of related features of urban systems should be taken into account. Such factors include the network density (i.e., the degree of spatial integration of the different parts of the city-region) and the openness of city-regions.

This chapter uses data on journey-to-work travel in 22 city-regions in England and Wales from 1981-2001. Employment and commuting patterns are a useful source for investigating the development of metropolitan spatial structure because labour market interactions between centres constitute the majority of all daily trips within city-regions (Clark and Kuijpers-Linde, 1994). In addition, commuting data is still the most elaborate, reliable, and relevant interaction data available. This chapter addresses the heterogeneity in metropolitan spatial structure present in the English and Welsh urban system by comparing the spatial structures of city-regions over time.

The remainder of this chapter is organised as follows. The next two sections (3.2. and 3.3) contain a discussion of the literature on changing urban systems. In particular, the chapter focuses on the level of the city-region (intra-urban scale). The current trend towards mega-city regions (Hall and Pain, 2006; Hoyler *et al.*, 2008) at a higher geographical scale is beyond the scope of this chapter. In section 3.4, the dataset and research methods are introduced. Section 3.5 contains an overview of the main findings. A discussion and conclusion follows in section 3.6.

3.2 From a Monocentric City to a Polycentric City-Region

From Cities to City-Regions

Among academics and policy analysts, the debate on urban development has shifted from the city to the city-region as primary unit of analysis (Parr, 2005; 2008; Davoudi, 2008). As indicated by Parr (2008, p. 3017) this increasing interest in the city-region as unit of analysis echoes '*a growing appreciation that in certain important respects the city is not a satisfactory unit of analysis, since many of its external interaction are with adjacent (and sometimes extensive) areas*'.[4]

Although there are multiple spatial imaginations of the city-region such as specific administrative units or NUTS-2 areas (Parr, 2005), this research assumes city-regions to be

[4] Yet, the concept of city-region is in fact much older and dates back to the work of Lösch (1944), Dickinson (1947), and Bogue (1949). A good overview of the development of the city-region concept is provided by Parr (2005) and Davoudi (2008).

functional urban regions. Embedded in urban systems theory, cities and their surroundings are herein perceived as functionally interdependent entities linked through economic flows, such as inter-firm trade, labour market interactions, and shopping (Berry, 1964; Parr, 1987). In this, the dominant flows determine the delineation of city-regions (Davoudi, 2008). The city-region is usually perceived as a principal city and its surrounding territory (Parr, 2005; 2008). The surrounding territory consists of suburban areas, rural villages and, most importantly, subordinate urban centres. These different parts of the city-region together form a functional economic space (Davoudi, 2008).[5]

From Monocentric to Polycentric City-Regions

The study of metropolitan spatial structure originates from urban location theory and can be traced back to the theoretical work by Alonso (1964) on the monocentric model, which was adapted from the work of Christaller (1933) on hierarchical urban systems. From a morphological point of view, the monocentric model predicts a strict division of labour between the central business district (CBD) and suburban areas, where the CBD is the source of labour demand and the suburbs are the source of labour supply. In other words, the size distribution of centres in terms of employment is highly unbalanced in a monocentric city. From a functional point of view, the monocentric spatial system is then best represented by a star-shaped pattern of interactions, where the journey-to-work flows are all directed from the suburbs to the CBD (Haggett and Chorley, 1967). As indicated by Parr (2008), the monocentric city model can be perceived as a special case of the traditional Löschian city-region (Lösch, 1944). Like the monocentric city, the traditional city-region is perceived as a nodal area in which the principal city is characterised by a deficit labour supply and the territory surrounding the principal city by a deficit labour demand (Parr, 1987; 2005). Accordingly, journey-to-work flows are directed from the surrounding territory to the principal city.

The monocentric model was challenged from two sides (Van der Laan *et al.*, 1998). First, the model was unable to explain the emergence of employment locations in the suburbs, and hence the emergence of sub-centres (Garreau, 1991). Likewise, at the level of the city-region, the monocentric model has been unable to explain a shift in employment from the principal centre to the subordinate centres in the surrounding territory and the

[5] For example, the city-region of Newcastle contains the principal city Newcastle, the suburbs Gateshead, North Shields and South Shields, the lower order urban centres Chester-le-Street, Durham and Sunderland, and rural areas in Tynesdale and North Northumberland.

resultant decrease of commuting from the surrounding territory to the principal city. Second, the existence of an enormous amount of 'excess' or 'wasteful' commuting – the difference between the average commuting distance projected by the monocentric density function based on travel-minimising behaviour and the actual required commuting distance – made the monocentric model unrealistic (Small and Song, 1994). The most obvious reason for the 'failure' of the monocentric model is the increasing percentage of journey-to-work travel from the principal city to the surrounding territory and between different parts of the surrounding territory.[6]

Whereas the monocentric concept gave way to that of polycentric city-regions, the actual resultant metropolitan spatial structure remains often unclear (Van der Laan, 1998).[7] For example, a polycentric city-region can be characterised by a spatial structure whereby exchange commuting only occurs between the original centre and the surrounding territory or by a more fragmented pattern in which the original principal city and subordinate centres has become indistinct. A more elaborate discussion of these issues is provided in the next section.

3.3 Metropolitan Spatial Structure

Conceptualising the Importance of Centres

Every assessment of spatial structure starts off within determining the importance of centres. As indicated by Preston (1971), one can make here a distinction between the absolute importance of a centre or its *nodality* and the relative importance of a centre or its *centrality*. In the light of employment and journey-to-work flows, the nodality of a centre can be expressed by the total number of jobs it provides, whereas the centrality of a centre can be defined by the number of jobs in excess of those demanded by the centre's own inhabitants. The distinction between nodality and centrality can be traced back to the work by Christaller (1933), who argued that if the importance of a centre was determined solely on the basis of its size, then part of its importance must be ascribed to the settlement itself as an agglomeration and another part to the settlement as a provider of jobs, goods and services to its surrounding territory. Accordingly, it is possible separate the external

[6] It should be noted that, over time, the monocentric model could also *over-predict* commuting distance as total commuting distance could drop when more people work and live in sub-centres (Small and Song, 1994). However, this would also mean that the predictions from the monocentric model are no longer reliable.
[7] The use of polycentricity should not be confused with the concept of multicentricity. Multicentricity refers to the existence of multiple centres, while polycentricity emphasises a certain balance in importance of these centres.

importance from the local importance of a city. The importance of a centre c in an open system (i.e., including linkages with other systems) can then be decomposed[8] as follows:

$\mathbf{C_{ci} = N_c - C_{co} - L_c}$, where

$\mathbf{C_{ci}}$ = the surplus of importance of a centre based on incoming flows from other places within the same spatial system; its *internal centrality*.
$\mathbf{N_c}$ = the absolute importance of a centre; its *nodality*
$\mathbf{C_{ce}}$ = the surplus of importance of a centre based on incoming flows from other places outside the spatial system; its *external centrality*.
$\mathbf{L_c}$ = the local importance of a centre based on internal flows (people working and living in the same place).

For example, when examining the importance of a centre as source of jobs in a city-region, it can be argued that $\mathbf{N_c}$ represent total employment in part of the city-region c, $\mathbf{C_{ci}}$ represents the incoming commuting in part of the city-region c from other parts of the city-region, $\mathbf{C_{ce}}$ represents the incoming commuting in part of the city-region c from places situated outside the city-region, and $\mathbf{L_c}$ represents the number of employees in the part of the city-region c that also live there.

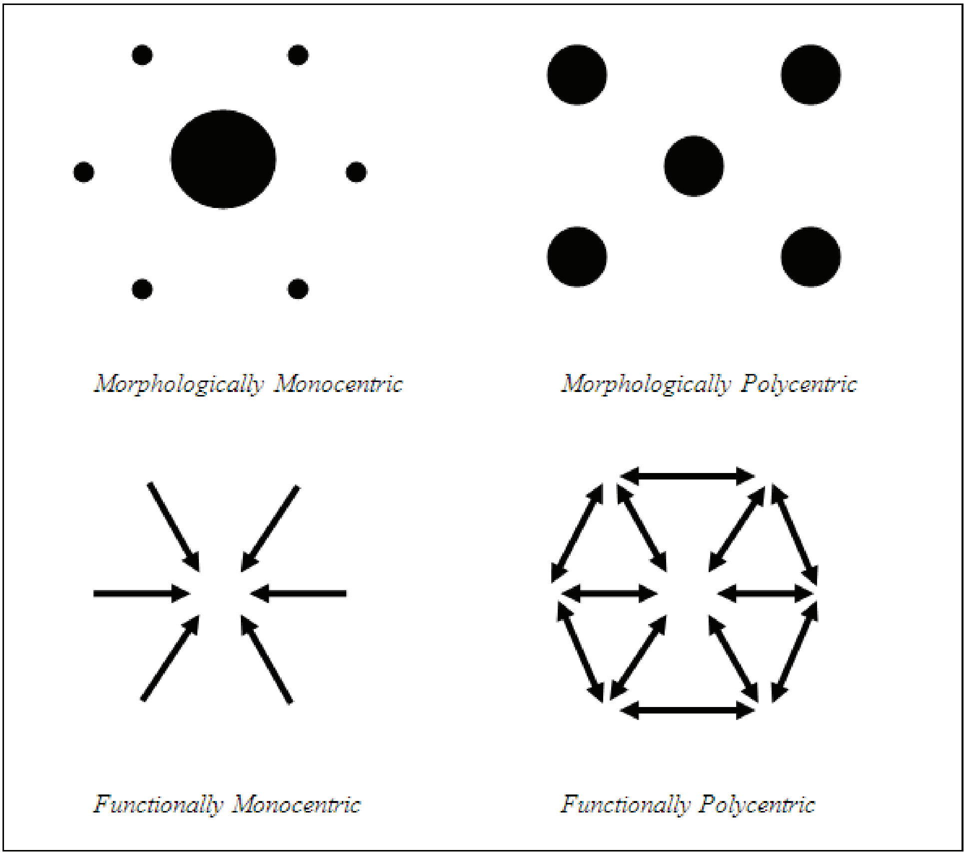
Polycentricity, Network Density and Openness of City-Regions

Analogous to the distinction between nodality and centrality, there are two main approaches to assess the spatial structure of city-regions (Green, 2007; Meijers, 2008b). The morphological approach is based on the attributes or internal characteristics of centres such as the number of jobs (see e.g., Spiekermann and Wegener, 2004; Meijers, 2008b). The functional approach classifies metropolitan spatial structure based on the structure of flows within urban systems (see e.g., Green, 2007; De Goei *et al.*, 2010). Both approaches look at the balance in the distribution of importance across centres, where polycentricity tends to be associated more with a balanced distribution of the importance of these centres (Kloosterman and Lambregts, 2001; Meijers, 2008b). Whereas the morphological approach assesses the balance in the size distribution or distribution of absolute importance of centres, the functional approach typically looks at the balance in the distribution of

[8] See Burger and Meijers (2010) for a more elaborate discussion of these issues.

functional linkages between centres (Burger and Meijers, 2011; Figure 3.1), where most often attention is paid to the distribution of intra-regional flows and, hence, *internal centrality* scores (e.g., Green, 2007).

Figure 3.1: Morphological Polycentricity versus Functional Polycentricity



For conceptual clarification and in line with graph theoretical conceptualisations of spatial structure (e.g., Limtanakool *et al.*, 2008), we explicitly disentangle the spatial structure of city-regions from related aspects of the spatial organisation of city-regions such as the degree of *network density* (i.e., the extent to which the different parts of a city-region are functionally linked) and *outward openness* (i.e., the extent to which the city-region is connected to other city-regions). Not including network density in our measure of functional polycentricity was necessary because it is possible to encounter urban systems that are strongly networked in a hierarchical organisation and urban systems that are not networked at all, where centres are relatively equal in terms of their connectivity to other centres. If both primacy and network density scores are combined, we may find that urban systems with a highly unbalanced distribution of functional linkages but a high network density would receive a similar score as urban systems with a highly balanced distribution of functional linkages but a low degree of network density (Burger and Meijers, 2011). A similar argument can be made with regard to the openness of a city-region.

This does not mean that the degree of network density and openness are not important aspects of the spatial organisation of a city-region. In fact, it can be expected that the increased mobility of households and businesses will result in an increasing network density within city-regions and an increasing openness in city-regions. Moreover, a functional polycentric urban region is non-existent without a minimum degree of interaction between centres (Champion, 2001; Parr, 2004).

A Typology of City-Regions Based on Commuting

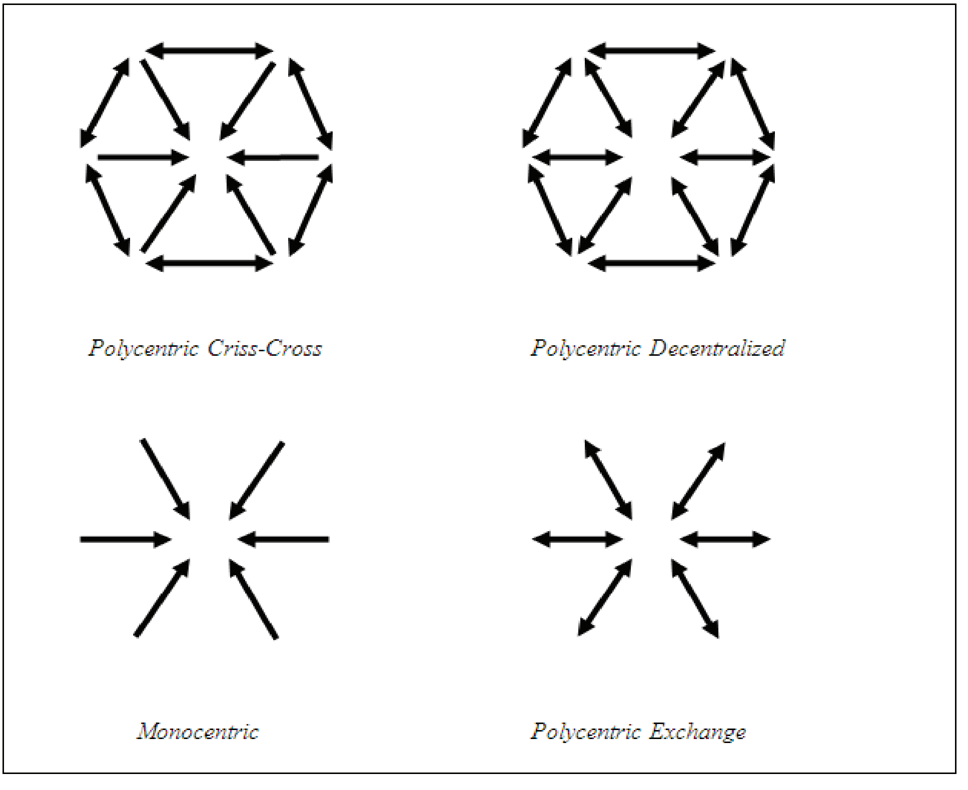
Based on the *orientation* of commuting patterns in city regions[9], it is possible to distinguish between four prototypical city-regions, as shown in Figure 3.2 (Van der Laan, 1998; Schwanen *et al.*, 2003). We distinguish between three types of journey-to-work patterns between different parts of a city-region: traditional commuting (commuting from the surrounding territory to the principal city), exchange commuting (commuting from the principal city to the surrounding territory) and criss-cross commuting (commuting between the different parts of the surrounding territory).

The monocentric city-region is characterised by a low degree of exchange and criss-cross commuting because the majority of commuters living in the surrounding territory travel to the principal city, while the surrounding territory attracts very few commuters. In a polycentric exchange city-region, commuting has become reciprocal; commuting is no longer directed solely from the surrounding territory to the principal city but also from the principal city to the surrounding territory. In a polycentric criss-cross urban system, the different parts of the surrounding territory have become more dominant because they now attract commuters from other parts of the surrounding territory. In this, parts of the surrounding territory have become complementary to the principal city and are

[9] It should again be stressed that we look here only at the directionality of the linkages between the different parts of the city-region and not at the strength of the linkages between the different parts of the city-region.

increasingly important as centres within the city-region. Commuting flows decentralise as the number of workers commuting between the different parts of the surrounding territory and bypassing the (former) principal city increases. Yet, the degree of exchange commuting remains low. Finally, a decentralised polycentric city-region is characterised by a multi-oriented commuting pattern in which there is no longer a dominant centre. In a polycentric decentralised system, there is a large amount of both criss-cross and exchange commuting. Two types of city-regions fit this classification: (1) a formerly monocentric city-region in which employment has spread from the urban core to the urban fringe (‘edgeless cities’; Lang, 2003) and (2) city-regions characterised by the historical co-location of multiple smaller centres (i.e., conurbations). In such urban systems, the amount of traditional commuting may become very small.

Figure 3.2: Functional Typology of the Spatial Structure of City-Regions



3.4 Empirical Setting and Methodology

Previous Research on Commuting and Spatial Structure in England and Wales

Despite a growing amount of theoretical literature on changing urban systems, only a small number of recent empirical studies have quantitatively assessed the development toward polycentric city-regions in England and Wales. Studies by Coombes *et al.* (2006), Nielsen and Hovgesen (2008), Green (2008) and De Goei *et al.* (2008; 2010) have analysed the dynamics of spatial structure in England and Wales empirically by using commuting data, where most work has been done on English and Welsh urban networks at the inter-urban and inter-regional scale (i.e. between city-regions).

Analysing commuting data for England and Wales, Green (2008) found that England and Wales became more connected at the inter-regional scale between 1981 and 2001. In addition, Green (2008) concluded that there is an increasing tendency for people to live and work at the urban periphery, where travel patterns have become increasingly diffused. On a similar note, Nielsen and Hovgesen (2008) examined the development of nation-wide commuting flows in England and Wales between 1991 and 2001. They found an increase of the average commuting distance during this period, which is exemplified by an increasing connectivity between rural areas and main centres.

Focusing on commuting network in the Greater South East, De Goei *et al.* (2008; 2010) concluded that the mega-city region could not be regarded as a functional polycentric urban region. However, they find some evidence for spatial integration at the intra-urban scale (i.e., the city-region), as well as a decentralisation of the urban system at the inter-urban scale in the sense that the hub function of London is decreasing in importance. On a similar note, Coombes *et al.* (2006) found some evidence for increasing linkage formation between the principal cities of the city-regions in the East Midlands urban network.

However, the empirical literature on spatial structure in general, and those studies in particular, pay limited attention to spatial heterogeneity present between different city-regions. The remainder of this chapter contributes to the existing empirical literature on urban systems by jointly addressing the dynamics, spatial heterogeneity and the specific polycentric pattern of city-regions in England and Wales.

Commuting and City-Regions in England and Wales

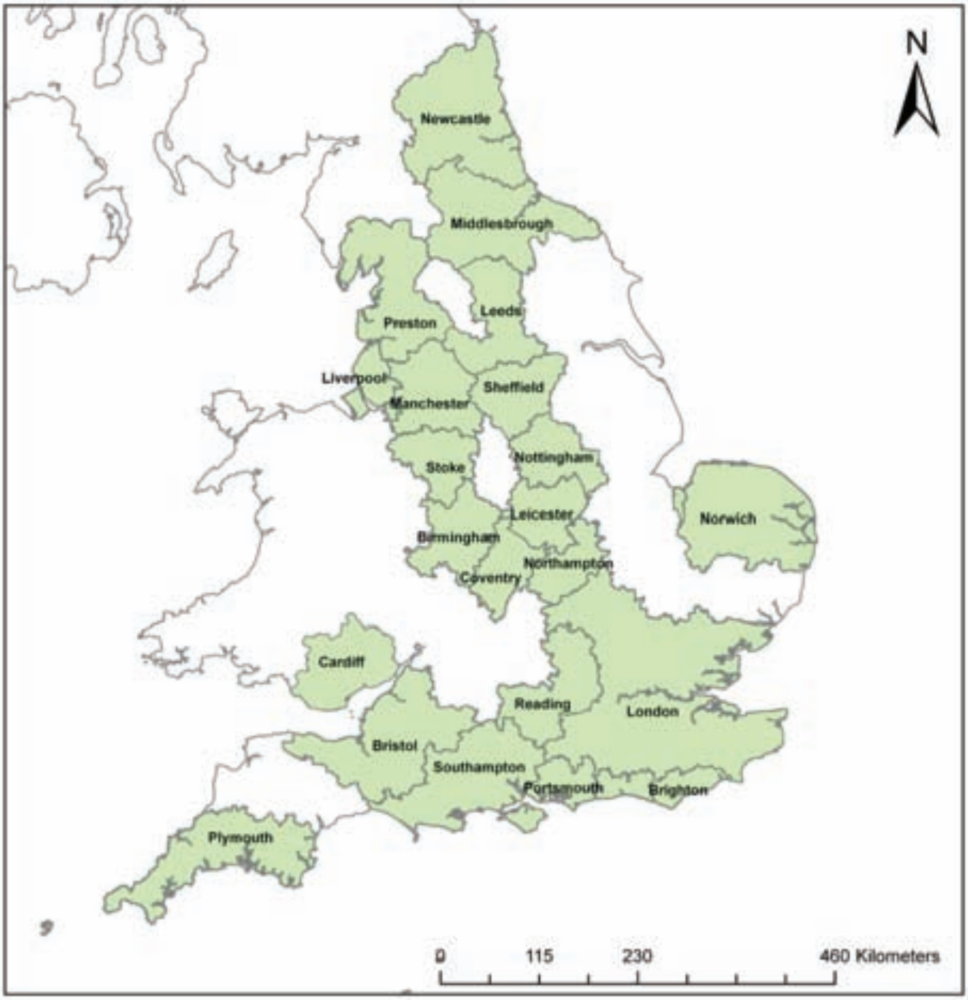
The present study used journey-to-work data between local authority districts form 1981 and 2001 to analyse the development of metropolitan spatial structures in England and Wales. These data were obtained from the Special Workplace Statistics (Set C) in the British census.[10] The Census Interaction Data Service (CIDS) 1991/2001 common geography was used to avoid potential problems with the changes of district-boundaries over the past twenty years (Boyle and Feng, 2002). A subdivision of city-regions was made using the common geography. In this, we used the classification by Coombes (2000), which comprises 43 British city-regions. We defined city-regions by functional linkages and areal associations based on the 2001 Census. In this, '*the city-regions are delineated on the basis of commuting data through an algorithm that optimises the boundaries on the basis of a size of employment criterion and a minimum threshold of self-containment of flows to workplaces*' (Robson *et al.*, 2006, p. 8). Accordingly, the classified city-regions are to a large extent self-contained in that most people (>80%) who work in city-regions also live there.

The delineation of Coombes (2000) is non-nodal and exhaustive since there may be several employment centres within each city-region, and every area in Great Britain is allocated to a city-region. Compared to other classifications of city-regions in England and Wales (see Robson *et al.*, 2006; Davoudi, 2008 for overviews), an obvious advantage of the Coombes classification is that it does not assume *a priori* the existence of only one main centre within a city-region. Hence, the bottom-up approach of delineating city-regions is useful for exploring polycentric patterns in a wider region (Davoudi, 2008). Based on the classification of city-regions by Coombes (2000), we selected the 22 largest English and Welsh city-regions, whereby the more rural areas are excluded because these

[10] Census output is Crown copyright and is reproduced with the permission of the Controller of HMSO and the Queen's Printer for Scotland. Sources: 1981 Census: Special Workplace Statistics (Set C) and 2001 Census: Special Workplace Statistics (Level 1)

areas are typically not metropolitan (for a similar selection, see Champion and Coombes, 2007). An overview of the city-regions included in the analysis is presented in Figure 3.3.

Figure 3.3: Selected 22 English and Welsh City-Regions



Quantifying the Spatial Structure of City-Regions

The degree to which incoming commuting and employment is centralised within city-regions is estimated to assess the development of metropolitan spatial structure of English and Welsh city-regions between 1981 and 2001. To assess the degree of morphological and functional polycentricity in a city-region, we used a primacy index (Van der Laan, 1998; Adolphson, 2009). The morphological primacy index is calculated as the ratio of employment in the largest centre (i.e., the principal city) and the total employment the city-region and is thus based on the balance in the distribution of nodality scores. The functional primacy index is calculated as the ratio of incoming commuting into the largest centre originating from the city-region and the total incoming commuting originating from the city-region and is thus based on the balance in the distribution of internal centrality scores. A city-region is considered morphological monocentric if its employment is highly concentrated in one (principal) city. A city-region is considered functional monocentric if most commuting flows originating from other parts of the city-region are directed at the principal city (and no flows are directed from the principal city to the surrounding territory). The larger the degree of morphological and functional primacy is in a city-region, the lower the degree of morphological and functional polycentricity in a city-region.

In addition to the summary measures of polycentricity, we look at the specific patterns of polycentricity, which correspond to the typology of polycentric spatial structures introduced in the previous section. In this, we make a distinction between the monocentric and three types of polycentric city-region: the exchange, the criss-cross, and the decentralised city-region. This typology is based on (1) the degree of exchange commuting, or the degree to which commuters living in the principal city are oriented toward the surrounding territory and (2) the degree of criss-cross commuting, or the degree of commuting between different parts of the surrounding territory. We compared the degree of exchange and criss-cross commuting with the degree of traditional commuting, where commuting is defined as journey-to-work travels between the area of residence and another area of employment. Hence, we exclude here journey-to-work travel of people who work and live in the same area. A more technical description of these measures is provided in Table 3.1.

Building on the discussion in the previous sections, we describe two additional features of city-regions. The degree of network density reflects the extent to which different parts of the city-region are networked or functionally interdependent and can be measured as the ratio of the actual connections between the different parts of the city-region compared to the total potential connections between the different parts of the city-region (Green, 2007). Here, the total potential connections between the different parts of a city-region are defined as the total number of employees in a city-region. A generally low ratio of the sum of internal centrality scores by the different parts of the city-region compared to the number of employees within a city-region indicates a low level of network density. Likewise, the openness of a city-region can be defined as the ratio of the number of employees in a city-region residing in other city-regions and total employment in a city-region (Patuelli *et al.*, 2009).[11]

Table 3.1: Orientation of Commuting and Four Types of Urban Systems

		Exchange Commuting	
Criss-Cross Commuting		**Low**	**High**
	High	Criss-Cross	Decentralised
	Low	Monocentric	Exchange

Notes
Exchange Commuting Index: IC(PC→ST) / [IC(PC→ST) + IC(ST→PC)]
IC(PC→ST) = Incoming commuting in the surrounding territory emerging from the principal city
IC(ST→PC)= Incoming commuting in the principal city emerging from its surrounding territory

Criss-Cross Commuting Index: IC(ST→ST) / [IC(ST→ST) + IC(ST→PC)]
IC(ST→ST) = Commuting between different parts of the surrounding territory
IC(ST→PC) = Incoming commuting in the principal city emerging from its surrounding territory

3.5 Empirical Results

Spatial Organisation of English and Welsh City-Regions

Table 3.2 indicates the spatial organisation of the 22 selected city-regions in England and Wales in 2001 on the basis of employment and commuting trips. Based on the morphological and functional primacy indices, the majority of city-regions exhibit some extent of a functional and morphological polycentric pattern. On average, only 36.7% of the incoming commuting flows to the city-region and 28.8% of employees concentrate in the principal city. Middlesbrough, Preston, Reading and Southampton are the most relatively polycentric city-regions in England and Wales. Other city-regions, such as Nottingham, Leeds and Leicester, can still be characterised as relatively monocentric. Overall, there is a strong correlation between the degree of functional and morphological polycentricity of 0.77 (see also Table 3.3); city-regions that are relatively functional polycentric are also relatively morphological polycentric.

[11] Alternatively, this measure can be conceptualised as the ratio of the sum of external centrality scores of the different parts of the city-region divided to the sum of nodality scores of the different parts of the city-region.

Table 3.2: Spatial Organisation of English and Welsh City-Regions (2001)

City Region	Functional Primacy	Morphological Primacy	Network Density	Outward Openness
Southampton	17.8	15.8	31.1	8.4
Reading	19.8	11.9	29.0	18.7
Preston	20.6	13.0	28.4	7.2
Plymouth	24.4	24.1	19.8	2.7
Middlesbrough	25.0	16.9	31.6	3.9
Brighton	26.7	31.5	22.4	8.0
Newcastle	33.3	22.2	37.1	4.2
Manchester	34.1	19.2	34.5	9.7
Birmingham	35.5	35.2	30.5	11.2
Cardiff	35.8	29.8	29.1	4.3
London	38.2	23.0	51.4	6.2
Bristol	39.5	28.0	24.6	7.2
Stoke	39.5	26.9	25.3	12.7
Portsmouth	40.4	28.5	22.2	11.2
Sheffield	40.8	39.4	20.4	7.9
Northampton	44.4	43.7	18.6	18.7
Norwich	45.9	22.0	28.0	5.5
Liverpool	46.2	31.7	28.3	10.6
Coventry	47.0	43.5	21.7	19.9
Leeds	49.0	50.8	13.7	14.0
Nottingham	49.5	35.5	38.7	11.3
Leicester	53.1	41.6	34.0	12.4
Mean	**36.7**	**28.8**	**28.2**	**9.8**
Std. Deviation	**10.3**	**10.7**	**8.2**	**4.9**

Note: sorted on Functional Primacy

Now we turn to related aspects of the spatial organisation of city-regions: the degree of network density and outward openness. Table 3.2 shows that on average 28% of the employees in a city-region commute between different parts of the city-region, while approximately 10% of the employees live outside the city-region in which they work. However, there are considerable differences between city-regions, especially with regard to the degree of network density. London[12] appears to be the most networked city-region, with

[12] Central London as principal city is here defined as the Camden, City of London, City of Westminster, Islington, Kensington and Chelsea, Lambeth and Southwark with together form the Central London Partnership.

over half of its employees commuting between the different parts of the city-region.[13] With respect to the outward openness of city-regions, (unsurprisingly) the geographically isolated city-regions (Cardiff, Middlesbrough, Newcastle and Plymouth) are the most closed, while smaller city-regions located in between larger city-regions (Coventry, Northampton and Reading) are the most open.

Concerning the relationship between the different aspects of the spatial organisation of city-regions (see Table 3.3), there is fairly significant negative correlation between the degree of morphological primacy and network density. This means that a high degree of spatial integration between parts of the city-region characterises morphological polycentric city-regions. However, a relationship between the degree of functional primacy and network density is virtually non-existent. Therefore, functional polycentric city-regions are not more networked than functional monocentric city-regions, which support the decision not to combine these two measures into one index.

Table 3.3: Correlation Matrix of the Different Dimensions of the Spatial Organisation of City-Regions

	(1)	(2)	(3)	(4)
(1) Functional Primacy	1.00			
(2) Morphological Primacy	0.77	1.00		
(3) Network Density	-0.07	-0.43	1.00	
(4) Outward Openness	0.34	0.45	-0.31	1.00

Relatively polycentric city-regions are less open than relatively monocentric city. As indicated by Burger and Meijers (2011), this occurs because monocentric city-regions often have a disproportionately large centre with a relative overrepresentation of higher-order functions. Because it is well known that higher-ranked employees (in terms of education and income) are willing to commute longer distances to work (Schwanen and Dijst, 2002), these city-regions are more likely to attract employees residing outside the city-region.[14]

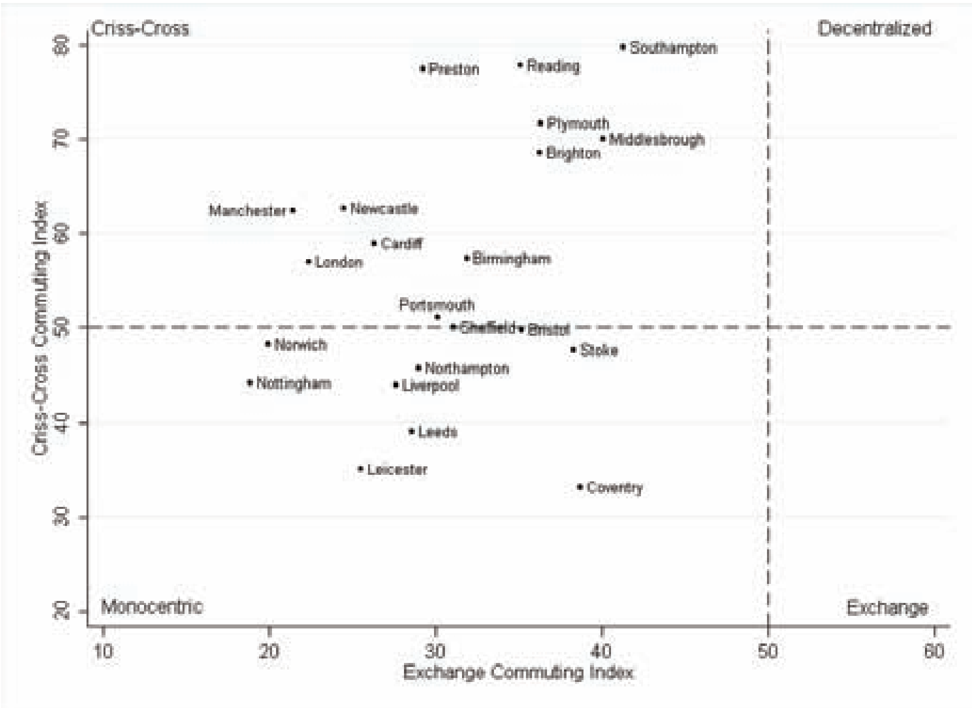
Yet, polycentric spatial structures differ across city-regions. Figure 3.4 indicates the presence of specific polycentric patterns for different English and Welsh city-regions. The demarcation lines represent the point at which the volume of criss-cross commuting is equal

[13] However, part of the variation between city-regions can be explained by the different areal units used to characterize the different parts of the surrounding territory. While for London boroughs are used

[14] Of course, the assessment of mono/polycentricity is to some extent dependent on the territorial delineation used as relations outside the region are not taken into account here. This is in geography better known as the Modifiable Areal Unit Problem (MAUP) (Openshaw and Taylor, 1979; Burger *et al.*, 2010). However, given that the city-regions in our study are to a large extent self-sufficient in terms of employment, we expect that this problem is limited in our analysis.

to the volume of traditional commuting and the point at which the volume of exchange commuting is equal to the volume of traditional commuting. The values on the horizontal axis indicate the ratio of the volume of exchange commuting compared to the volume of traditional commuting, while the values on the vertical axis indicate the ratio of the volume of criss-cross commuting compared to the volume of traditional commuting. According to this figure, the monocentric model and decentralised polycentric model prevail.

Figure 3.4: Functional Spatial Structures in England and Wales (2001)



With respect to the indicated geographical differences in metropolitan spatial structure, the city-regions in Nottingham-Sheffield-Leicester triangle have a relatively monocentric structure. Bristol, Coventry and Stoke represent more of an exchange commuting model. Brighton, Middlesbrough, Plymouth, Preston, Reading and Southampton can be characterised as city-regions in between a criss-cross and decentralised spatial structure. In the latter three city-regions, the volume of criss-cross commuting is over three times the volume of traditional commuting. The large city-regions around London, Birmingham, Newcastle, Cardiff, and Manchester fall between a monocentric and criss-cross spatial structure. Most strikingly, many city-regions in Southeast England are characterised by a relatively high level of decentralisation, while the larger city-regions in North England and the Midlands tend to have the most monocentric spatial structures.

The Dynamics of the Spatial Structure of City-Regions, 1981-2001

This section discusses the changes in the spatial organisation of the 22 English and Welsh city-regions over the two last decades of the 20th century. Table 3.4 shows the change in spatial organisation between 1981 and 2001 in terms of percentage points (pp). A number of conclusions can be drawn from the data. First, there is a clear tendency toward polycentric spatial structures, exemplified by a general decrease of morphological and functional primacy. In addition, city-regions have become more networked and open.

Second, with respect to geographical differences, the pace of polycentric development has generally been faster in city-regions in the Midlands and South England than in city-regions in North England and Wales. Bristol, Coventry, Leicester, London, Portsmouth, and Stoke have shown the largest polycentric development, closely followed by Birmingham, Norwich, and Plymouth. London and Portsmouth show a much greater tendency toward a functional polycentric structure than towards a morphological polycentric structure.[15] On the contrary, Leeds and Nottingham have become more monocentric, while the metropolitan spatial structures of other city-regions (Cardiff, Middlesbrough, and Sheffield) have shown only small changes. In general, there is a significant correlation of 0.84 between the change in functional primacy and the change in morphological primacy (see Table 3.5).

Yet, the city-regions that have become relatively more polycentric have not become relatively more networked; Middlesbrough and Cardiff have shown a much higher degree of spatial integration than London or Portsmouth. There is also a significant positive correlation of about 0.55 between an increase in functional or morphological primacy and an increase in network density. Although this might appear counterintuitive, it can be explained that a relative decrease in journey-to-work trips from the surrounding territory to the principal city coincides with a relative increase of journey-to-work trips within the

[15] Yet, overall, there is a strong correlation of 0.84 between the change in functional primacy and the change in morphological primacy.

different parts of the surrounding territory. The correlations between changes in outward openness and changes in primacy were insignificant.

Table 3.4: Changes in Spatial Organisation of English and Welsh City-Regions in Percentage Points (1981-2001)

City Region	Δ Functional Primacy	Δ Morphological Primacy	Δ Network Density	Δ Outward Openness
London	-13.7	-2.6	0.7	1.6
Bristol	-12.9	-6.6	2.6	2.8
Portsmouth	-12.5	-5.1	0.2	2.7
Coventry	-11.0	-7.2	3.0	7.9
Leicester	-11.0	-8.3	2.5	3.8
Stoke	-10.3	-6.9	2.4	3.5
Norwich	-9.9	-4.0	3.4	1.7
Plymouth	-9.4	-6.3	5.3	1.0
Birmingham	-8.3	-6.1	2.2	4.0
Manchester	-7.4	-3.3	3.6	4.6
Southampton	-7.1	-5.0	4.0	2.9
Liverpool	-5.3	-4.4	-0.9	2.8
Reading	-5.3	-2.6	2.7	7.8
Preston	-4.6	-0.3	5.4	3.0
Newcastle	-4.4	-1.9	5.7	1.8
Brighton	-4.1	-3.3	2.9	1.0
Sheffield	-4.0	-1.3	3.9	3.1
Cardiff	-1.7	2.3	7.1	1.9
Northampton	-1.7	-0.1	5.3	6.2
Middlesbrough	-0.6	0.7	7.9	-2.3
Nottingham	2.0	0.2	3.1	4.3
Leeds	7.1	3.6	4.9	5.4
Mean	**-6.2**	**-3.1**	**3.5**	**3.2**
Std. Deviation	**5.2**	**3.2**	**2.1**	**2.3**

Note: sorted on Δ Functional Primacy

Table 3.5: Correlation Matrix of Changes in the Different Dimensions of the Spatial Organisation of City-Regions

	(1)	(2)	(3)	(4)
(1) Δ Functional Primacy	1.00			
(2) Δ Morphological Primacy	0.84	1.00		
(3) Δ Network Density	0.53	0.56	1.00	
(4) Δ Outward Openness	0.04	-0.09	-0.26	1.00

Turning to the development of specific spatial structures, Figure 3.5 shows that most city-regions are developing toward a more decentralised pattern, whereas city-regions in South

England and the Midlands tend to do this at a faster pace than city-regions in North England and Wales. In Cardiff and Northampton, only some exchange commuting has developed; in Middlesbrough, only some criss-cross commuting has developed.

These findings are supported by the shift in relative share of the different types of journey-to-work trips in the city-regions over time (see Table 3.6). According to this table, many city-regions experienced a large decrease in the share of journey-to-work trips within the principal city (column 1) and a small decrease in the relative share of journey-to-work trips *within* the different parts of the surrounding territory (column 2). Concerning the relationship between the principal city and its surrounding territory is concerned, column 3 shows a decrease in the relative number of journey-to-work trips from the surrounding territory to the principal city (ST → PC; column 3; traditional commuting) and an increase of the flows from the principal city to the surrounding territory (PC → ST; column 4; exchange commuting). The data lead to the conclusion that the surrounding territory has become relatively more important. The latter point is also strengthened by the fact that the share of commuting *between* the different parts of the surrounding territory (ST → ST; column 5; criss-cross commuting) has increased. Overall, the surrounding territory became more important as final destination for journey-to-work trips.

Figure 3.5: Changing Functional Spatial Structure in England and Wales (1981-2001)

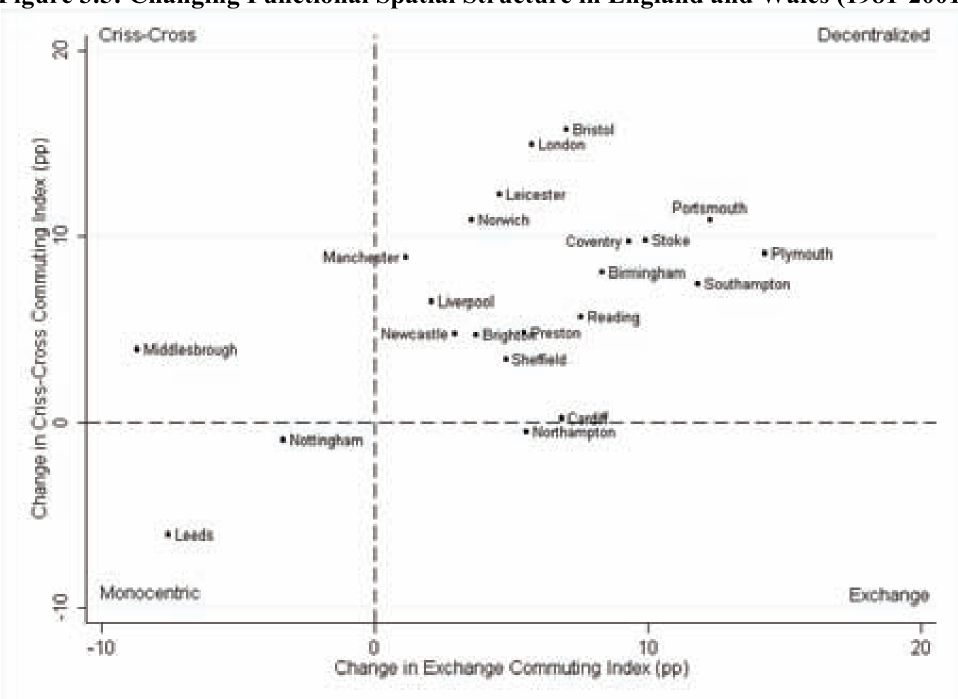


Table 3.6: Shift in Relative Share of the Different Types of Journey-to-Work Trips in Percentage Points (1981-2001; shaded cells more than 3 percentage points change)

City-Region	1 Within PC	2 Within ST	3 ST → PC	4 PC → ST	5 ST → ST
Birmingham	-4.7	2.5	-1.6	1.2	2.5
Brighton	-2.9	0.0	0.0	0.5	2.4
Bristol	-5.0	2.4	-1.8	0.7	3.7
Cardiff	0.1	-7.2	2.2	1.7	3.2
Coventry	-6.3	3.3	-0.6	1.9	1.7
Leeds	-0.5	-4.5	3.0	0.6	1.3
Leicester	-6.2	3.7	-2.1	0.8	3.8
Liverpool	-2.6	3.5	-2.0	-0.2	1.2
London	-0.8	0.1	-6.7	0.4	7.0
Manchester	-2.4	-1.2	-1.1	-0.1	4.7
Middlesbrough	-1.5	-6.4	1.8	-0.5	6.6
Newcastle	-2.2	-3.5	0.5	0.7	4.4
Northampton	-1.5	-3.9	2.1	1.5	1.7
Norwich	-3.2	-0.2	-0.9	0.5	3.8
Nottingham	-2.4	-0.7	2.2	-0.4	1.2
Plymouth	-6.2	0.9	-0.1	1.4	4.0
Portsmouth	-2.2	2.1	-2.7	1.3	1.5
Preston	-0.5	-4.9	0.1	0.6	4.7
Reading	-1.5	-1.2	-0.9	0.6	3.0
Sheffield	-1.9	-1.9	0.9	1.1	1.8
Southampton	-3.8	-0.1	-1.2	1.1	4.1
Stoke	-5.4	3.0	-1.4	1.7	2.1
Mean	-2.9	-0.6	-0.5	0.8	3.2
Std. Deviation	2.0	3.3	2.1	0.7	1.6

Within PC = Within Principal City, Within ST = Within Surrounding Territory, ST→PC = From Surrounding Territory to Principal City, PC → ST = From Principal City to Surrounding Territory, ST→ST = Between Different Surrounding Territories

City-regions which experienced a considerable shift toward a decentralised metropolitan spatial structure are often the city-regions which experienced a relatively large decrease in the share of principal city residents employed in the principal city (Table 3.6; within PC; column 1) or a large decrease in the share of traditional commuting (Table 3.6; ST→PC; column 3), as in the case of London. With respect to the surrounding territories, we find that city-regions in which the different parts of the surrounding territory have experienced an increase or only a small decrease in the share of journey-to-work trips within the different parts of the surrounding territory (Table 3.6; within ST; column 2) have decentralised most. This indicates that an increasing labour demand within the different parts of the surrounding territory coincides with a rise of criss-cross and exchange commuting and a decrease of traditional commuting.

Yet, the amount of decentralisation is, on average, still rather modest, and the spatial structure of city-regions is generally changing at a low pace. Given the time period of 20 years under review in this chapter, it can be argued that radical changes in the spatial structure of English and Welsh city-regions did not occur. However, there are also considerable differences between city-regions because their spatial structures can move in different directions and at different paces. The grey-marked cells in Table 3.6 indicate which city-regions showed the largest changes. Coventry, Leicester, and Stoke experienced large decreases in the share of the commuting within the principal city and large increases in commuting within the different parts of the surrounding territory. In Cardiff, Middlesbrough, Leeds, Newcastle, Northampton, and Preston, the share of the commuting within the different parts of the surrounding territory decreased considerably. London, in particular, had a relatively large decrease in traditional commuting as well as a large increase in criss-cross commuting. Criss-cross commuting also significantly increased in the Middlesbrough, Newcastle, and Southampton city-regions.

It is clear that city-regions that have transitioned to a more functional polycentric spatial structure are characterized by a decrease in traditional commuting and an increase in exchange and criss-cross commuting. The much greater tendency of London and Portsmouth toward a functional polycentric structure than towards a morphological polycentric structure can easily be explained by the fact that the decrease in the share of journey-to-work trips within the principal city has been limited in these city-regions.

3.6 Concluding Remarks and Limitations

The geography and planning literature has often assumed that all modern metropolitan systems are becoming polycentric. At the same time, the heterogeneity in the development of city-regions has not been the main object of various studies. Our analysis of commuting and employment data shows that, although many city-regions are becoming more polycentric, the spatial structure is differing considerably across city-regions. A related question is which kind of spatial structure prevails in specific regions. During the period 1981 – 2001 decentralisation in the spatial structure occurred across city-regions. These results are in line with the findings of De Goei *et al.* (2010) for the Greater South East UK, which also observed decentralisation at the intra-urban scale, exemplified by a relative increase in exchange and criss-cross commuting. Similar trends towards decentralisation of employment and population at the intra-urban scale are observed in Denmark (Nielsen and Hovgesen, 2005), France (Aguilera and Mignot, 2004), and Germany (Guth *et al.*, 2009).

Nevertheless, the extent of change in the overall spatial pattern is modest. In addition, the results show a large spatial differentiation. It was found that not all city-regions are moving in the same direction. Whereas the majority of city-regions in South England and the Midlands are becoming more polycentric, the spatial structure of many city-regions in North England is hardly changing or even becoming more monocentric. Having observed these different trends, the question remains why some city-regions become polycentric in form and other city-regions do not. Further empirical research should address this question in detail by quantitatively linking the spatial heterogeneity in the dynamics of metropolitan spatial structure with the heterogeneity in the initial shape, economic and socio-cultural developments and local and regional land use policies across city-regions.

Further research can use different approaches (De Goei *et al.*, 2010). First, more detail on the relationship between changing metropolitan spatial structure and the increasing flexibility and mobility of firms is needed. In particular, the link between advancements in transport, ICT, a developing service economy, and changes in metropolitan spatial structure deserves further attention. A starting point here would be the research of Ioannides *et al.* (2008), which has shown that ICT weakens agglomeration forces and provides incentives to relocate economic activities to smaller centres. Particular attention should be paid to how changes in the balance between agglomeration economies and diseconomies (e.g., pollution, crime) trigger changes in the spatial organisation of metropolitan areas and how a group of functionally linked centres share agglomeration economies (Meijers and Burger, 2010).

Secondly, the relationship between the changing metropolitan spatial structure and increasing flexibility and mobility of households can be further examined. Advances in transport and ICT make households not only more mobile, but can also change residential preferences. Advances in transport and ICT allow for the potential of changes in the demography of developed economies and the life styles of people and can thus affect metropolitan spatial structure (Champion, 2001). Such demographic developments include the rise of two-earner and single person households, the increasing number of working women, higher life expectancy, and a lower fertility (Hall and White, 1995). These demographic developments have changed the residential preferences of large groups of people, causing changes in the spatial organisation of urban systems (Van Ham, 2002).

Thirdly, the effect of local and regional policies on metropolitan spatial structure is a matter that can be analysed further. This includes policies that have the explicit intention to change metropolitan spatial structure and policies which unintentionally result in a change in metropolitan spatial structure. Likely, here are multiple drivers behind the changing spatial organisation of city-regions. However, these drivers may differ across various locations. In addition, the original shape of city-regions also influences changes in their spatial organisation are. Accordingly, it will be important to distinguish between city-regions and different determinants of metropolitan spatial structure.

Although commuting constitutes one of the most important economic interactions within a city-region, an important limitation of this study is that it only examined commuting and employment data. Several authors have pointed out that journey-to-work travel is not a perfect indicator for all economic interaction within a territory and should be used alongside other forms of economic interaction to gain a realistic insight into the interdependence of places and structure in urban systems (Lambregts *et al.*, 2005; Hewings and Parr, 2007). Accordingly, policymakers should be careful drawing inferences solely based on this study. Places are not only functionally connected through labour market relations, but also through trade, capital movements, leisure trips, and shopping trips (Lambooy, 1998; Parr, 2005). Admittedly, commuting trips are often the only type of data available and may provide a surrogate representation of other types of spatial interaction (Parr, 2005).Yet the degree to which commuting relations are a good proxy for other types of spatial interaction is far from clear and should be addressed in future research on metropolitan spatial structure. In particular, it is interesting to examine whether polycentric city-regions can still be regarded as functional polycentric when other types of economic interaction are taken into consideration. A similar point can be made with regards to morphological polycentricity and the internal characteristics of centres taken into consideration.

The evaluation of spatial structure is quintessentially scale-dependent and contingent on both the choice of analytical framework (European, national, regional, local) and the measurement of functional spaces dependent on the type of economic interaction (Hall and

Pain, 2006; Parr, 2008).[16] In our analysis, we evaluated the spatial structure of city-regions delimited on the basis of commuting and employment data. However, some urban functions, such as centres of corporate control and the supply of specialised goods and services, have a larger geographical scope and are concentrated in only a few major cities (Parr, 2008). In this light, the city-regions of Brighton, London, Northampton, Reading, Southampton, and Portsmouth studied in this chapter can be considered secondary city-regions within some primary city-region at a higher geographical scale with London as principal centre.

Lambregts *et al.* (2005: 32) then also rightly remark that '*polycentricity is up to certain extent in the eye of the beholder*'. Preferably, indicators suggesting a territory is polycentric should be weighed against indicators suggesting otherwise, taking into account the spatial scale at which polycentricity is studied. Only in this fashion, it will be possible to completely grasp how territories are spatially organised and how this spatial organisation changes over time. Such thorough understanding of these processes is necessary in order to explain the dynamics of spatial structure and to inform policy.

[16] Of course, the delimitation is to some extent also dependent on the delimitation algorithm and procedure that is used (Cörvers *et al.*, 2009).

Chapter 4:

Polycentricity and the Multiplexity of Urban Networks

Abstract[1]
Empirical studies on polycentric urban regions (PURs) tend to analyse their spatial organisation by examining only one type of functional linkage between cities. However, it has generally been accepted that urban networks are multiplex phenomena and that spatial interactions between cities can take many different forms, for example, commuting, business travel, shopping trips, corporate-control relations and inter-company trade. The spatial organisation of each of these functional linkages is not necessarily identical, and, therefore, a region can appear to be polycentric and spatially integrated based on the analysis of one type of functional linkage but monocentric and loosely connected based on the analysis of another type of functional linkage. The aim of this chapter is to stimulate further discussion on the multiplexity of urban networks with regard to polycentric development policies and the relational complexity of urban regions. Focusing on one PUR (Randstad Holland) and comparing the geographical scope and spatial structure of different functional networks within it, we examine the extent to which different urban networks can overlap. We show that such an analysis not only provides a better understanding of how functional polycentricity, spatial integration and urban-network development at the level of the PUR play out in practice but will also help planners and policy-makers understand what functions can best be regionally coordinated.

[1] This chapter is currently under review and has been co-authored with Bert van der Knaap and Ronald Wall. It has been slightly edited to fit the format of this book.

4.1 Polycentricity in Planning and Practice

Whereas European spatial planning in the 1980s was mainly concerned with land-use regulation and specific development projects, the 1990s were characterised by a revival of strategic spatial planning (Albrechts *et al.*, 2003; Albrechts, 2004; Healey, 2004). This reorientation in spatial planning meant a shift in focus from the physical planning of space-using functions such as housing, industry, transport and nature to the development of strategic frameworks and new visions for regional development. This resurgence of interest in strategic spatial planning can be seen as a departure from the neoconservative and postmodern disbelief in the 'makeability of society' (Albrechts, 2004) and is fuelled in part by the problems of coordinating public policy, promoting urban and regional competitiveness through the development of a collective asset base and mitigating inequalities of opportunity across cities and regions (Healey, 2004).

In this 'new' strategic spatial planning (cf. Healey, 2004), polycentricity is a catchphrase; polycentric development policies have mainly been introduced to encourage a more balanced spatial distribution of economic activities between geographic units (cities, regions) across an area as well as higher levels of urban and regional competitiveness (Meijers and Romein, 2003). The rationale behind such policies differs from area to area and ranges from the overconcentration of economic activities in one place and the underutilisation of resources in other places to the desire to prevent exodus from rural areas, promote environmentally sustainable development, and increase economic and social cohesion and solidarity in general (Meijers *et al.*, 2007).

Polycentricity can mean different things at different geographical scales (Kloosterman and Musterd, 2001; Davoudi, 2003; Meijers *et al.*, 2007; Vandermotten *et al.*, 2008). At the level of the European Union, polycentricity has mainly been introduced to stimulate growth outside of the areas known as the 'Pentagon' "*to ensure regionally balanced development, and create global economy integration zones*" (Commission of European Community, 1999, para. 67). At the national level, polycentric development policies have aimed to achieve competitiveness and cohesion by reducing disparities in development between regions and between cities at different levels in the national urban hierarchy (Meijers *et al.*, 2007). At the regional level, academic discussion and policy debate has predominantly focused on the development of Polycentric Urban Regions (PURs), which can be best described as a set of historically and spatially separate metropolitan areas comprising a larger, functionally interrelated urban region (Kloosterman and Musterd, 2001). As indicated by Faludi (2004), such polycentric spatial constellations are supposed to be more competitive than their monocentric counterparts because they provide opportunities to take advantage of some of the positive factors associated with large agglomerations, such as broader labour markets, luxury goods and services and airports, while avoiding some of the negative factors associated with such agglomerations, such as pollution, crime and congestion.

Despite the scale-dependent interpretation of polycentricity, one of the common characteristics of polycentric development policies is that they all seek the spatial integration of particular regions (i.e., the enlargement of particular functional regions) through urban network development. At the continental and national levels, it is believed that equality will be improved by strengthening urban-rural relationships through the creation of a network of internationally accessible metropolitan regions (well-distributed across the European Union or across the country in question). At the regional level, functional linkages between medium-sized cities and towns within a PUR are promoted to achieve synergies between the different parts of the region (Meijers, 2005) and so that they will be able to compete with their monocentric counterparts, such as London and Paris (Dieleman and Faludi, 1998). This is supposed to create a favourable setting for economic growth, especially when the cities and towns in such an urban network complement each other in terms of their economic specialisations. Polycentric development policies seem to combine the ostensibly conflicting objectives of regional cohesion and competitiveness (Waterhout, 2002).[2]

Although polycentricity has featured prominently as a normative strategic planning concept in policy documents and the academic literature, less attention has been paid to polycentricity as an analytical construct for studying the spatial organisation of geographic areas (Van Houtum and Lagendijk, 2001; Davoudi, 2003). Indeed, most of the planning and geography literature has focused on polycentricity as a spatial-planning vision as well as on capacity-building in and governance of polycentric areas, where polycentricity is perceived as a goal in itself. However, the number of studies that assess empirically how well the polycentric model fits the reality of contemporary urban systems is gradually increasing. This development has been spurred not only by an increase in the availability of data on urban networks but also by the increasing need to assess the validity and usefulness

[2] At the same time, evidence that a polycentric region was functionally integrated would also support planning on larger geographical scales than that of the city or region in question to manage those spatial interdependencies (Turok and Bailey, 2004).

of the notion of polycentricity in the context of polycentric development policies (Meijers, 2008b).

In particular, many scholars have questioned the extent to which PURs really operate as functionally integrated entities and whether spatial planning really contributes significantly to the development of a PUR (see, for example, Albrechts, 2001). Although it is often argued that the monocentric city is being replaced by the polycentric urban network as the dominant form of spatial organisation, it remains unclear to what extent the PUR model accurately reflects spatial reality. The existence of multiple urban centres in close proximity to each other does not necessarily even imply that there are strong functional links between those centres, let alone that the ostensible PUR is functionally polycentric in that the orientation of the functional links (for example, commuting, shopping, and trade) within that PUR are multidirectional. Taking these considerations into account, several scholars have argued that there is limited spatial integration and urban network formation at the level of the PUR, even in regions that are considered archetypical PURs from a morphological point of view, such as the Basque country (Van Houtum and Lagendijk, 2001; Meijers *et al.*, 2008), the Randstad in Holland (Lambooy, 1998; Lambregts *et al.*, 2006; Van Oort *et al.*, 2010), and the Flemish Diamond (Albrechts, 2001; Cabus and Vanhaverbeke, 2006; Hanssens *et al.*, 2011). As a PUR cannot exist in practical terms without a minimum amount of interaction between the various parts (Champion, 2001; Parr, 2004; Governa and Salone, 2005), this purported lack of integration raises serious questions for the many policy attempts to initiate and sustain polycentric economic-development trajectories in Europe.

However, Lambregts (2009) rightly notes that the degree of polycentricity and spatial integration that can be seen in a particular region is highly dependent on the indicators used to measure it. Urban networks are multiplex phenomena and, therefore, polycentricity and spatial integration can be studied by evaluating different types of functional linkages between cities and regions, for example, commuter trips (Van der Laan, 1998; Aguilera, 2005; De Goei *et al.*, 2010; Burger *et al.*, 2011a), telephone calls (Camagni and Salone, 1993; Halbert, 2008), intra-firm networks (e.g., the POLYNET study documented in Hall and Pain (2006) and Hoyler *et al.* (2008)), and inter-firm networks (Van Oort *et al.*, 2010; Hanssens *et al.*, 2011). The spatial organisation of each of these types of functional linkages is not necessarily similar and, therefore, a region may appear polycentric and spatially integrated with respect to one type of functional linkage but monocentric and loosely connected with respect to another type of functional linkage.[3] Most of the empirical studies have evaluated the spatial organisation of regions by looking only at one, or at most two or three, types of functional linkages. Similarly, spatial planners have limited themselves to mere abstract descriptions of concepts such as the PUR and have difficulty envisioning regions in a more refined way, partly due to a dearth of data on how a given city or town is linked with other places in the wider territory (Healey, 2004; 2006). As the appropriate level for meaningful policy-making differs across types of functional relationship, it is difficult to develop a cohesive set of policy recommendations for PUR development based on only one type of relationship.

The aim of this chapter is to stimulate further discussion on the multiplexity of urban networks in the context of polycentric development policies and the 'relational complexity' (cf. Healey, 2006) of urban regions. Focusing on the PUR and comparing the geographic scope and spatial structure of different functional networks, we analyse the extent to which different urban networks overlap. In this study, we examine the networks of the Randstad region in the Netherlands, which has been described as an archetypical PUR in the geography and planning literature (Lambregts *et al.*, 2005; 2006). We argue that by taking into account the multiplexity of urban networks, to the meaning of functional polycentricity, spatial integration and urban network development at the level of the PUR from an analytical point of view can be better understood. With respect to polycentricity as a normative planning strategy, insights into the complex structure of polycentric areas will help policy-makers to decide what functions would be best organised at the PUR level. At a more general level, this investigation makes a valuable contribution to the debate regarding the appropriate scales for governance.

The remainder of this chapter is organised as follows. Section 4.2 gives a more detailed introduction to the notions of functional polycentricity, spatial integration, and the multiplexity of urban networks. Section 4.3 introduces the Randstad region in the Netherlands as an empirical setting and describes the data and the methodology. Section 4.4 summarises the empirical results, and Section 4.5 presents a discussion of the implications and our conclusions.

---

[3] This has been demonstrated empirically by, for example, Lambregts *et al.* (2005; 2006), whose analyses of commuting patterns, intra-company office networks and inter-company business-services networks give very different pictures of the spatial organisation of the Randstad region in Holland. Similar conclusions can be drawn with regard to other regions based on the work of Limtanakool *et al.* (2009) and Lüthi *et al.* (2010).

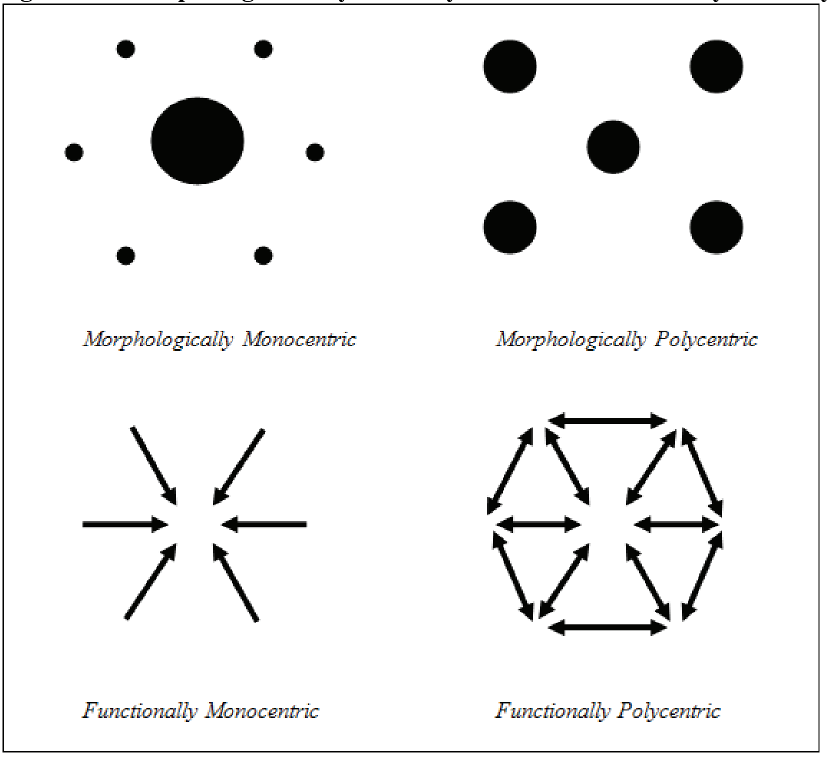
4.2 Polycentric Urban Regions and the Multiplexity of Urban Networks

Polycentric Urban Regions, Functional Polycentricity and Spatial Integration

Recent studies assessing the spatial reality of the PUR model have drawn particular attention to the degree of functional polycentricity and spatial integration of the regions so described (e.g., Hall and Pain, 2006; De Goei *et al.*, 2010, Burger *et al.*, 2011a; Coombes *et al.*, 2011; Hanssens *et al.*, 2011). Functional polycentricity defines the importance of particular centres in an urban network on the basis of their centrality within that network and assesses whether the centres are equally important in terms of their network position. Because it is based on the multidirectionality of the links in urban networks, the measurement of functional polycentricity differs from the measurement of morphological polycentricity, which is based on the extent to which people, companies or employment are evenly distributed across the different centres within a territory (Green, 2007; Burger and Meijers, 2011; see Figure 4.1). In other words, the morphological approach focuses on the characteristics of nodes rather than the characteristics of links; in the morphological approach, the importance of the centres is usually assessed based on their relative size. As the application of the PUR model is largely based on the ostensible existence of functional *links* between different centres in terms of the physical movement of goods, people and services, the notion of functional polycentricity is coming to be more widely used in the empirical literature than its morphological counterpart (Burger *et al.*, 2011a).

Nevertheless, the functional and morphological approaches share the same basic principle, in that both characterise polycentric areas as consisting of a group of urban centres that are relatively equal in terms of their importance (Kloosterman and Lambregts, 2001; Meijers, 2008b). Drawing on central-place theory (Christaller, 1933; Lösch, 1944), and the urban-systems literature (Berry, 1964; Bourne and Simmons, 1978), Burger and Meijers (2011) draw a theoretical link between morphological and functional polycentricity by arguing that if the importance of a city is only determined on the basis of its size, part of that importance can be attributed to the city being a provider of jobs, goods, services and capital to its own population and another part can be attributed to the city being a provider of jobs, goods, services and capital to other places. For example, the total employment in a city can be broken down into 1) employment of people who both work and live in that city and 2) employment of people who work in that city but live elsewhere (i.e., people who are incoming commuters). In this example, the morphological approach would evaluate the spatial distribution of total employment, whereas the functional approach would evaluate the spatial distribution of incoming commuting flows only. In a functionally polycentric system, there is no obvious orientation towards any particular centre, and the centres are relatively equal in terms of the magnitude of their external linkages or their *centrality*.

Figure 4.1: Morphological Polycentricity versus Functional Polycentricity



Another important aspect of a PUR is its degree of spatial integration. In its most general meaning, spatial integration refers to "*the creation and maintenance of intense and diverse patterns of interaction and control between formerly separate social spaces*" (Lee, 2009, p. 398). Within the PUR model, spatial integration can be seen as referring to the existence of functional links between historically and geographically separate metropolitan areas. De Goei *et al.* (2010) and Van Oort *et al.* (2010) have argued that a PUR functions as an urban network if the probability of interaction is determined solely by the sizes of the cities and towns in it and the physical distances between them. Hence, controlling for size and distance, interdependencies between cities within one part of PUR should not be stronger than interdependencies between cities across different parts of the PUR. A similar argument can be made with respect to functional polycentricity; if size and distance are controlled for, the interdependencies between cities at different levels of the urban hierarchy (e.g., core-periphery relationships) should not be stronger than the interdependencies between cities at the same level of the hierarchy.

In analytical work on polycentricity, it is important to not to conflate the degree of spatial integration with the degree of functional polycentricity; they are different theoretical constructs (Burger and Meijers, 2011). There are spatial systems that are strongly networked as well as monocentric and spatial systems that are not networked at all but are polycentric. In fact, previous empirical research has shown that there is no correlation between the degree of functional polycentricity and degree of spatial integration, indicating that they should be treated as two distinct aspects of the spatial organisation of regions (Burger and Meijers, 2011; Burger *et al.*, 2011).

The Multiplexity of Urban Networks

In the geography and planning literature, it is generally acknowledged that urban networks are multiplex in that they are comprised of '*multidirectional flows of not only economic but also social, cultural and environmental activities*' (Davoudi, 2008, p. 51). Different places are functionally connected not only by labour-market relationships but also by trade, capital movement, and consumer travel as well as commutes for school, social visits and leisure trips (Masser, 1972; Lambooy, 1998; Turok and Bailey, 2004; Parr, 2005; Hewings and Parr, 2007; Van der Knaap, 2007). This results in a complex web of inter-regional relationships, where cities and regions are dependent on other cities and regions for education, labour, capital and intermediate goods as well as markets for products. Examples of different types of functional links are given in Table 4.1. Although the functional linkages differ in their economic importance (e.g., social visits versus trade), it should be noted that cities and regions are above all human phenomena and that they are as much social, cultural and environmental entities as economic entities (Davoudi, 2008). Although it can be argued that the PUR is mainly an economic concept that focuses on regional competitiveness and cohesion, strategic planning around PURs could well be extended to incorporate other policy fields.

Although the multiplexity of urban networks has been widely recognised in the academic and policy discourse, most empirical studies have only used commuting data to analyse the functional spatial organisation of areas at the local and regional scale because they are often the only type of data available (Parr, 2005; De Goei *et al.*, 2010).[4] This is not by definition problematic, as commuter trips can be used as a surrogate representation for other types of spatial interactions in cases where 1) the other linkages shape the internal structure of metropolitan areas in the same manner that commuting does and 2) the geographical scope of the interactions is similar (Bode, 2008). The geographical scope and spatial structure of different functional linkages are undeniably related, at least to some extent, as many of these activities take place in the context of other activities (Masser, 1972). For example, an individual can travel from home to work, do some shopping during the lunch break, and play billiards with colleagues after work. A similar view is found in space-time geography (see, for example, Hägerstrand, 1970; Thrift, 1977), which examines how people fit their various daily activities into their space-time budget. These activity patterns are quintessentially interdependent because activities affect and constrain each other. In this paradigm, the institutions to which people belong (e.g., households and companies) and with which they interact (e.g., stores, schools, and other companies) can be treated similarly.

Table 4.1: Examples of Functional Linkages across Space

Producer	Linkage	Attractor
Workers' residences	Journeys to work (Commuting)	Workplaces
Children's residences	Journeys to school	Schools
Consumers' residences	Shopping trips	Stores
Workers' residences	Business travel	Customer firms
Supplier firms	Buyer-Supplier (Inter-Firm Trade)	Customer firms

However, different functional linkages do not necessarily have the same geographical scope, and no individual network can give a complete picture of the spatial interdependencies between different cities and regions. It is quite clear that the geographical scope of commuting is generally smaller than that of corporate ownership and that people are willing to travel longer distances on recreational trips than for daily shopping. There are thus no uniquely definable regional boundaries, and the geometry of functional regions '*is best characterized by multiplicity, fuzziness and overlaps*' (Davoudi,

[4] As Davoudi (2008) points out, this has also resulted in the dominance of an economics-based conceptualisation of functional regions.

2008, p. 57). Related research by Coombes and his colleagues has shown that the functional regional boundaries that can be drawn based on journeys to services or movement related to housing markets (measured by migration patterns) can be very different from the functional regional boundaries that can be drawn based on journeys to work (Coombes and Wymer, 2001; Robson *et al.*, 2006).

In addition, different places can fulfil different functions within an urban network, and places that are central with respect to one function are not necessarily central with respect to other functions. However, the most important cities are those that *connect the global with the local* in that they operate as places in which daily activity patterns, trade in goods and services, information and communication networks and corporate-control networks come together. From this premise, it follows that some functions will be more evenly distributed across different places than other functions; in particular, the more national- and international-level functions (e.g., corporate control) are concentrated in only a few places. The degree to which a region can be characterised as polycentric is then dependent to a certain extent on 'the eye of the beholder' (cf. Lambregts, 2005), as it is dependent on the lens through which it is assessed.[5]

The discussion of the multiplexity of urban networks is not confined to analysing the co-existence of different space-time relationships and the spatial organisation of those relationships; it also inevitably draws attention to interdependencies between the different geographical scales (Van der Knaap, 2007). As we mentioned above, companies and households have a multiscalar spatial orientation with respect to the different activities that they undertake. Some of their activities are very local, whereas others transcend regional boundaries and thereby connect different geographical scales. For example, all of the international functions within a PUR may be concentrated in one city (for example Amsterdam, London, or Paris), but the manufacturers and service companies supplying such an international city and the highly educated workforce employed in that international city may be scattered across the wider urban region (for example, the Randstad in Holland, the Greater South East in Britain, or the Bassin Parisien). Therefore, if the position of the city within the global network of international cities changes, it also affects the labour and commodities markets of the wider urban region. This mutual dependence can be the basis

[5] Similarly, an urban system may have a predominantly polycentric structure at the regional level and a predominantly monocentric structure at the local level or vice versa. For example, commuting, trade and shopping could be multidirectional at the level of the PUR but unidirectional at the level of the individual metropolitan areas (see also De Goei *et al.*, 2010).

for the regional coordination of at least some of the functions within a PUR. Although some functions can be organised individually at the local level, other functions are better organised collectively. In executing such collective coordination, it is important to identify the supralocal functions and the stakeholders that should be involved in the planning process. This does not mean that it is easy to build 'organising capacity' (cf. Meijers and Romein, 2003). Different stakeholders, such as public institutions, business organisations, and pressure groups, can often have divergent interests, which can lead to competition within and between the levels of government and between a wide variety of actors. We will discuss this problem further in this chapter.

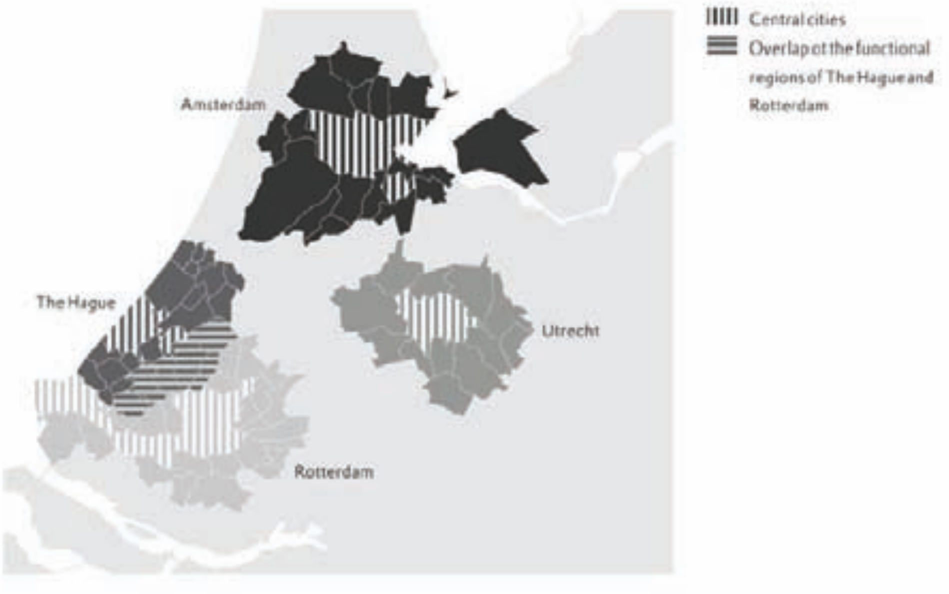
4.3 Urban Networks in the Randstad Region

The Empirical Setting: Randstad Holland

The Randstad is a conurbation in the western part of the Netherlands, in which four major cities, i.e., Amsterdam, Rotterdam, Den Haag, and Utrecht, and a number of smaller towns, including Delft, Dordrecht, Haarlem and Leiden, are situated in close proximity to each other. As shown in Figure 4.2, the Randstad can be conceptualised as consisting of four *subregions*, each of which includes one of the four major cities and the lower-order municipalities (i.e., suburbs, which may be secondary urban centres, villages or hamlets) that are centred around that city. In the literature on spatial structure, the Randstad has often been hailed as a prototypical PUR; since the publication of *Werkcommissie Westen des Lands* (Working Commission for the Western Netherlands) (1958) and the work of Sir Peter Hall in the 1960s (Hall, 1966), as well as in debates on spatial planning, the Randstad has often been perceived as a single, contiguous urban region that functions as an integrated economic entity. However, the Randstad is not an administrative unit, there is no formal Randstad authority, and the Randstad still lacks effective governance (Lambregts *et al.*, 2008). Governance of the Randstad is spread across three levels: the municipalities, the provinces and the central government. Despite serious attempts to build capacity at the Randstad level in the second half of the 20^{th} century, the overall goal of encouraging polycentricity and the spatial integration of the entire Randstad have been subject to various trends in planning and policy-making (see Lambregts and Zonneveld, 2004; Lambregts *et al.*, 2008).

In the 1980s and 1990s, Dutch urbanisation policies focused largely on the development of compact cities. However, more recently, borderless regions, polycentric development, urban networks and overlapping physical infrastructure and social networks have become the central themes in regional and national strategic planning documents, including the draft version of the *Vijfde Nota Ruimtelijke Ordening* (Fifth Netherlands National Planning Document), the *Nota Mobiliteit* (Policy Document on Mobility), the *Nota Ruimte* (National Spatial Strategy) and the *Amsterdam Structuurplan* (Amsterdam Structure Plan). According to Van der Burg and Dieleman (2002), there were a number of reasons behind this shift in focus from compact cities to urban networks in national urbanisation policies. Amongst other reasons, municipalities and metropolitan areas were seen as being too small to be appropriate units for planning because housing and labour mobility increasingly involved the crossing of local boundaries and because global competition was seen as favouring larger urban areas. As Meijers and Romein (2003) point out, these recent policy documents strongly emphasise regional coordination and cooperation of a sometimes far-reaching nature, in that municipalities that are considered part of an urban network are to develop spatial plans in mutual consultation.

Figure 4.2: Randstad Holland



A proposal to create a Randstad province that was put forward by a commission led by former Dutch prime minister Wim Kok was recently rejected, and the latest policy document, *Structuurvisie Randstad 2040* [Structural Vision Randstad 2040], favours the concentration of the major international functions in the Amsterdam region and the spatial integration of the northern and southern parts of the Randstad separately instead of the integration of the Randstad as a whole. Lambregts *et al.* (2008) argue that one of the reasons for this change in policy is that it appears to be difficult to build a regional organising capacity in the Randstad and establish voluntary cooperative agreements between the different stakeholders involved. In this situation, efforts at regional coordination and cooperation fail not only because different stakeholders have divergent interests but also because the proponents of a stronger governance at the level of the Randstad cannot convince other stakeholders that it is the appropriate scale for planning and policy-making. A historical account of the Randstad as a spatial-planning concept is beyond the scope of this chapter, but Lambregts and Zonneveld (2004) and Lambregts *et al.* (2008) provide excellent overviews of the subject.

Various scholars have also questioned whether the Randstad really constitutes a PUR, as the formation of functional links between the different parts of the Randstad has been limited (e.g., Lambooy, 1998; Ritsema van Eck *et al.*, 2006; Van Oort *et al.*, 2010), and have stressed that having the ambition of creating a polycentric and spatially integrated region does not automatically result in a polycentric and spatially integrated region. A recent OECD report (2007, p. 15) concludes pessimistically that '*although its morphology as a polycentric metropolitan area gives the Randstad as a whole the opportunity to benefit from the proximity of its several cities and their natural landscapes...these opportunities are currently underused*'. One of the problems is that the spatial-planning conceptualisation of the Randstad is predominantly based on its morphological aspects rather than its functional aspects (Healey, 2004; 2006). Although polycentricity and spatial integration are cited as important characteristics of the Randstad region, planning documents continue to describe these issues in very abstract terms. They fail to translate the complexity of spatial interdependencies into multiplex, relational spatial representations (Healey, 2004, p. 535) and are at best an '*uneasy attempt to combine a geography of place with particular qualities and a geography of flows*'. In other words, strategic planning for the Randstad often does not take into account the differences in the scope of and appropriate scale of governance for different functional linkages.

In this chapter, we build on the existing literature by evaluating the different functional relationships between municipalities within the Randstad. The few empirical studies that have analysed PURs in terms of multiplex urban networks (e.g., Lambregts *et al.*, 2005, 2006; Ritsema van Eck *et al.*, 2006) have indicated that the degree to which a region appears to be functionally polycentric depends on the type of functional linkage examined. Similarly, the degree of spatial integration of the different subregions varies across functions. For example, Lambregts *et al.* (2005; 2006) show that although commuting is still restricted to separate subregions, the Randstad constitutes a single market for companies that provide business services to multinational corporations. At the same time, most of these multinationals are concentrated in Amsterdam, which causes the Randstad to appear fairly monocentric.[6]

Interdependencies at the level of the Randstad do certainly exist. It is therefore important to identify those strategic issues for which there is a significant degree of spatial integration at the level of the PUR and subsequently build a regional organising capacity to realise the Randstad's potential. Currently, there appears to be a lack of understanding amongst planners and policy-makers in the Randstad as to *how* cities and towns are linked (Healey, 2004; 2006). This, in turn, results in a lack of support for regional coordination and cooperation, and the level of support is already low because of the divergent interests of the stakeholders involved. Given these considerations, insights into the multiplexity of urban networks may provide a tool for spatial planning and policy-making to build the organising capacity at the level of the Randstad PUR.

Data

To gain insights into the multiplexity of urban networks, we have used three data sources related to 1) daily-activity patterns, 2) intra-firm networks, and 3) inter-firm networks. First, data on activity patterns were obtained from the *Mobiliteitsonderzoek Nederland* (Dutch National Travel Surveys) for the period of 2004-2008. These data are collected on an annual basis; on average, 50,000 individuals participate in the survey. Of the nearly 550,000 trips in the dataset, which includes geographical information about the origin and destination of the trip, over 130,000 (almost 25%) had as their destination one of the municipalities in the Randstad. Amongst these trips, it is possible to distinguish six types of functional link: journeys to work, journeys to school, business travel, shopping trips,

[6] Lüthi *et al.* (2010: 114) observe a similar pattern in the Munich region, which they classify as '*a hierarchically organized polycentric mega-city region and high-grade localized system of value chains*'.

leisure trips, and social visits. Journeys to work can be further subdivided into trips made by working individuals with a high level of educational achievement (ISCED 5-6), those with a moderate level of educational achievement (ISCED 3-4) and those with a low level of educational achievement (ISCED 0-2). By weighting the data to make them representative of the Dutch population as a whole[7] and aggregating the data at the municipality level (LAU-2), we were able to construct a multidimensional network of activity patterns for the Randstad. In such networks, a municipality with many incoming connections can be considered central.

Second, the data on the 10,000 most important corporations headquartered in the Netherlands and their respective subsidiaries were used to analyse intra-firm relationships. These data were obtained from the Reach and *Kamer van Koophandel* (Chamber of Commerce) databases, in which headquarters and subsidiary firms are coded by geographic coordinates and economic sectors. We made a further distinction between manufacturing, wholesale distribution and business services, based on the classification of the headquarters. Of the 111,883 subsidiary firms in the database, 63,624 (56.9%) are owned by firms whose headquarters are located in one of the 69 Randstad municipalities. By aggregating the data at the municipality level, the relative importance of cities and towns can be assessed within corporate networks. In this analysis, the degree of centrality of a municipality in the urban network was determined based on the number of subsidiary firms (i.e., connections) that corporations headquartered in that municipality have. This can be considered to be a measure of the level of ownership that companies in a particular city have of firms in other cities; a municipality with many incoming subsidiary-headquarters connections has considerable control over other municipalities and is, therefore, central in the urban network. A more detailed description of how this type of data analysis is constructed can be found in Wall *et al.* (2009) and Wall and Van der Knaap (2011).

Third, data on inter-firm relationships in the Randstad were obtained from the survey by Van Oort *et al.* (2010) of companies based in the Randstad, in which the companies were asked to indicate the main sources and destinations of their most important selling and purchasing activities. The data were gathered in a 2005 survey of more than 20,000 firms in manufacturing, wholesale, and commercial services that had more than one employee based in the Randstad (Van Oort *et al.*, 2010). The 1,676 companies that responded to the survey (8%) were representative in terms of their regional distribution and stratification by firm size.[8] The data were aggregated at the municipality level. A

[7] The weighting factors were included in the data as analysed.

[8] A random, stratified sample, taking size and region into account, was extracted from the LISA database, which is an employment register including all Dutch establishments (see Van Oort, 2007). The survey focused on

municipality with many connections in terms of the total number of selling and purchasing relationships can be considered central.[9]

Quantifying the Spatial Organisation of the PUR

Although the spatial organisation of the PUR has many facets and networks can be compared in many ways, we focus here on two particular aspects of that organisation: functional polycentricity and spatial integration. The degree of functional polycentricity is determined by the balance in the importance of the region's urban centres in terms of their *centrality* within the urban network. In our analysis, centrality scores are based on the number of incoming functional linkages, excluding intra-municipality linkages. When the urban centres in the Randstad's network are more equal in importance, the region is more functionally polycentric. To assess the distribution of the importance of urban centres within the Randstad region in terms of the different types of functional linkage, we used the commonly used ordinary-least-squares log-log rank-size regression method (see also Meijers, 2008b; Burger and Meijers, 2011). The major indicator is the slope of the regression line that best fits these rank-size distributions, which ranges between 0 (polycentric) and $-\infty$ (completely monocentric). In other words, a flatter downward slope of the regression line indicates a more functionally polycentric region. In contrast, a steeper downward slope of the regression line indicates a more functionally monocentric region.[10]

In comparing different types of functional linkage, it is best to base the rank-size regressions on a fixed number of centres (see also Meijers, 2008b; Burger and Meijers, 2011). In our analysis, we treated the Randstad as a closed system (always using the same set of 69 municipalities) and estimated the coefficients for the four and ten most-central municipalities. As an example, Figure 4.3 shows the rank-size distributions (including the 95% confidence intervals) of the four most-central municipalities in the Randstad in terms of incoming commuting and social visits. As can be seen in the graphs, the rank-size distributions can differ considerably across types of functional linkage; in this example, incoming social visits give a more polycentric picture of the Randstad than incoming commutes.

---

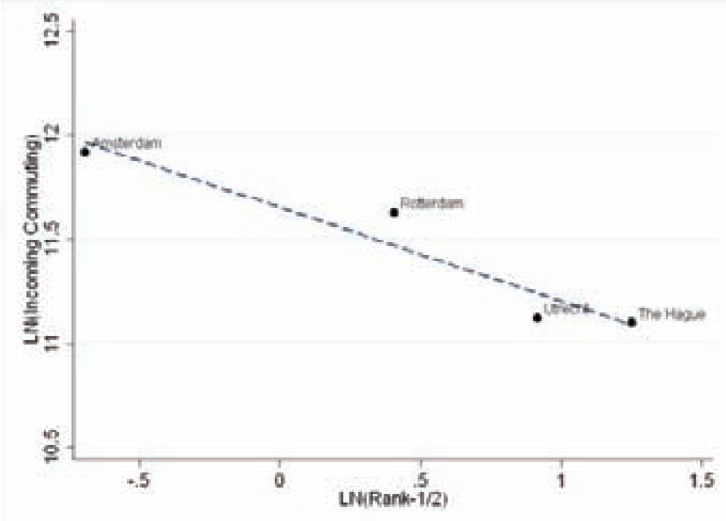
companies' ten most important selling and purchasing relationships with other establishments within or outside of their own municipality. The limitation of the data to ten relationships may lead to a potential bias in the analysis of the network structure towards large establishments, but large establishments are not overrepresented in cities in the Randstad (Van Oort *et al.*, 2010). We were not able to analyse the different sectors separately.

[9] Because of the limitations of the data, we are not able to distinguish between incoming and outgoing connections in this case.

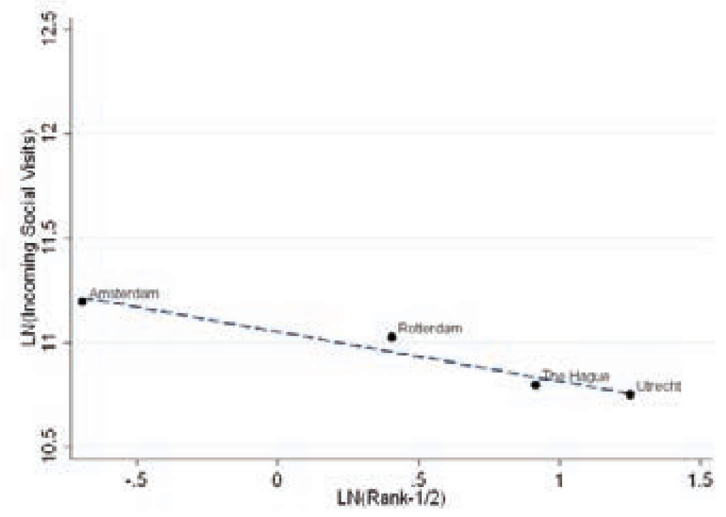
[10] We used the specification of Gabaix and Ibragimov (2011) to estimate the coefficients.

Figure 4.3: Rank-size Distributions Measuring Monocentricity versus Polycentricity for Two Types of Functional Linkages

(A) Commuting



(B) Social Visits



Following previous research (Green, 2007; Burger and Meijers, 2011; Burger *et al.*, 2011a), we measured the degree of spatial integration by evaluating network density. Network density can be conceptualised as the ratio of the number of actual connections between centres to the number of potential connections between centres (Green, 2007). In this study, we investigated two aspects, namely the *internal network density* and the *overall network density*, of the Randstad. The internal network density is a measurement of the number of connections between the municipalities in the Randstad as a proportion of the total number of connections originating from the municipalities in the Randstad and reflects the relative importance of the other Randstad sub-regions compared to the own subregions. The overall network density is a measurement of the connections between municipalities in different subregions of the Randstad as a percentage of the total number of connections. For both of these indicators, a low score indicates a low degree of spatial integration.

4.4 Polycentricity, Integration and the Multiplexity of Urban Networks

Geographical Scope and Overlap amongst Urban Networks

Table 4.2 gives an overview of the geographical scope of different functional linkages targeted at municipalities in the Randstad. To determine the scope of each type of link, we distinguished between linkages originating from 1) the same municipality, 2) other municipalities in the same subregion, 3) other municipalities in the Randstad, 4) other municipalities in the Netherlands, and 5) locations outside the Netherlands.[11] The data in the table show that the geographical scope of the spatial interaction varies from very local (for shopping and education) to predominantly international (subsidiary-headquarters relationships). More than 80% of all journeys to school and shopping trips whose destination is a municipality in the Randstad originate within the same subregion. In contrast, only one out of six subsidiary-headquarters relationships are within the same subregion.

[11] It should be noted that these distinctions depend on our definition of the Randstad. A large number of trips that we analyse as having originated outside the Randstad in fact originated in urban centres that are in close proximity to the Randstad but are not part of the Randstad according to our delimitation. Because we are mainly interested in comparing different types of functional linkage and are focusing on the polycentricity and integration of the four largest urban centres in the region, this delimitation is appropriate. However, this caveat underlines that the definition of the boundaries of functional regions is heavily dependent on the functional relationship under consideration (see also, Brown and Holmes, 1971).

Table 4.2: Geographical Scope of Different Functional Links Targeted at Municipalities in the Randstad

	Within Same Municipality %	Elsewhere within same Subregion %	Elsewhere in the Randstad %	Elsewhere in the Netherlands %	Outside the Netherlands %
Activity Patterns					
Commuting	38	29	12	21	0
- *Less-well-educated workforce*	*46*	*30*	*7*	*17*	*0*
- *Medium-educated workforce*	*39*	*31*	*9*	*20*	*0*
- *Highly-educated workforce*	*30*	*26*	*19*	*25*	*0*
Journey-to-school	62	17	7	15	0
Business travel	31	22	13	33	1
Shopping trips	78	13	2	8	0
Leisure trips	62	18	5	14	1
Social visits	53	20	9	18	0
Intra-firm Relationships					
Subsidiary-HQ relationships	14	2	6	10	68
- *Manufacturing*	*11*	2	*5*	*12*	*70*
- *Wholesale*	*11*	2	*3*	*5*	*79*
- *Business services*	*24*	*3*	*13*	*13*	*47*
Inter-Firm Relationships					
Buyer-supplier relationships	22	16	20	28	15

On the basis of these data on geographical scope, it is also possible to identify those functions for which coordination and cooperation would be most relevant at the level of the Randstad. Relative to other types of functional linkage, there appears to be a significant degree of network formation with respect to inter-firm relationships, in the form of buyer-supplier relationships and business travel. However, it should be noted that, even for these latter types of spatial interaction, connections within the same subregion are more numerous than those with municipalities in other subregions of the Randstad (see also Van Oort *et al.*, 2010).

In the analysis of commuting patterns, significant differences were found in the geographical scope of the labour-market areas for more highly educated individuals and less-well-educated individuals. Whereas less than 25% of the less-well-educated working population live in a different subregion from the one they work in, nearly 45% of the more highly educated working population does so (within the latter group, about 20% come from elsewhere in the Randstad and the other 25% come from outside the Randstad, most often from the bordering municipalities). This finding confirms the results of previous research on Dutch travel behaviour, which has shown that individuals of a higher socioeconomic status are more likely to engage in long-distance travel (Van Ham, 2002; Limtanakool *et al.*, 2006). In addition, it signifies that commuting patterns (and perhaps also other types of functional linkage) are far from homogeneous and that complexity should be taken into account when examining spatial-interaction data.[12] Indeed, as Meijers and Romein (2003) have suggested, the Randstad may function more like a PUR for some particular subparts of the population.

Functional Polycentricity and Network Density

Having examined the geographical scope of the different functional linkages analysed, we now turn our attention to the two most important aspects of the PUR: the degrees of functional polycentricity and spatial integration. As a benchmark, we also estimated the degree of morphological polycentricity, based on total population and number of establishments, using a similar rank-size regression method. The rather high coefficients (close to zero) for the rank-size regressions of the four largest urban centres (Amsterdam,

[12] However, it is often difficult to obtain such detailed, broken-down data for functions of interest. For example, it is well known from the central-place literature that most inter-regional shopping trips are for purchases of luxury goods rather than daily shopping goods (Dijst and Vidakovic, 2000). Although these trips represent different types of functional linkage, it is most often not possible to make such distinction in the analysis of data on shopping trips.

Rotterdam, The Hague and Utrecht) for population (-0.31) and employment (-0.42) indicate that the Randstad is morphologically a fairly polycentric region.

In our analysis of functional polycentricity, we found that the coefficients of the rank-size regressions for the ten most functionally polycentric largest urban centres are slightly more unevenly distributed than the rank-size regressions for the four most functionally polycentric centres (see Table 4.3, Columns 1 and 2). This finding highlights that the Randstad is polycentric at the inter-urban level but consists of four rather monocentric subregions (see also Van Oort *et al.*, 2010; Burger and Meijers, 2011). With regard to the differences between types of functional linkage, especially inter-municipal shopping and social visits, the connections appear to be multidirectional, having relatively very low rank-size coefficients. In contrast with inter-municipal shopping and social visits, the rank-size coefficients for population (-0.31 for the four largest centres) and employment (-0.42 for the four largest centres) show that those morphological features are less evenly distributed in the Randstad. The patterns of inter-municipal business travel and buyer-supplier relationships are also quite polycentric.

In contrast, the distribution of subsidiary-headquarters links (i.e., of corporate-control functions) is relatively skewed, especially with respect to business services, in that a disproportionate share of these relationships involve headquarters in the Amsterdam region (see Table 4.3, Column 3). Our analysis confirms the results of previous studies by Lambregts *et al.* (2005; 2006) and Wall (2009), who found that Amsterdam is the only truly global city in the Randstad. In fact, if we had limited our sample to the top 100 Dutch companies or performed analyses on the top 100 European or global companies, an even more monocentric pattern would likely have emerged with Amsterdam firmly positioned at the top of the Randstad hierarchy (see Wall, 2009). We found a similar pattern when we analysed only the concentration of incoming subsidiary-headquarters links in the Amsterdam region, which is the most central region with respect to all of the functional linkages under consideration (see Table 4.3, Column 3).

The degree of spatial integration (see Table 4.3, Columns 4 and 5) corresponds closely with the geographical scope of different types of functional linkage described in the previous section; the degree of spatial integration in the Randstad region is also function-dependent.

Table 4.3: Degrees of Functional Polycentricity and Spatial Integration Based on Functional Linkages

	Functional Polycentricity (N=4)	Functional Polycentricity (N=10)	Concentration in Amsterdam subregion	Internal Network Density	Overall Network Density
Activity Patterns					
Commuting	-0.45	-0.95	0.40	0.15	0.12
- Less-well-educated workforce	*-0.40*	*-0.91*	*0.40*	*0.08*	*0.07*
- Medium-educated workforce	*-0.45*	*-0.97*	*0.40*	*0.11*	*0.09*
- Highly-educated workforce	*-0.35*	*-1.00*	*0.39*	*0.25*	*0.19*
Journey-to-school	-0.41	-1.04	0.30	0.08	0.07
Business travel	-0.31	-0.88	0.37	0.20	0.13
Shopping trips	-0.25	-0.73	0.30	0.02	0.02
Leisure trips	-0.46	-0.87	0.38	0.06	0.05
Social visits	-0.24	-0.68	0.31	0.11	0.09
Intra-firm Relationships					
Subsidiary-HQ relationships	-0.66	-1.15	0.42	0.28	0.06
- Manufacturing	*-0.83*	*-1.15*	*0.38*	*0.27*	*0.05*
- Wholesale	*-0.42*	*-0.95*	*0.34*	*0.20*	*0.03*
- Business services	*-0.84*	*-1.62*	*0.48*	*0.33*	*0.13*
Inter-Firm Relationships					
Buyer-supplier relationships	-0.33	-0.67	0.33	0.34	0.20

Given the aforementioned problems with delimiting the boundaries of the Randstad, the level of network formation with respect to the commuting patterns of the highly educated working population, business travel, intra-firm relationships and inter-firm relationships can be considered to be moderately high. This finding is broadly in line with the work of Lambregts *et al.* (2005; 2006), who found that the Randstad constitutes a single market for firms that provide business services to multinational corporations. On the other hand, other flows, such as commuting of the less-well-educated workforce, shopping and journeys to school remain relatively local. Figures 4.4-4.8 illustrate the difference between different types of flows (the graphs for the other functional relationships are available on request).

Although the Randstad does not (yet) function as a spatially integrated region, the potential seems to exist for organising these particular functions at a higher level of governance than that of the individual subregions and especially for organising these functions between the four larger cities (see also Van Oort *et al.*, 2010). In terms of key strategic issues, policies could be developed to further improve labour mobility, especially for the more highly educated portion of the workforce, to solve, for example, the problem of simultaneous high unemployment in one part of the region and a scarcity of potential employees in other parts of the region (Meijers and Romein, 2003). In addition, transportation and infrastructure policies could be developed to support commuting and trade flows between the different subregions (Albrechts and Lievois, 2004). However, for very local functions such as retail and education, the Randstad might not be the appropriate level at which to formulate and implement spatial planning policies. At the same time, the local focus of these daily activity patterns is at the root of one of the basic problems in generating support for governance at the PUR level; the most visible functional relationships are the most local ones (see also Lambregts *et al.*, 2008). Indeed, whereas functional relationships at the level of the Randstad certainly exist, they are less numerous; however, they are not by any means economically insignificant. Conversely, most subsidiary-headquarters relationships have an international orientation, and the overall network density within the Randstad for those types of functional link is very low. In addition, the corporate-control network is relatively monocentric, which seriously weakens its potential for aiding in the building of organising capacity.

Figure 4.4: Commuting of Less-Well-Educated Workforce in the Randstad

Figure 4.5: Commuting of Highly-Educated Workforce in the Randstad

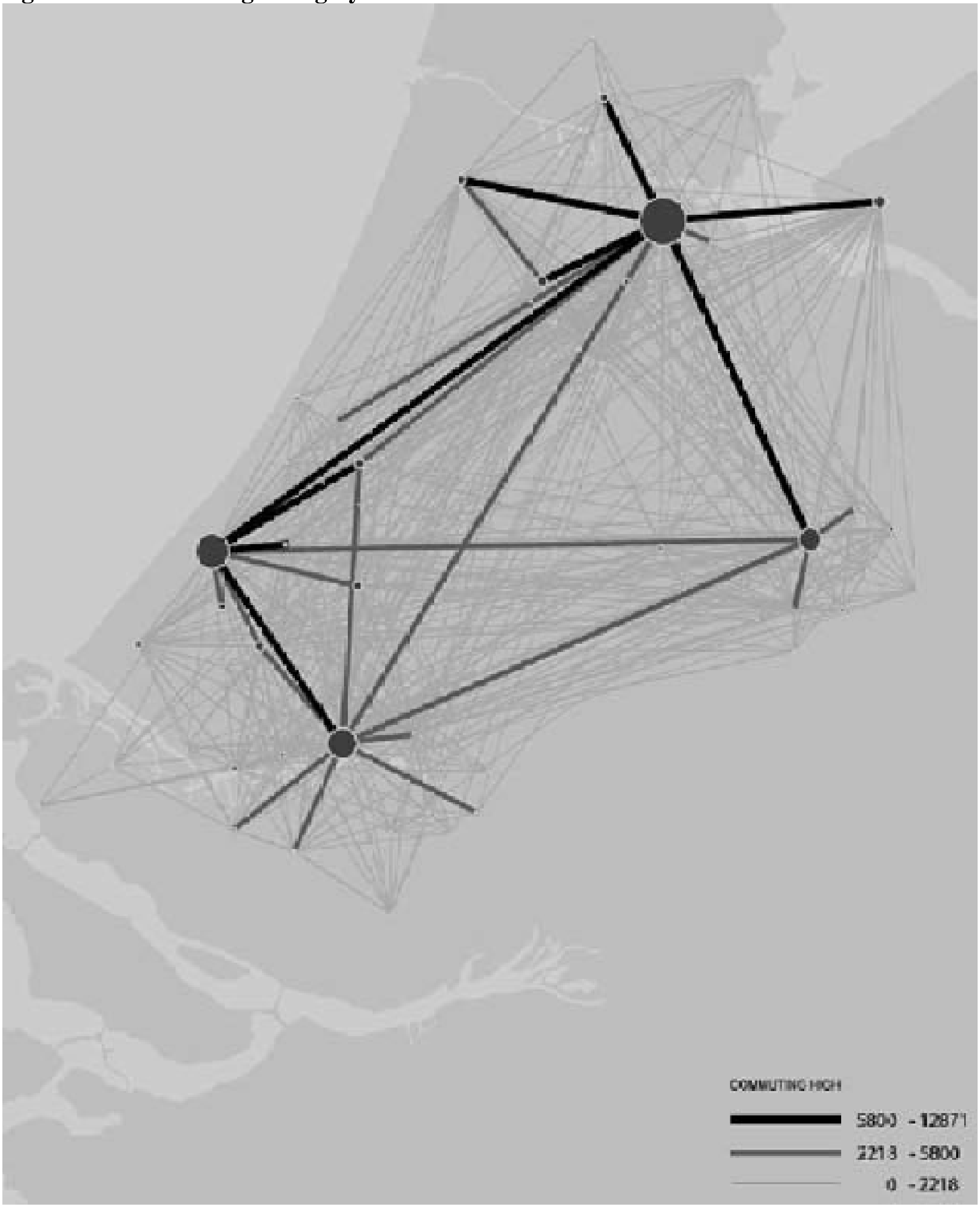


Figure 4.6: Shopping in the Randstad

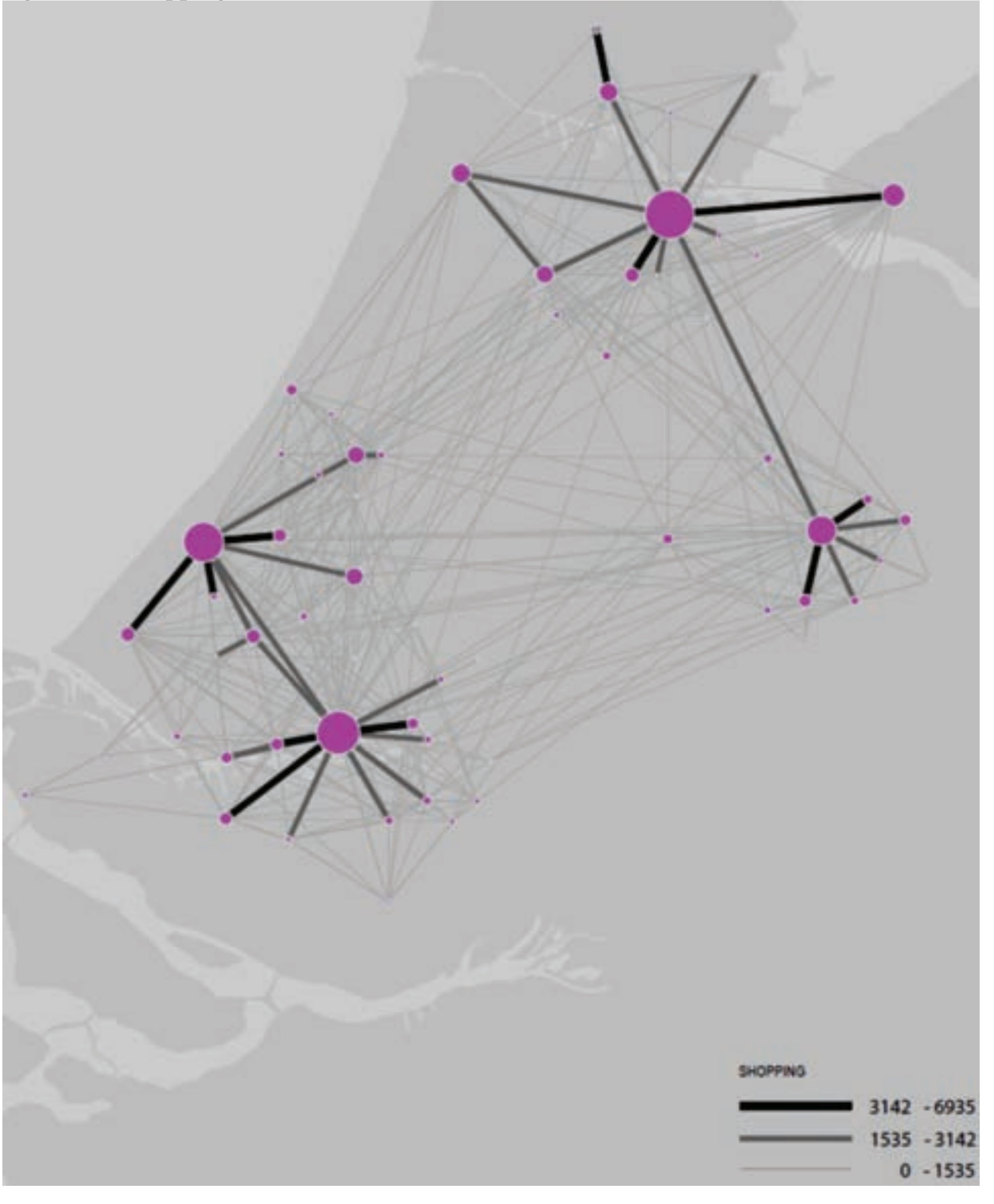


Figure 4.7: Business Travel in the Randstad

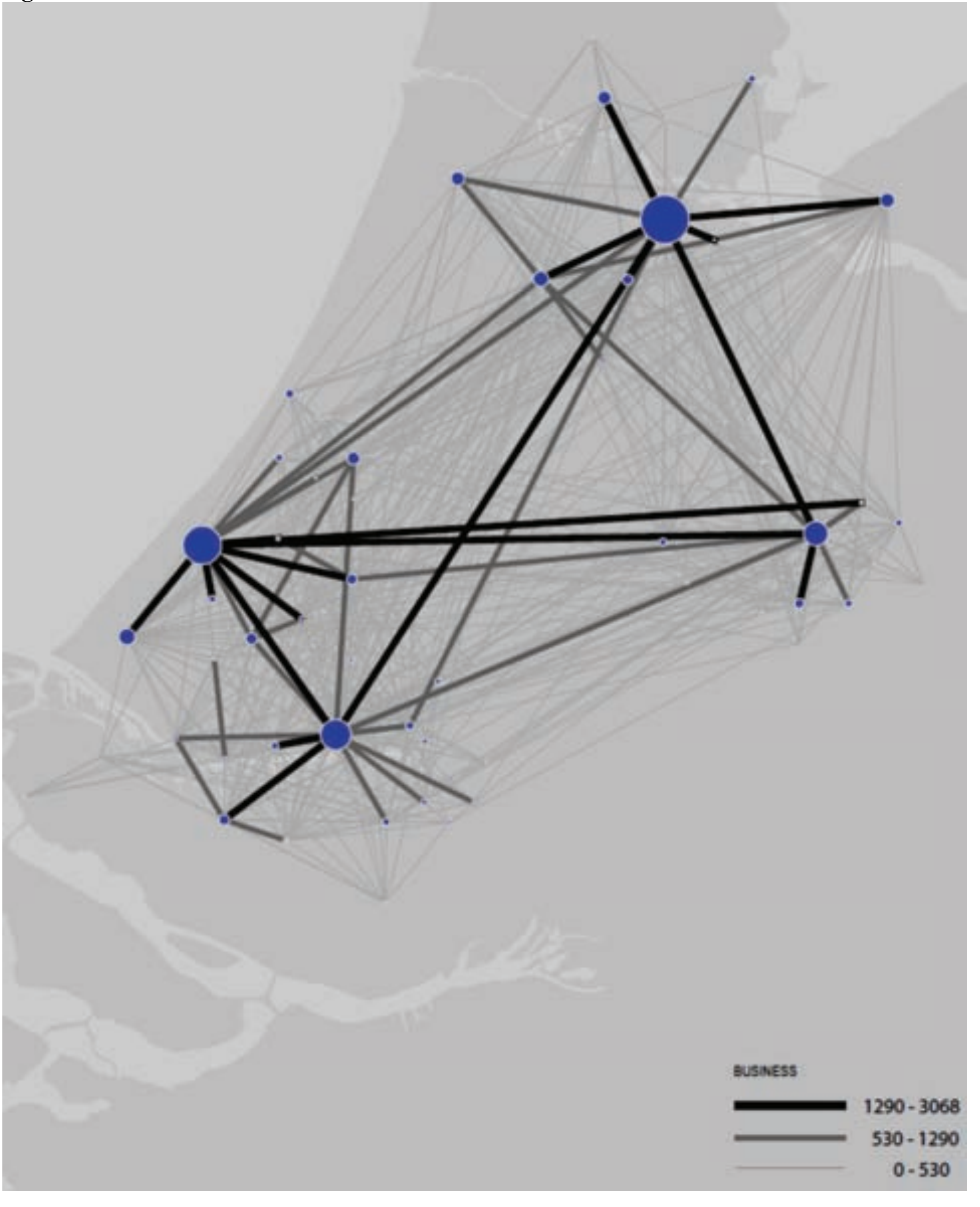
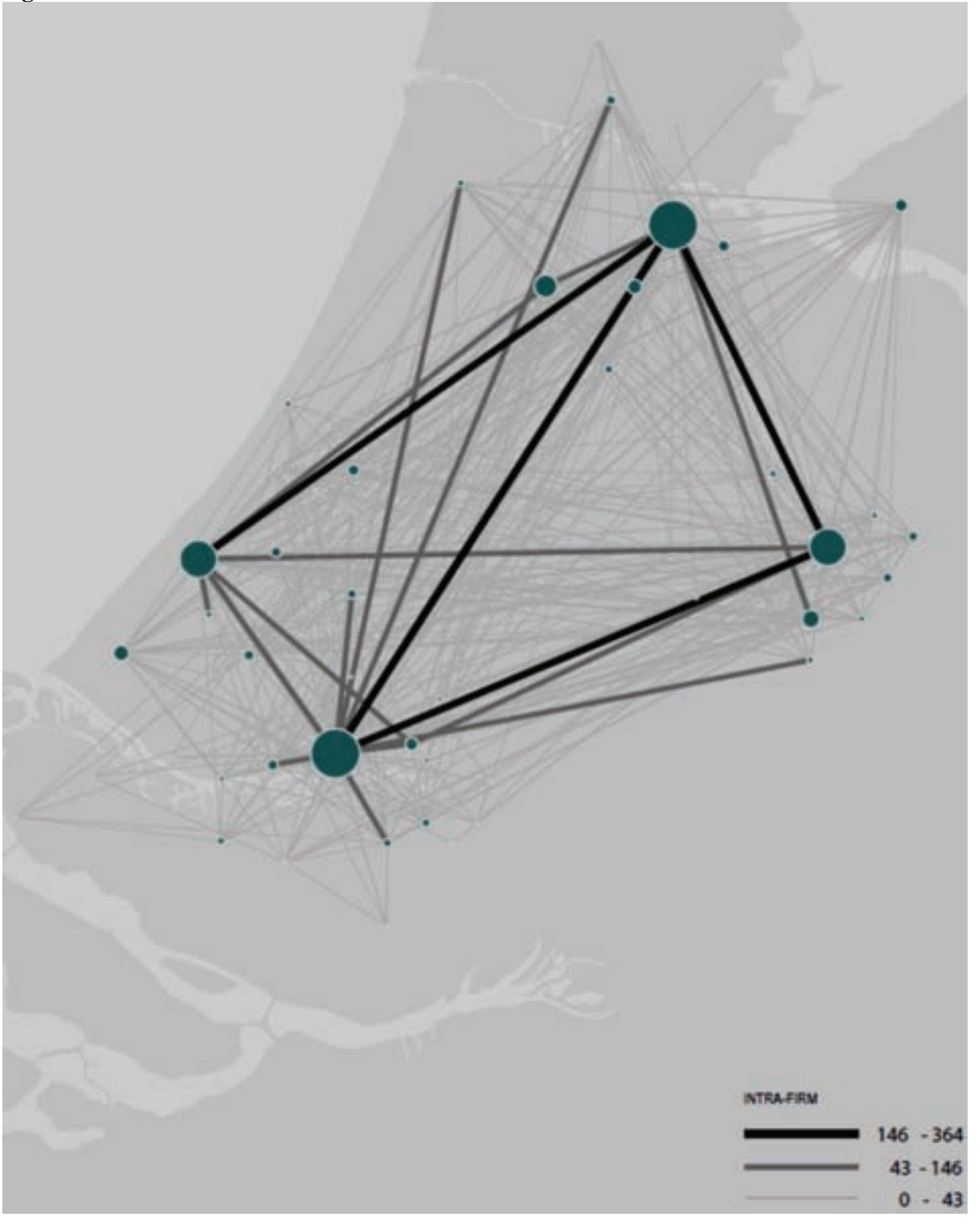


Figure 4.8: Intra-Firm Relations in the Randstad



4.5 Multiplexity in a Policy Perspective

In this chapter, we have examined the multiplexity of urban networks within the context of the PUR. The analyses of commuting, journeys to school, business travel, shopping-related travel, trade and investment flows in the Dutch Randstad have highlighted different aspects of the relational complexity of that PUR; these analyses have provided some indications as to whether regional planning and policy-making would be useful at the level of the PUR in general and the Randstad in particular. Although the Randstad is undeniably polycentric from a morphological point of view (at least in comparison with similarly-sized regions across the world), it is not necessarily polycentric from a functional point of view, in that Amsterdam can be considered its only truly global city (see also Lambregts *et al.*, 2005; 2006 and Wall, 2009). In addition, the degree of spatial integration between the different parts of the Randstad appears to be limited; this observation echoes the findings of other studies on PURs. Further research, including a more formal, econometrics-based testing framework (see, for example, De Goei *et al.*, 2010 and Van Oort, 2010) is needed to confirm our findings with regard to the spatial organisation of the Randstad.

Although these results raise some serious questions for the many planning and policy attempts to encourage the development of an integrated Randstad region, we have also shown that the Randstad is more polycentric and spatially integrated with respect to some functions (e.g., the labour market for the highly educated working population and various business-related functions) than others (e.g., retail trade and education). These findings have important implications for public policy and spatial strategic planning, in that urban-network policies should be focusing mainly on regional coordination and cooperation with regards to the supralocal functions by taking into account the existing power relationship between the cities and towns within a PUR.

This does not mean that regional coordination and cooperation are impossible with respect to more local functions. However, the lack of functional coherence limits what can be achieved by PUR-level governance. Because PURs are often not administrative units, regional cooperation and coordination is already difficult; commitment to the process is often on a voluntary basis, and different stakeholders often have divergent interests, which can lead to competition within and between levels of government and among the wide variety of actors involved. Albrechts (2001, p. 743) also rightly points out that '*only when the issue at stake surpasses the capacity of the individual cities and a win-win situation can be provided, may cities be willing to consider delegating parts of their competence to* *another authority*'. It is easier to generate support for organising around supralocal functions at the level of the PUR when stakeholders can be more easily convinced that the PUR is the appropriate scale for policy-making.

However, it is also important to take into account those divergent interests and the existing hierarchical and power relationships within a PUR, while keeping in mind that these interests and relationships may be structured differently with respect to different functions. Because a PUR is generally characterised by an absence of *accepted* hierarchies between its largest cities, some authors have argued that regional coordination and cooperation are easier in the absence of such accepted hierarchical and power relationships (see e.g., Lambregts *et al.*, 2008). In addition, not all municipalities in the Randstad are dependent to the same extent on the success of the PUR. For example, Amsterdam has managed to achieve global-city status and has grown considerably without intensive regional coordination and cooperation at the level of the Randstad (Lambregts *et al.*, 2008). However, at the same time, Amsterdam would probably not be able to maintain this position in worldwide corporate networks without the Randstad region providing business services and highly qualified labour. Similarly, the different functions within the Randstad are also interdependent, which results in a complex urban network of functional relationships between places, where the success of regional cooperation and coordination is especially dependent on the perceived need to organise these functions at the PUR level and on the commitment of all of the relevant stakeholders. On the other hand, if the spatial organisation of a particular supralocal function is relatively monocentric, the success of regional coordination and cooperation will depend to a greater extent on the attitude of the leading stakeholder.

This contrast again highlights the significance of existing tensions and cooptition within PURs and the need to carefully select the key strategic issues that can best be coordinated at the regional level. Strategic planning must also take into account the effects of polycentricity and spatial integration on regional performance. Although the development of a PUR may result in the pooling of resources and the development of complementarities between its cities, it is as yet unclear to what extent a PUR actually outperforms a region consisting of individual metropolitan areas with respect to supralocal issues. Although more literature on this topic has been appearing (e.g., Lee and Gordon, 2007; Meijers and Burger, 2010), much more work is necessary.

Chapter 5:

Revealed Competition for Greenfield Investments between European Regions

Abstract[1]

In the modern economy, cities are assumed to be in fierce competition over attracting foreign investments in leading sectors of the world economy. Despite the rich theoretical discourse on these 'wars', it remains unclear which territories are competing with each other over which types of investments Combining insights from international economics, international business, and urban systems literature, we develop an indicator to measure revealed competition between territories for investments based on the overlap of investment portfolios of regions. Taking competition for greenfield investments between European regions as a test subject, we identify competitive market segments, derive the competitive threat a region faces from other regions, the competitive threat regions pose to other regions, and the most important market segments in which regions compete. We show that European regions with similar locational endowments pose a fiercer competitive threat to one another. In addition, regions that are sufficiently large and distinctive, face the smallest average competitive threat from all other regions.

[1]This chapter is currently under review and has been co-authored with Bert van der Knaap and Ronald Wall. It has been slightly edited to fit the format of this book.

5.1 Introduction

In a globalising world in which the mobility of capital and the number of sites that are suitable for any particular business location steadily increases, cities and regions increasingly compete over drawing multinational corporations (MNCs) to their territory. These 'place wars' can take place at local, regional, national, continental, or even global spatial scales (Gordon, 1999). To boost their economies and increase their standards of living, cities and regions have to work on their ability to successfully compete with other territories (i.e., *competitive advantage*) over attracting foreign investments in leading sectors of the world economy (Storper, 1997; Kitson *et al.*, 2004).[2] Today, local and regional governments not only use incentive-based policies (e.g., subsidies, taxes) but also capacity-building policies such as government spending on amenities, education, physical infrastructure, and public transportation networks to foster the attractiveness of their territory (Begg, 1999). At the same time, taking advantage of a territory's sources of competitive advantage has moved to the central stage in local and regional development policy: the marketing and branding of cities and regions has become a 'booming business' (Paddison, 1993; Van der Berg and Braun, 1999), while budgets for place promotion are ever increasing (LeRoy, 2005; Markusen and Nesse, 2007).

The increasing interest in urban and regional competitive advantage has resulted in a substantial number of ranking lists, in which cities and regions are compared on the basis of their internal characteristics, such as their economic performance (Kresl and Singh, 1999), global connectivity (Taylor, 2004), creativity and innovativeness (Florida, 2005), and quality of life (Rogerson, 1999). This benchmarking of cities and regions is not only found in academia and commercial research but is also strongly embedded in public policy and popular culture. Today, local authorities increasingly publicise their relative competitive stance with that of other areas (Malecki, 2002; Kitson *et al.*, 2004), while many magazines (e.g., *Fortune Magazine*, *Forbes*, *Money*) seem to be obsessed with rankings how cities and regions compare to each other (McCann, 2004). In this light, several studies and policy reports have also addressed the competitive advantage of territories in attracting foreign investments (e.g., UNCTAD, 2001).

Nevertheless, in the discussion on urban and regional competition, it remains unclear which territories are competing with each other over which types of investments. In other

[2] At the same time, attracting many (high-level) investments can be a source of competitive advantage in that it generates a demonstration effect (Budd, 1998) as well as agglomeration externalities.

words, most studies that present performance rankings of cities and regions implicitly assume that all cities and regions compete to the same extent with each other and little attention is paid to identifying the scope and intensity of territorial competition. This assumption is not surprising, as competition is often conceptualised as a characteristic of a market in economics, and therefore, all local and regional governments would compete over foreign investments. Still, the 'market for investments' is highly segmented or, at best, not a level playing field. Despite the increasing mobility of capital, only a limited number of locations can satisfy the criteria of an MNC that would like to invest in a particular project abroad (Lall and Pietrobelli, 2002; Dunning and Narula, 2004; Narula and Bellak, 2009). This fact is reflected in the location choice process of MNCs, in which the majority of all potential locations in the world are not even considered by company site selectors (Aharoni, 1966; Buckley *et al.*, 2007; Mataloni Jr., 2010).[3]

The need to focus on capitalising particular potentials that a city or region has is increasingly recognised and anticipated by local and regional development agencies that try to attract specific foreign investments to their territory and to articulate distinctive assets of their region in promotional marketing (Raines, 2004). In this respect, cities and regions have also become aware that foreign investments are not a sine qua non for economic growth (Mencinger, 2003; Barba Navaretti and Venables, 2004) and that it is best to attract investments that complement their economic structure to profit most from spillovers (Dunning and Narula, 2004; Narula and Bellak, 2009). Inter-territorial relationships, then, are not necessarily competitive in nature but can also be cooperative in how firms use places in different ways (Taylor *et al.*, 2010; Taylor, 2011). Cities and regions can be complementary to the extent that they exploit different sources of competitive advantage and, hence, fulfil different economic roles within the urban system (Gordon, 1999; Van Oort *et al.*, 2010).[4]

Exploring the intensity of competition between regions over foreign investments fills an urgent need in the academic literature and in policy discourse. First, shifting the focus from measuring competitive advantage to measuring competition can contribute to the literature on territorial competition by providing a method to estimate the degree to which

---

3 This is also reflected in the very uneven distribution of foreign investments across the world (see e.g., Wall *et al.*, 2011).

4 This is also reflected in the work of Hewings, Sonis and associates (e.g., Hewings *et al.*, 1996; Sonis and Hewings, 2000; Márquez and Hewings, 2003), who have shown that economic growth in one place does not necessarily obstruct but can also stimulate growth in other places.

cities and regions are in competition, to identify clusters of competitive cities and regions, and to analyse the sources of territorial competition. Second, identifying the most important competitors of cities and regions provides a much better foundation for benchmarking (Bristow, 2005; Luque-Martínez and Muñoz-Leiva, 2005) as well as valuable input for local and regional policymakers. For example, having identified the most important competitors of a particular city or region, it becomes easier for government officials to recognise which aspects of territorial competitive advantage should be improved to increase the likelihood of attracting foreign investments. Hence, a good understanding of the competition and complementarities in urban systems clears the path to more goal-directed and effective strategic planning and policy-making with regard to territorial competitive advantage and long-term economic development strategies (Porter, 2000; Malecki, 2004).

Combining insights from international economics, international business, and urban systems literature, we develop an indicator to measure ***revealed competition*** between territories for investments. Focusing on the overlap of investment portfolios, it is argued that regions are in competition to the extent that they receive investments for the same functions, for the same sectors, and from similar parts of the world. In particular, we focus on the measurement of competition for greenfield investments (new investments as well as expansions) between NUTS-2 regions in the European Economic Area (EEA)[5] and in Switzerland. European integration, which has facilitated the free movement of capital, goods, and workers and has gradually removed economic, social, and cultural differences between countries, has blurred national boundaries, resulting in the growth of territorial competition (e.g., Cheshire and Gordon, 1995; 1998; Gordon, 1999; Budd, 1998; Begg, 1999; Cheshire, 1999; Lever, 1999; Markusen and Nesse, 2007; Chien and Gordon, 2008). Today, MNCs increasingly perceive Europe as a relatively integrated territory rather than a collection of independent countries. Hence, European regions with similar characteristics situated in different countries are often perceived as closer substitutes than dissimilar regions in the same country (Basile *et al.*, 2009). As location decisions involved in greenfield investments are not influenced by past capital instalments of the investee (unlike

[5] Here, we define the EEA as the EU-25, Iceland, Norway, and Liechtenstein.

the acquisition of existing companies), these types of investments are useful for examining regional competition.[6]

The remainder of this chapter is organised as follows: In Section 2, we focus on the conceptualisation of territorial competition for foreign investments within the context of MNC behaviour and the European enlargement. Section 3 introduces our measure of revealed competition between regions. Section 4 introduces our data. Section 5 provides an empirical analysis of competition between European regions, and section 6 contains the discussion and conclusion.

5.2 Competition for Greenfield Investments

Multinationals and Location Choice

Foreign investments are long-range investments made by an MNC in a country other than the country in which the MNC has its home base. Based on Dunning's OLI paradigm (1993), firms decide to invest abroad when they have market power given by the ownership (O) of products or production processes, a location advantage (L) in locating their plant in a foreign country rather than in their home country, and an advantage gained from internationalising (I) their foreign activities in fully owned subsidiaries rather than carrying them out through market transactions (trade) or networked relationships with other firms (licensing and franchising).

From the perspective of the internal organisation of the MNC, it is possible to distinguish between horizontal and vertical foreign investments (Barba Navaretti and Venables, 2004). Horizontal foreign investments involve investments in which a firm 'duplicates' abroad a number of its activities conducted in the home country. The main trade-off faced by firms engaging in this type of investment is between the increased sales, strategic advantage, and lower transport costs to be gained from operating abroad versus the forgone economies of scale at the plant level. Vertical foreign investments are investments in which a firm decides to geographically disperse its activities by function, whereby some of these functions are performed abroad. Here, the main trade-off is between the lower factor costs associated with investing abroad versus the increased trade costs and foregone economies of scale at the firm level.

---

6 Cross-border greenfield investments constitute about 22% of all FDI in the world. The bulk of FDI takes the form of cross-border mergers and acquisitions (Brakman *et al.*, 2006).

Related to the OLI paradigm and the distinction between horizontal and vertical foreign investments, Dunning (1993; 1998) mentions four main motivations for firms to internationalise the production process and stress the location advantage: (1) access to natural resources (i.e., the natural resource-seeking motive); (2) access to new markets (i.e., the market-seeking motive); (3) the restructuring of production to reduce the costs of production related to labour, machinery and materials and increase efficiency (i.e., the efficiency-seeking motive); and (4) access to strategically related created assets (i.e., the strategic-asset-seeking motive). According to Narula and Bellak (2009), these motives can, in turn, be divided into two types. The first three motives are asset-exploring activities in that the main objective of the MNC is to generate economic rent through the use of firm-specific capabilities that it already possesses. The last motive is an asset-augmenting activity driven by the need of firms to acquire or augment specific assets related to technological capabilities, management skills, or marketing expertise.

The success of a region in attracting foreign investments largely depends on its relative attractiveness vis-à-vis other regions in terms of local resource availability. One can think here of an abundance of natural resources, large domestic markets, special tax breaks for MNCs, or a large pool of skilled workers. However, the relative importance of the different sources of competitive advantage varies across the motives of MNCs to invest abroad. A manufacturing plant predominantly needs low-wage modestly skilled labour and cheap land; sales and marketing offices call for a large domestic market in order to prosper; and high competence investments, such as R&D and headquarters functions, require high-level local resources that are often associated with agglomeration economies, clusters of related activities, and specialised skills (Narula and Bellak, 2009). Hence, MNCs with different motives to invest abroad will tend to focus on different location characteristics.

Along these lines, it can be argued that MNCs are constrained in their location choice by local resource availability, and not all regions are suitable for all types of investments because they lack the appropriate specialised location advantages. For example, it is highly unlikely that Citibank will move its European headquarters to Tórshavn on the Faeroe Islands, or that the South African mining company De Beers will build a diamond extraction facility on the French Riviera, or that Mattel will set up a Barbie manufacturing plant in downtown London. These regions would not even be considered by MNCs for the simple reason that they do not meet the minimum requirements to be considered as good locations for the above-mentioned types of investments (Raines, 2003; Mataloni Jr., 2010).[7] Especially for investments in knowledge-intensive sectors and R&D and headquarters functions, the number of potential locations is limited given the very specific location requirements with respect to human capital.

In this light, Narula and Bellak (2009) and McCann (2011) have indicated that there exists a clear hierarchy of foreign activities in Europe, with the most advanced economies hosting the highest value-added activities, such as headquarters and R&D functions.[8] In contrast, foreign investments in Central and Eastern Europe are generally confined to lower value-added activities such as manufacturing plants and sales and marketing offices. Empirical support for this hierarchy is provided by Defever (2005) and Castellani and Pieri (2010), who show a concentration of foreign investments in R&D and headquarter functions in the core regions of Western Europe, while logistics, production, sales and marketing units are more evenly spread across the continent. Similar differences can be observed when examining economic sectors instead of activities: foreign investments in knowledge-intensive manufacturing and services are more spatially concentrated than their less knowledge-intensive counterparts (Castellani and Pieri, 2010). The wider distribution of the less knowledge-intensive investments suggests a higher degree of territorial competition for these types of investment projects (Raines, 2003).

Territorial Competition for Foreign Investments

The majority of all potential locations in the world are not even considered by MNCs that aim to set up a subsidiary. This selectiveness of MNCs has important implications for territorial competition. Within the economic geography and regional science literature, territorial competition refers to "*the actions of economics agents that are taken to enhance the standard of living in their own territories, such as regions, cities, or countries*" (Poot, 2000, p. 205). Accordingly, it is not the regions that are in competition, but groups representing territorially based economic interests (Gordon and Cheshire, 1998). In particular, local and regional government officials engage in competitive activity because of electoral pressures to create jobs and safeguard business interests. In addition, officials often wish to be perceived as proactive in stimulating local and regional economic development (Turok, 2004; Markusen and Nesse, 2007). In recent years, the focus on territorial competition has grown along with an emphasis on attracting foreign investments

[7] As indicated by Gordon (1999) and Raines (2004), territorial competition would then also be most prevalent for the more standardized investments such as production plants.

[8] The development of such pattern was already predicted by Hymer (1970)

(Lovering, 2003), where foreign investments are seen as both an instrument and an indication of territorial competitiveness. 'Competitive' territories attract more foreign investments, while foreign investments are thought to increase the competitive advantage of territories by creating new employment and bringing new knowledge and technologies to a region.[9]

In principle, regions compete to have the best locational endowments (Budd, 1998). However, there are many different policies to increase territorial competitiveness, ranging from incentive-based (tax benefits and subsidies) to capacity building policies related to improving the quality of place. As indicated by Raines (2003) and Turok (2004), the most recent initiatives of authorities to attract foreign investments involve the augmentation and exploitation of regional assets related to specialised labour pools, university research, and even lifestyle and culture (Turok, 2004). These initiatives not only include capacity-building policies aimed at boosting long-run productivity, but also the selective attraction of inward investments using incentives and a marketing focus that emphasise and reinforce the distinctive strengths of a territory (Raines, 2003). In other words, local and regional policies tend to focus on enhancing the 'stickiness' of places (cf. Markusen, 1996). With respect to foreign investments, the aim is not only to attract high value-added investments, but also to avoid the relocation of firms and attract re-investments by MNCs already present in the region.

By developing a distinctive competitive advantage and targeting specific investments, authorities also try to avoid vulnerability and intensive territorial competition by creating a 'market niche'. Investments requiring high asset specificity especially are closely linked to particular locations (Phelps and Raines, 2003). This focus on the distinctiveness of regions echoes a sector- and function-based response to territorial competition (Raines, 2003), in which regions improve and exploit the characteristics that distinguish them from other regions (Begg, 1999). Such acquisition strategy for inward investments linked to a functional and sectoral focus for aspects of regional development also has clear attractiveness for the organisation of marketing around coherent descriptions of a region's competitive advantage (Raines, 2003). Thus, officials also increasingly realise that the nature of a particular investment limits the number of locations that can satisfy its criteria,

---

[9] Nevertheless, most local and regional development policies are not specifically targeted at attracting foreign investments and maintaining MNC establishments, but at stimulating the business climate in general (Budd, 1998; Malecki, 2004; Turok, 2004).

and a region can best attract investments that complement their economic structure. First, it will require less effort from regions to attract these kinds of investments. Given that MNCs match corporate assets and locational requirements, it is important to target those investments for which the region is part of the consideration set of MNCs. Second, it can be expected that MNC establishments that are better embedded in the regional economic structure are less likely to relocate and more likely to receive reinvestments at a later stage.

These factors do not mean that all differentiation and discrimination policies are equally well founded, as some sectors and functions are clearly preferred over others by authorities. Today, biotechnology, software, and financial and business services are popular targets, while labour-intensive and less knowledge-intensive services tend to be neglected. Acquisition strategies based on groundless mimicry of successful regions, such as Silicon Valley and Cambridge, are also still commonly practiced in local and regional development policies and place marketing (Malecki, 2004; Turok 2004; 2009). Turok (2009) rightfully questions the use of such wasteful policies by less well-endowed regions. In fact, it is unrealistic to expect that every territory can become a financial centre or a leading knowledge-driven economy. Also, given the specific location requirements of an MNC, the opportunities for attracting high-quality investments are extremely limited for those regions. Not only is such strategy a waste of time and money, but it also under-utilises the assets present in a region.

Along these lines, competition based on low taxes and low-wage labour has not disappeared. Regions that lack high-skilled labour and a sophisticated economic base are often desperate to attract low value-added foreign investments, such as sales and marketing offices and production-based units (Malecki, 2004). As these relatively standardised investments do not require specific location factors and because MNCs can play off governments against each other, incentive-based competition is expected be fiercest for these types of investment (Raines, 2003).

However, the European Union has always tried to avoid such a ‘race-to-the-bottom’ by banning most subsidies to business for plant locations (Cheshire and Gordon, 1998; Markusen and Nesse, 2007), where only some underdeveloped countries are allowed to attract foreign investments using incentive-based policies. However, as indicated by Markusen and Nesse (2007), this regulatory scheme of the European Union does not extend to local and regional governments’ use of their own resources or taxing policies to attract MNCs, except when national authorities compensate them for such inducements.

Although such local and regional discretionary powers are at present relatively limited, it can be expected that they will increase in the future when European countries transfer economic development policies to sub-national levels of government.

MNCs, Territorial Competition and Territorial Complementarities

However, there can also be competitive tensions between subsidiaries of the same MNC (Phelps and Fuller, 2000; Phelps and Raines, 2003). As indicated by Phelps and Fuller (2000), subsidiaries can have autonomous corporate agendas and, hence, within the same MNC subsidiaries compete for repeat investments. Phelps and Fuller (2000) address intra-MNC competitive processes that are initiated by changing divisions of labour within the MNC in which subsidiaries can win or lose responsibilities. Indeed, such competition can be fierce in light of corporate restructuring, in which some subsidiaries must be discontinued, whereas other subsidiaries receive reinvestments and can expand. Therefore, territorial competition can be perceived as an unintended consequence of the goal-directed behaviour of firm establishments, in which governments become involved because foreign activity is important for territorial competitive advantage (Raines, 2003). Hence, territories compete because subsidiaries of the same MNC compete.

Nevertheless, this dynamic provides an incomplete description of the relationships between territories. Relationships between MNC subsidiaries can be complementary in that they fulfil different functions within the organisation. In this respect, Beaverstock (2001) and Taylor (2010) highlight an example of financial and other services providers in Frankfurt and London. By means of interviews with practitioners in firms that had offices in both cities, it became clear that the relationship between Frankfurt and London was mainly complementary: London served as a strategic centre for global business, while the Frankfurt office was mainly serving the European market. Thus, both cities are used by the same MNC, but in different ways.

Within the wider literature of inter-firm relationships, it is argued that territories are not necessarily in competition, as they can have distinct competitive advantages used by firms for different reasons and, hence, can cooperate on the basis of mutuality (Gordon, 1999; Van Oort *et al.*, 2010; Taylor, 2010). In this respect, complementarities are present between differently specialised regions that are linked through input-output relations (Scott and Storper, 2007).[10] Based on the tension between competition and complementary relations between territories, Burger *et al.* (2011b) define three conditions for the existence of territorial competition: (1) sectoral market overlap, (2) functional market overlap, and (3) geographical market overlap. These conditions closely correspond to different dimensions of urban systems as outlined by Gordon (1999). Accordingly, in the 'market for investments', in which territories supply and MNCs demand locations, territorial competition would be high when territories receive investments for the same functions and sectors from similar parts of the world.

MNCs, European Integration and Territorial Competition

The viewpoint of the existence of investments between similar subsidiaries/regions is more prevalent within an integrated market. In international economics, attention has been paid to horizontal foreign investments, in which MNCs build to overcome high trade costs. In this situation, there is a complementary relationship between similar subsidiaries within the same MNC. Although these subsidiaries conduct the same economic activities, they serve different markets. Thus, territorial competition between regions with similar locational endowments is also more opaque.

However, within the light of globalisation and European integration, vertical investments gain significance due to a reduction of trade costs at the expense of horizontal investments. The removal of tariff and non-tariff barriers to trade and the free movement of capital and labour in the European Union in combination with decreasing transportation costs and improved information and communication technologies is generating a European economy in which MNCs can concentrate particular activities of their value chain in one single location. According to Cheshire and Gordon (1995, p. 111), "*companies are increasingly restructuring themselves to serve the European market as a whole rather than a set of national markets. They eliminate national headquarters and have just a European headquarters; they have European-wide marketing strategies; they streamline their production range and concentrate their production*".

Horizontal foreign investments can be considered a substitute for trade (Barba Navaretti and Venables, 2004), where MNCs can overcome trade barriers by setting up foreign subsidiaries to serve foreign markets. By the creation of the Single Market, such

[10] For example, a region specialized in financial services, can provide these services to a territory specialized in manufacturing, and vice versa.

trade barriers have been diminished within the Europe, thus discouraging horizontal foreign investments between countries within the European Union. Due to market enlargement, foreign investments from outside the European Union have increased, but this often takes the form of export-platform foreign investments in which the whole of the European Union is served by a non-European MNC from one single location (Neary, 2002). At the same time, the decrease of barriers to trade has stimulated investments of the vertical variety, which is complementary to trade. Due to decreased investment and trade costs, MNCs could no longer easily take advantage of differences in factor prices between regions, resulting in a slicing up of the value chain.

These developments not only occur in manufacturing industries but increasingly so in services, where trade costs have traditionally been higher due to intensive face-to-face interaction (Glaeser and Kohlhase, 2004; McCann, 2008). However, due to technical advancements, such as the acceptance of English as the *lingua franca* and the liberalisation of trade in services, the fragmentation of the commodity chain is also becoming a more common practice in services (Deardoff, 2001; Head *et al.*, 2009). Hence, it is expected that territorial competition for services functions will further increase in the near future.

5.3 Quantifying Territorial Competition for Investments

The degree of territorial competition (and complementarities) over attracting foreign investments can be assessed by examining the overlap in investment portfolios. The investment portfolio of a territory reveals the competitive advantage for foreign investments in that territory (UNCTAD, 2001). Hence, the investment portfolio of a territory displays information about the attractiveness of territories for particular foreign investments. In this manner, it is acknowledged that MNCs can use territories in different ways, and territories that have similar locational assets function as substitutes. Accordingly, relations between territories with similar investment portfolios are competitive, while relations between territories that have different investment portfolios are cooperative. Based on our theoretical framework, three conditions for the existence of competition between regions for investments have been identified: (1) sectoral similarity in investments, (2) functional similarity, and (3) geographical similarity. Accordingly, the revealed competition between territories is high when they receive investments for the same sectors and functions from similar parts of the world.

Although relatively absent in the study of foreign investments, similarity indices have been extensively used in the social sciences to assess revealed competition between members of a given population based on niche overlap. In its original connotation, a niche of species is defined as the set of environmental states in which a species thrives, and it typically consists of the resources on which a species depends for its survival, such as its natural habitat from which it collects food. From the 1970s onwards, the concept of niche has been introduced in the social sciences, most notably in organisation studies (Hannan and Freeman, 1977; Podolny *et al.*, 1996) and social network analysis (McPherson, 1983; Burt and Talmud, 1993).

Likewise, in international economics, the Finger-Kreinin index (Finger and Kreinin, 1979) has been used to assess the competitive threat one country poses the other (see e.g., Jenkins, 2008; Duboz and Le Gallo, 2011). This measure uses a relative Manhattan index-based indicator to measure the similarity in export structure between two countries. Applied to the context of foreign investments, the degree of similarity in the investment portfolio structure of regions i and j can be expressed as the overlapping of market segments h between i and j. A market segment is here defined as a group of investments that share the same (1) sector, (2) function, and (3) world region of origin. Hence, foreign investments in low-tech manufacturing production plants originating from Asia are treated as a different segment from that consisting of investments in financial services headquarters originating from North America. More formally, the similarity S between the investment portfolios of regions i and j can be expressed as follows:

$$S_{ij} = \sum_{h=1} \min(x_{ih}, x_{jh}), \tag{5.1}$$

in which x_{ih} is the share of the market segment h in region i's portfolio of investments, and x_{jh} is the share of the market segment h in region j's portfolio of investments. If the value of the index equals zero, the markets of regions i and j are completely different, and the intensity of competition between the two regions would be at a minimum. In other words, the relationship between the regions can be regarded as fully complementary. If the value of the index equals one, the markets of regions i and j completely overlap, and the intensity of competition between the two regions would be at a maximum.

However, a serious drawback of the relative Manhattan distance is that it does not take into account the absolute number of investments, and accordingly, it only reflects the degree of competition well when the sizes of the regions are more or less equal (Jenkins, 2008). By focusing on portfolio structure instead of the number of investments, the index implies that the competitive threat posed by region A to region B is the same as the competitive threat posed by region B to region A, which only works when both regions are relatively similar in (economic) size. The illogicality of this measurement also becomes clear when, for example, region A is London and region B is Lapland (see also Jenkins, 2008). From the perspective of a region that is concerned about the competition it faces from a region such as London, what is important is the proportion of its investment portfolio for which it has to compete with London as a location of residence. In other words, the share of these investments in the portfolio of London does not matter as such. As such, territorial competition should be based on an absolute advantage principle and not on a comparative advantage principle (Camagni, 2002). Accordingly, we use a weighted similarity index (see also Leelawath, 2007) to assess the competitive threat regions pose to one another. For any investment type, a region will experience fierce competition from a competitor region if (1) the investments constitute an important part of the region's investment portfolio and (2) the level of these investments is at the same level as that of its competitor region. Formally, the competitive threat *C* region *j* poses to *i* can be expressed as follows:

$$C_{ji} = \sum_{h=1} s_{ih} \left(1 - \frac{|X_{ih} - X_{jh}|}{(X_{ih} + X_{jh})}\right), \tag{5.2}$$

In which s_{ih} is the share of market segment *h* (sector by function by world region) in region *i*'s portfolio of investments, X_{ih} is the number of investments region *i* receives in market segment h, and X_{jh} is the number of investments region *j* receives in market segment *h*. Like the relative Manhattan index, the weighted similarity index ranges from 0 (complementary relationship) to 1 (competitive relationship). The proposed index is asymmetric in that the territorial competition region A receives from region B does not necessarily have to be the same as the territorial competition region B receives from region A.

However, a weakness of this revealed competition measure is that outcomes are, at least to some extent, dependent on the definition of the different market segments (see also Kellmann and Schroder, 1983). Here, we have considered a classification that includes neither too many nor too few separate segments, while taking into account theoretical considerations of plausibility and functionality. Based on our data (described in the next section), the market segments are delineated by 9 broad sectors, 7 functions, and 5 world regions of origin.[11] The result is 315 (9*7*5) potential market segments. In 262 of these 315 potential segments, 1 or more investments were made.

5.4 Data

To analyse the degree of competition between European regions, we make use of the Financial Times fDI Markets database, a detailed register of cross-border investments that are made worldwide. The greenfield projects that are covered include new investments and expansions, but not mergers, acquisitions, or joint ventures. More specifically, we focus on investment projects in 264 NUTS-2 regions[12] across 29 European countries (EU-25 as well as Iceland, Liechtenstein, Norway and Switzerland) for the period 2003-2010. These data are recorded on the basis of formal announcements by the media, financial information providers, industry organisations, and market and publication companies. All projects are cross-referenced with multiple sources, and 90% of all investment projects are validated with company sources. No official minimum investment size exists, although investment projects creating less than 10 full-time jobs or involving a total investment of less than $1 million are relatively uncommon. Overall, the database contains 27,550 investments made in Europe by 12,240 MNCs. Approximately one third of these investments are made by the top 500 firms. For 23,525 (85.1%) of these investments, detailed information was available regarding the region in which the investment was made.

Figures 5.1-5.3 show the distribution of these investments in Europe across broad sectors, economic functions, and world region of origin (see Appendix 5A and 5B). Figure 5.1 shows that most investments are relatively equally spread across sectors. Most investments were made in the ICT and telecommunications sectors (19.3%) and the low-tech manufacturing (15.0%) sector. However, when we examine at the distribution of investments across economic functions (i.e., the stage or activity within the value chain of the firm) in Figure 5.2, we see a strong concentration of investments in production plants

[11] The taxonomy of sectors and functions is based on the classification presented in the work of Van Oort (2004), where the subsectors within the broad sectors have related production processes and locational demands. A similar taxonomy was for the different functions (see also Castellani and Pieri, 2010). The categorization of countries in five world regions (Western Europe, Rest of Europe, North America, Asia-Pacific and Rest of the World) is based on the idea that motivations for intra-bloc investments (investments form the EU into the EU) are substantially different from inter-bloc investments. Likewise, motivations for MNCs from developing countries to invest in Europe are substantially different from those of developing countries.

[12] This excludes Andorra (AD00), Faeroe Islands (FO00) Greenland (GL00), Gibraltar (GI00), Guernsey (GG00), Isle of Man (IM00), Jersey (JE00) and Monaco (MC00). However, data for these territories is available upon request.

(31.1%) and sales and marketing offices (25.7%). Headquarters and R&D units are less targeted functions. Most investments (52.2%) made by MNCs are based in Western Europe (Figure 5.3).

Figure 5.1: Distribution of Inward Investments across Sectors

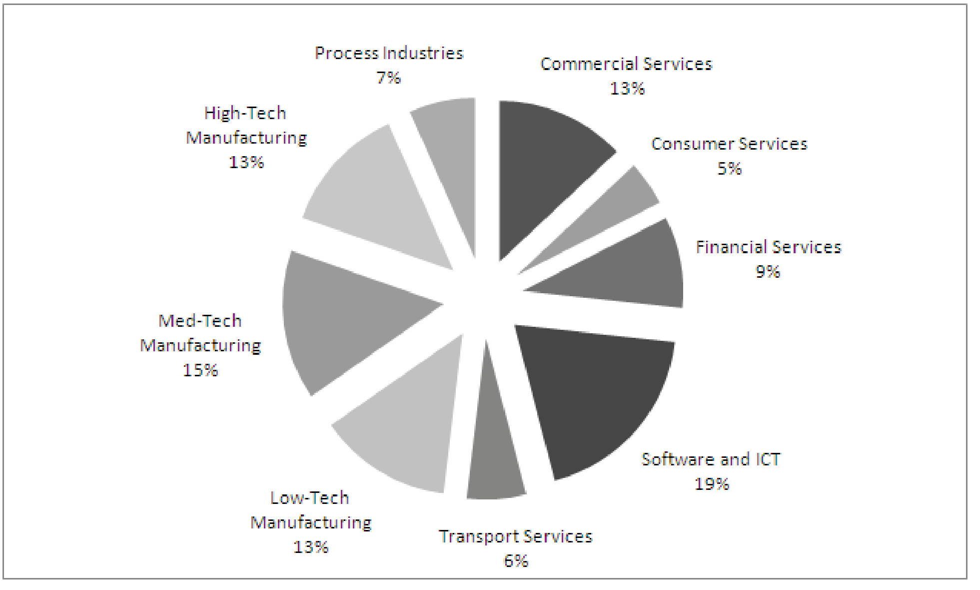


Figure 5.2: Distribution of Inward Investments across Functions

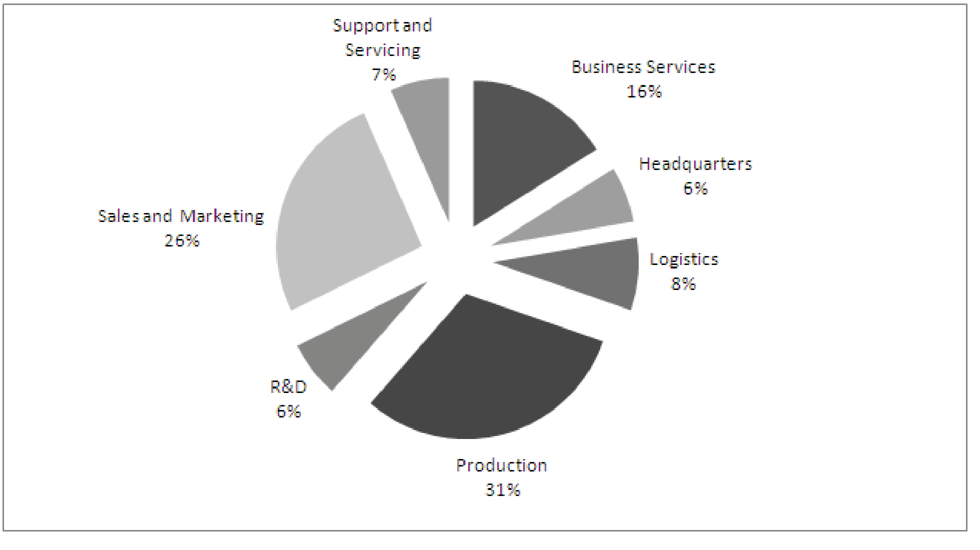


Figure 5.3: Distribution of Inward Investments across World Regions

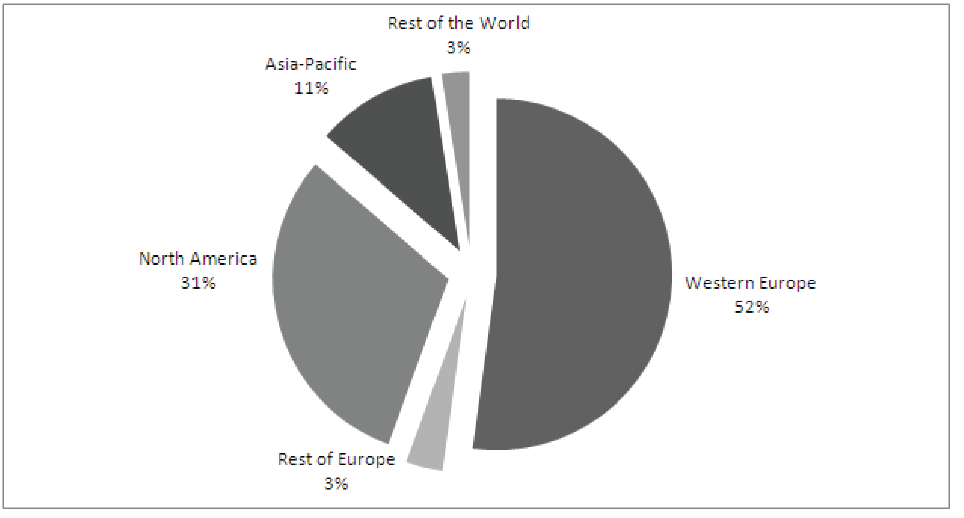


Table 5.1 gives an indication of the spatial distribution of foreign investments in Europe by presenting the top 20 regions in Europe in terms of the number of inward investments they receive. Most foreign investments are targeted at Greater London (7.1%) and the Ile-de-France (4.5%, Paris) region. Not surprisingly, this concentration mainly includes investments in business services, sales and marketing, and headquarters functions in the ICT and telecommunications, financial services, commercial services, and high-tech manufacturing sectors. In reality, most top European top regions are overspecialised in attracting foreign investments in higher value-added sectors and functions.[13] Nevertheless, there are also strong indications of the existence of complementarities among top European regions. For example, Ile-de-France (FR10, Paris) specialises in ICT and commercial services, and Rhône-Alpes (FR71, Lyon) specialises in high-tech manufacturing, medium-tech manufacturing, process industries, and transport services. Along these lines, most region pairs are not completely competitive or complementary but are somewhere in between these two extremes.

[13] Most regions with a strong overspecialization in inward foreign investments in lower-value added sectors (e.g., low-tech manufacturing) and functions (e.g., production plants) can be found in peripheral Europe.

Table 5.1: Investment Portfolios of the Top 20 NUTS-2 Regions

Rank	Region	Name (Main City)	Investments (% of total)	Sector Specialization(s) (LQ>1.2)	Function Specialization(s) (LQ>1.2)
1	UKI	Greater London	1661 (7.1%)	Financial Services, ICT, Commercial Services, Consumer Services	Business Services, Sales and Marketing, Headquarters
2	FR10	Ile-de-France (Paris)	1069 (4.5%)	ICT, Commercial Services	Sales and Marketing, Business Services
3	IE02	Southern and Eastern Ireland (Dublin)	696 (3.0%)	Financial Services, ICT, High-tech Manufacturing, Consumer Services	Headquarters, R&D, Support and Servicing, Business Services
4	ES51	Cataluña (Barcelona)	554 (2.4%)	Low-tech Manufacturing, Transport	R&D, Headquarters, Logistics
5	DEA1	Düsseldorf	526 (2.2%)	Low-tech Manufacturing, Commercial services	Headquarters, Sales and Marketing, Business Services
6	ES30	Communidad de Madrid	519 (2.2%)	Financial Services, ICT, Commercial Services	Business Services, Sales and Marketing
7	DE21	Oberbayern (Munich)	437 (1.9%)	ICT, High-tech Manufacturing, Commercial Services	Sales and Marketing, Business Services, R&D
	HU10	Közép-Magyar. (Budapest)	437 (1.9%)	Consumer Services, Commercial Services	Support and Servicing, R&D
9	PL12	Mazovia (Warsaw)	417 (1.8%)	Commercial Services, Transport, Financial Services	-
10	DE71	Darmstadt (Frankfurt)	373 (1.6%)	Financial Services, ICT, Commercial Services	Business Services, Sales and Marketing, Support and Servicing
11	ITC4	Lombardia (Milan)	356 (1.2%)	Financial Services, High-tech Manufacturing, ICT	Sales and Marketing, Business Services
12	NL32	Noord-Holland (Amsterdam)	336 (1.4%)	ICT, Financial Services, Commercial Services	Headquarters, Support and Servicing, Business Services
13	FR71	Rhône-Alpes (Lyon)	333 (1.4%)	High-tech Manufacturing, Medium-Tech Manufacturing, Process Industries, Transport	Sales and Marketing, Headquarters
14	CZ01	Praha (Praha)	290 (1.2%)	Consumer Services, Commercial Services, Financial Services, Transport	Business Services, R&D, Sales and Marketing
15	DK01	Hovedstaden (Copenhagen)	283 (1.2%)	ICT, Commercial Services, High-tech Manufacturing	Headquarters, Business Services, Sales and Marketing, R&D
16	PL51	Lower Silesia (Wroclaw)	267 (1.1%)	Medium-tech Manufacturing, High-tech Manufacturing, Low-tech Manufacturing	Production plants
	SE11	Stockholm	267 (1.1%)	Financial Services, ICT, Commercial Services	Business Services, Sales and Marketing
18	UKJ1	East Anglia (Cambridge)	255 (1.1%)	ICT, High-tech Manufacturing	Headquarters, Sales and Marketing, R&D, Support and Servicing,
19	AT13	Wien	253(1.1%)	Consumer Services, Financial Services, Commercial Services	Business Services, Headquarters, Sales and Marketing
20	BE10	Brussels	249(1.1%)	Commercial Services, ICT	Business Services, Headquarters, Sales and Marketing

5.5 Structure of Territorial Competition

Competition across Sectors, Functions and World Region of Origin

Revealed competition within market segments can be compared by dividing the sum of the weighted similarity index across region pairs and relevant market segments by the maximum possible overlap for the relevant segments.[14] Table 5.2 shows the revealed competition between European regions for different types of investments by sector and function. From this table, it is clear that competition over investments in the low value-added sectors and functions is higher than across the high value-added sectors and functions. The competition for investments in process industries (0.48) and low-tech manufacturing (0.43) is much higher than for business services (0.13) and software and ICT (0.13). Likewise, the competition for investments in production (0.45) and logistics (0.34) is much higher than for headquarter functions (0.06), which is consistent with the expectation that territorial competition is fiercest for those investments that do not require highly specific location factors and the observation that investments in the lower value-added segments are more equally distributed across European regions than investments in the higher value-added segments.

In addition, competition for investments from Western Europe is much fiercer than competition for investments from other parts of the world. The latter are concentrated in only a few European regions. For example, London receives only 3.1% of all investments from Western Europe. At the same time, it receives 12.5% of all investments from North America, 9.5% of all investments from the Asia-Pacific region, 6.6% of all investments from the rest of Europe, and 12.1% of all investments from the rest of the world. As indicated by Rugman and Verbeke (2005), the scope of most MNCs is continental and not global, and there are only a few truly global regions in the European urban network that link the other European regions to the rest of the world, including Greater London, Ile-de-France, and, to a lesser extent, the regions around Dublin (North America); Madrid (North- and Latin America); Frankfurt (North America and Asia-Pacific); Munich (North-America and Asia-Pacific); Amsterdam (North-America); Dublin (North-America); and Düsseldorf (Asia-Pacific).[15]

---

[14] Typically, this is a situation in which the investments in the relevant segments are perfectly equally distributed across the regions. Hence, the maximum possible overlap is computed as the share of investments in the relevant market segments in the investments times the number of region pairs.

[15] On a similar note, most foreign investments originating from Eastern Europe are still targeted at East European countries. For example, almost 60% of all Latvian foreign investments in European countries are targeted at Estonia and Lithuania.

Table 5.2: Revealed Competition across Sector, Function and World Region of Origin

Sector		Function		World Region of Origin	
Process Industries	0.48	Production plants	0.45	Western Europe	0.35
Low-tech Manufacturing	0.43	Logistics	0.34	North America	0.18
Medium-tech Manufacturing	0.31	Business Services	0.15	Asia-Pacific	0.12
High-tech Manufacturing	0.21	Sales and Marketing	0.17	Rest of Europe	0.04
Transport Services	0.33	Servicing and Support	0.13	Rest of the World	0.06
Software and ICT	0.13	R&D	0.16		
Financial Services	0.18	Headquarters	0.06		
Commercial Services	0.13				
Consumer Services	0.22				

Table 5.3: Most Competitive Market Segments in European Market for Investments

Rank	Number of Investments	Overlap (%)	Sector	Function	World Region of Origin
1	659	84.4	Processing Industries	Production	Western Europe
2	1469	62.5	Low-tech Manufacturing	Production	Western Europe
3	423	58.1	Low-tech Manufacturing	Production	North America
4	685	52.1	Transport Services	Logistics	Western Europe
5	189	43.5	Processing Industries	Production	Western Europe
6	1078	43.4	Medium-tech Manufacturing	Production	Western Europe
7	380	43.4	Consumer Services	Production[a]	Western Europe
8	509	40.9	High-tech Manufacturing	Production	Western Europe
9	359	40.6	Medium-tech Manufacturing	Production	North America
10	279	40.1	Low-tech Manufacturing	Logistics	Western Europe

a This mainly include the construction of hotels and entertainment facilities

Looking at the top 10 competitive market segments in Table 5.3, the competition appears to be fiercest for West-European and North-American (efficiency-seeking) investments in production units in the low- and medium-tech manufacturing industries. The lowest degree of competition can be found in the smallest market segments. However, there are also a considerable number of large market segments (consisting of more than 100 investments) in which the degree of territorial competition is relatively low (that is, an overlap of <0.13). As shown in Table 5.4, this predominantly includes North American (market- and strategic-asset-seeking) investments in financial and other commercial services offices.

Table 5.4: Least Competitive Large Market Segments in European Market for Investments

Number of Investments	Overlap (%)	Sector	Function	World Region of Origin
341	4.2	Software and ICT	Headquarters	North America
380	5.0	Financial Services	Business Services	North America
193	6.4	Software and ICT	Sales and Marketing	North America
210	7.7	High-tech Manufacturing	Sales and Marketing	Asia-Pacific
169	8.8	Financial Services	Sales and Marketing	North America
655	9.0	Commercial Services	Business Services	North America
162	10.4	Commercial Services	Sales and Marketing	Western Europe
1177	12.2	Software and ICT	Sales	North America
337	12.8	Software and ICT	Support and Servicing	North America
283	13.0	Software and ICT	R&D	North America

Revealed Competition between Regions

The relationships between some regions are more competitive than the relationships between others. Table 5.5 shows the most important competitors of the Greater London (UKI) and Lower Silesia (PL51) regions as well as the regions to which Greater London and Lower Silesia pose a competitive threat. As indicated in Table 5.1, these regions have distinct specialisations in foreign investments. Whereas London ranks first in the number of inward investments in business services, financial services, and ICT and software, Lower Silesia ranks first in the number of inward investments in production plants. The relationship between Greater London and Lower Silesia is essentially complementary. Both the competitive threat that Lower Silesia poses to London (0.05) and the competitive threat that Greater London poses to Lower Silesia (0.23) can be considered to be very low.

From Table 5.5, it is clear that the main competitor regions of Greater London are not the same as the competitor regions of Lower Silesia. Whereas London mainly faces competition from Ile-de-France (0.57), Dublin (0.36), and Madrid (0.35), Lower Silesia is mainly ‘at war’ with Barcelona (0.67), Western Slovakia (0.62), and Silesia (0.59). In general, the competitors of London seem to be less ‘local’ than the competitors of Lower Silesia, which mainly concern East European regions that draw on low- and medium-tech manufacturing.

A similar observation can be made with respect to the regions to which Greater London and Lower Silesia pose a threat. Regions that face considerable competition from Greater London include both large regions with a similar investment portfolio (e.g., Ile-de-France, Communidad de Madrid, and Hovedstaden) and small regions receiving only a small number of specific investments (e.g., Niederbayern, Drenthe, and Småland). Still, the relationships between regions are not necessarily competitive but can also be complementary. For example, Merseyside (UKD5), Derbyshire and Nottinghamshire (UKF1), Surrey, East and West Sussex (UKJ2), and Devon (UKK4) do not face a competitive threat from London, having less than a 25% overlap of their investment portfolio with London's.

The Gravity of Revealed Competition and Complementarities

Distinctiveness in relation to complementary relationships between European regions can be analysed by using a gravity-type regression model.[16] Following our theoretical discussion, it can be argued that similarity in locational endowments induces competition between regions, and dissimilarity in locational endowments generates complementarities between regions in attracting foreign investments. To explain the geography of competition and complementarities in the European regional network, we include variables that measure the absolute value (modulus) of the difference in location characteristics between regions. These variables can be linked to the main motivations of MNCs to invest in foreign regions (see Section 2.1.). More specifically, we take into consideration variables related to the attractiveness of locations and that are often used in the analysis of the location choice of MNCs (see, e.g., Head and Mayer, 2004; Defever, 2005; Basile *et al.*, 2008; 2009; Brienen *et al.*, 2010), as they can be linked to the different motivations of firms to invest abroad.

Our dependent variable is the log of the weighted similarity index for the period 2003-2010, as presented in equation 2. For natural resource-seeking motives, we include *employment in mining and quarrying* as a share of total employment. For market-seeking motives, we include market size, GDP per capita, and accessibility. In line with the market-seeking hypothesis, larger regions in terms of *Gross Value Added* tend to be more attractive to MNCs because MNCs are thereby able to serve a larger market. *GDP per capita* measures the purchasing power in the region, while the multimodal index of *accessibility* is included to capture the quality of the infrastructure, as it can be expected that regions that are better accessible by air, rail, or road will receive more investments.

[16] For the use of gravity models (spatial interaction models) in economics and geography, see for example Fotheringham and O' Kelley (1989) and Burger *et al.* (2009)

Table 5.5: Main Competitive Relationships of Greater London and Lower Silesia

Competitive threat posed by Greater London:				**Competitive threat posed by Lower Silesia:**			
Code	**Region name**	**Main city**	**Overlap**	**Code**	**Region name**	**Main city**	**Overlap**
FR10	Ile-de-France	Paris	0.570	ES51	Cataluña	Barcelona	0.668
IE02	Southern and Eastern Ireland	Dublin	0.357	SK02	Západné Slovensko	Nitra	0.623
ES30	Communidad de Madrid	Madrid	0.344	PL22	Silesia (Slaskie)	Katowice	0.594
DE21	Oberbayern	Munich	0.325	HU10	Közép-Magyarország	Budapest	0.556
DE71	Darmstadt	Frankfurt	0.287	HU21	Közép-Dunántúl	Székesfehérvár	0.552
NL32	Noord-Holland	Amsterdam	0.273	EE00	Estonia	Tallinn	0.538
ITC4	Lombardia	Milan	0.267	HU22	Nyugat-Dunántúl	Gyor	0.534
DEA1	Düsseldorf	Düsseldorf	0.250	FR71	Rhône-Alpes	Lyon	0.533
PL12	Mazowiecki	Warsaw	0.224	LT00	Lithuania	Vilnius	0.506
ES51	Cataluna	Barcelona	0.222	PL12	Mazowiecki	Warsaw	0.504
Greater London posing competitive threat to:				**Lower Silesia posing competitive threat to:**			
Code	**Region name**	**Main city**	**Overlap**	**Code**	**Region name**	**Main city**	**Overlap**
FR10	Ile-de-France	Paris	0.668	SK02	Západné Slovensko	Nitra	0.770
DE22	Niederbayern	Nürnberg	0.565	PL22	Silesia (Slaskie)	Katowice	0.670
ES30	Communidad de Madrid	Madrid	0.549	HU21	Közép-Dunántúl	Székesfehérvár	0.670
NL13	Drenthe	Assen	0.544	HU22	Nyugat-Dunántúl	Gyor	0.664
DE13	Freiburg	Freiburg	0.528	PL11	Lódzkie	Lódz	0.614
PL33	Swietokrzyskie	Kielce	0.526	FR41	Lorraine	Metz	0.589
AT34	Vorarlberg	Bregenz	0.521	CZ04	Severozápad	Ústí nad Labem	0.585
SE21	Småland	Jönköping	0.517	FR30	Nord - Pas-de-Calais	Calais	0.583
ES13	Cantabria	Santander	0.510	HU31	Észak-Magyarország	Miskolc	0.556
DK01	Hovedstaden	Copenhagen	0.504	BE33	Liège	Liège	0.556

Table 5.6: Variables Included in the Regression

Variable	Description	Source
Natural resource intensity difference	Absolute difference of share of employment in mining and energy of region *i* and *j*	CE
Market size difference	Absolute difference of log of value added of regions *i* and *j*	CE
GDP per capita difference	Absolute difference of log of (regional GDP/population) of regions *i* and *j*	CE
Accessibility difference	Absolute difference of log of multimodal accessibility index of regions *i* and *j*	ESPON
Wage per hour difference	Absolute difference of log of (wages/total hours worked) of regions *i* and *j*	CE
Population density difference	Absolute difference of log of (regional population / total area in km^2) of regions *i* and *j*	CE
R&D intensity rate difference	Absolute difference of number of number of patent application per million labour force between regions *i* and *j*	Eurostat
University degree rate difference	Absolute difference share of population (>15) with university degree rate (ISCED 5-6) of regions *i* and *j*	Eurostat
Social charges rate difference	Absolute difference of social charges rate of region *i* and *j* (measured at country level)	EY HC
Corporate tax rate difference	Absolute difference of statutory corporate tax rate of regions *i* and *j* (measured at country level)	EY Tax
Physical distance	Log of the geodesic distance between region *i* and *j*	-
Country dissimilarity	Takes value 1 when located in a different country	-

CE = Cambridge Econometrics, EY HC = Ernst & Young Human Capital database, EY Tax = Ernst & Young International Tax database

Accessibility is here estimated using a multimodality index. For efficiency-seeking motives, we include *wage per hour*, *social charges rate*, and *corporate taxes* as covariates. The social charges rate is provided by the Ernst & Young International Human Capital database and is calculated as the non-wage labour costs (payroll taxes, social security contributions, recruitment costs) as a percentage of the total labour costs (Brienen *et al.*, 2010). The costs of capital are captured by the corporate tax rate and are measured as the statutory tax percentage rate at the national level and obtained from the Ernst & Young International Tax database (also see Brienen *et al.*, 2010). Both the social charges rate and the tax rate are measured at the country level. Finally, strategic asset-seeking motives are measured by the *number of patents per million labour force* and *working population with higher education (ISCED 5-6) as a share of total working population*. All variables are measured for the years 2006-2007. Finally, we include distance and similar country dummies to account for unobserved similarities between countries located in close proximity to each other or falling under the same institutional regime.

Table 5.6 provides an overview and description of the variables included in the model. We estimate a two-way fixed effects model, including region fixed effects. Such a doubly constrained gravity model ensures that the observed degree of competition equates the expected degree of competition and yields consistent parameter estimates for the variables of interest (Fotheringham and O'Kelly, 1989; Bröcker and Rohweder, 1990; Burger *et al.*, 2009). In addition, it controls for omitted variable bias and for the fact that the competitive threat that, for example, Greater London poses to other regions is generally greater than the competitive threat that small regions such as Niederbayern, Drenthe, and Småland pose to other regions. In a cross-sectional setting, a fixed effects specification implies the inclusion of region-specific 'exporter' (i.e., regions that pose a competitive threat) and 'importer' (i.e., regions that face competition) dummy variables. Sufficient information was available for 241 of the 264 regions, yielding 57840 (241*240) observations in our regression model.[17] The VIF statistics indicated no multicollinearity problems.[18]

[17] In particular, information was missing for the EFTA countries (Iceland, Liechtenstein, Norway, and Switzerland), Denmark, and some extra-territorial regions belonging to Spain and Portugal (Azores, Madeira, Ceuta, Melilla).

[18] VIF statistics are available upon request.

Table 5.7: OLS on Revealed Competition between Regions

	Model 1 Ln(C_{ji})	Model 2 Ln(C_{ji})
Regional level		
Natural resource intensity difference	-2.39 (.865)**	-2.39 (.865)**
Market size difference	0.01 (.008)	0.01 (.007)
GDP per capita difference	-0.21 (.023)**	-0.21 (.023)**
Accessibility difference	-0.04 (.018)*	-0.04 (.018)*
Population density difference	-0.05 (.006)**	-0.05 (.006)**
Wage per hour difference	-0.09 (.015)**	-0.09 (.014)**
Patenting rate difference	-0.01 (.005)*	-0.01 (.006)*
University degree rate difference	-0.45 (.068)**	-0.45 (.068)**
Physical distance	-0.08 (.008)**	-0.06 (.008)**
Country level		
Social charges rate difference	0.08 (.081)	
Corporate tax rate difference	0.05 (.100)	
Situated in different country		-0.07 (.015)**
Observations	57840	57840
'Importer' fixed effects	YES	YES
'Exporter' fixed effects	YES	YES
R-squared	0.62	0.62
Root MSE	0.84	0.83
**p<0.01, *p<0.05, robust standard errors in parentheses		

Table 5.7 show the results of the estimation of the log-normal model using the White estimator to obtain robust standard errors.[19] Overall, it can be inferred that, consistent with the theory, most variables have the expected sign and are highly significant. Regions that differ in natural resource abundance, income levels, wage costs, accessibility, population density, patent intensity, and population with a university degree pose a relatively small competitive threat to one another. For example, if the difference in wage per hour between two regions doubles, the degree of revealed competition between regions drops by 9%, holding everything else constant. Likewise, an increase in the difference in the share of the population with a university degree by 1 percentage point increases the degree of revealed competition between regions by 0.36 percentage points. We find a negative and significant effect of physical distance and the country dissimilarity dummy on the degree of revealed competition between regions, holding everything else constant (see Model 2).[20] Although

[19] A Poisson regression (available on request) provided similar results.

[20] As there was considerable multicollinearity between the tax rate and country dissimilarity dummy we ran separate regressions.

this can signify that the European market is not (yet) an integrated territory, the significance of the distance and country dissimilarity variables might also reflect unobserved differences between regions, where regions located in the same country and in close proximity to each other share locational similarities not accounted for in the model.

Competitive vs. Cooperative Regions

Some regions face a higher threat of competition than others. The average competitive threat region *i* faces from other regions *j* can be estimated by summing the revealed competition coefficient (equation 2) for *i* over all competitor regions *j* and dividing this value by the number of regions in the sample. Likewise, the competitive threat region *j* poses to other regions *i* can be estimated by summing the revealed competition coefficient for *j* over all competitor regions *i*. As the revealed competition measure is asymmetric, the average competitive threat a region poses does not have to be the same as the average competitive threat a region faces.

Table 5.8 provides an indication of which regions pose the largest (smallest) threat to all other regions and which regions face the largest (smallest) competition from all other regions. From the table, it can be observed that Greater London, Paris and Dublin, which are sufficiently large and distinctive, face the smallest average competitive threat from all other regions. In contrast, small, peripheral regions such as Hedmark og Oppland in Norway appear to encounter greater difficulties because they face a relatively large competitive threat from other regions. At the same time, most of these regions do not pose a large threat to other regions (correlation = -0.55). The regions that pose the largest competitive threat to other regions include some usual suspects (Ile-de-France, Lombardia, and Oberbayern) as well as some less obvious candidates (Southwestern Scotland, Rhône-Alpes, and Andalucía). The latter group mainly consists of large regions receiving numerous foreign investments in medium to highly competitive market segments, including the high-tech manufacturing and processing industries. A better understanding of the competitive threat a region poses or faces can be obtained by means of a linear regression analysis on the average competitive threat using the location factors introduced in the previous subsection (5.3) as explanatory variables. We use the logarithm of the competitive threat a region poses or faces as dependent variables.

Table 5.8: Regions Facing Largest (Smallest) Competitive Threat from Other Regions and Regions Posing the Largest Competitive Threat to Other Regions

Facing smallest competitive threat from other regions				**Posing largest competitive threat to other regions**			
Code	**Region name**	**Main city**	**Overlap**	**Code**	**Region name**	**Main city**	**Overlap**
UKI1	Greater London	London	0.046	UKM3	South Western Scotland	Glasgow	0.529
FR10	Ile-de-France	Paris	0.076	ITC4	Lombardia	Milan	0.525
IE02	Southern and Eastern Ireland	Dublin	0.103	DEA2	Köln	Köln	0.513
DEA1	Düsseldorf	Düsseldorf	0.122	FR71	Rhône-Alpes	Lyon	0.500
NL32	Noord-Holland	Amsterdam	0.130	ES61	Andalucia	Sevilla	0.491
ES30	Communidad de Madrid	Madrid	0.131	FR10	Ile-de-France	Paris	0.471
DE71	Darmstadt	Frankfurt	0.132	DE71	Darmstadt	Frankfurt	0.466
DE21	Oberbayern	Munich	0.133	DE21	Oberbayern	Munich	0.466
UKJ1	Berkshire, Bucks, and Oxfordshire	Oxford	0.136	FR82	Provence-Alpes-Côte d'Azur	Marseille	0.465
ES51	Cataluña	Barcelona	0.139	HU10	Közép-Magyarország	Budapest	0.461
Facing largest competitive threat from other regions				**Posing smallest competitive threat to other regions**			
Code	**Region name**	**Main city**	**Overlap**	**Code**	**Region name**	**Main city**	**Overlap**
PL52	Opolskie	Opole	0.378	NL12	Friesland	Leeuwarden	0.047
NL34	Zeeland	Middelburg	0.379	ITF2	Sardegna	Cagliari	0.043
ITF2	Molise	Campobasso	0.381	GR21	Ipeiros	Ioannina	0.035
AT34	Vorarlberg	Bregrenz	0.388	NO02	Hedmark og Oppland	Hamar	0.030
PL62	Warminsko-Mazurskie	Olsztyn	0.403	ITE3	Marche	Ancona	0.029
DEB2	Trier	Trier	0.408	GR13	Dytiki Makedonia	Kozani	0.021
ITE2	Umbria	Perugia	0.424	GR42	Notio Aigaio	Ermoupoli	0.016
NO02	Hedmark og Oppland	Hamar	0.425	NO06	Trøndelag	Trondheim	0.016
GR24	Sterea Ellada	Lamia	0.435	FR83	Corse	Ajaccio	0.013
PT20	Azores	Ponta Delgada	0.458	GR11	Anatoliki Makedonia	Komotini	0.004

Table 5.9: OLS on Competitive Threat Posed and Faced by Regions

	Model 3 Ln(Threat Posed)	Model 4 Ln (Threat Faced)	Model 5 Ln(Posed/Faced)
Regional level			
Ln Market size	0.49 (.049)**	-0.14 (.020)**	0.64 (.047)**
Ln Accessibility	0.37 (.100)**	-0.09 (.045)*	0.47 (.131)**
Ln Population density	-0.01 (.037)	-0.07 (.016)**	0.06 (.042)
Ln Wage per hour	-0.62 (.095)**	0.03 (.046)	-0.66 (.102)**
Ln Patenting rate	0.10 (.042)*	0.02 (.019)	0.08 (.044)
University degree rate	1.98 (.389)**	-1.05 (.206)**	3.06 (.400)**
Natural resource intensity	2.33 (4.80)	-2.76 (1.51)	5.17 (4.77)
Country level			
Social charges rate	-0.13 (.777)	-0.07 (.286)	-0.07 (.872)
Corporate tax rate	-3.56 (.647)**	1.56 (.294)**	-5.17 (.674)**
Observations	241	241	241
R-squared	0.53	0.53	0.70
Root MSE	0.49	0.21	0.48
**p<0.01, *p<0.05, robust standard errors in parentheses			

Table 5.9 shows the results of the estimation of the log-normal model. The regression results show that those regions that stand out in terms of a large market size, good accessibility, a skilled labour force, knowledge infrastructure, low taxes, and low wages pose the largest competitive threat to other European regions (Model 3).[21] None of the European regions possesses all these qualities, but it at least provides an explanation for the competitive threat that the above-mentioned second-order West European regions (Southwestern Scotland, Rhône-Alpes, and Andalucía) pose to other regions. Population density and natural resource abundance play a less important role. Examining the competitive threat that regions face (Model 4), it is – consistent with our expectations – shown that large, accessible and densely populated regions face a relatively smaller competitive threat. In addition, skilled labour force and low tax rate reduce the average competitive threat a region faces from all regions. A similar picture is obtained when conducting a regression analysis on the degree to which a region poses a threat to other regions relative to the degree to which a region faces a competitive threat from other

[21] In these regressions, GDP per capita had to be omitted due to a high degree of collinearity with the wage variable.

regions (Model 5). These results convincingly show that there are indeed two ways to outcompete other regions in attracting investments: having capacity-building policies that stimulate the knowledge base of the regions and incentive-based policies that reduce the cost of capital and labour. However, the successfulness of these policies is definitely dependent on the type of investments that a region wishes to attract. Whereas, capacity-building policies would be more

5.6 Conclusions and Discussion

This chapter introduces an indicator to measure the intensity of competition between pairs of regions, which can be considered the most fine-grained level at which competition can be measured. Regions are considered to be in competition when they have overlapping investment portfolios in terms of (1) sectors in which it is invested, (2) functions in which it is invested, and (3) geographical origin of the investment. Using the revealed competition measure as a building block, it is possible to identify competitive market segments, derive the competitive threat a region faces from other regions, the competitive threat regions pose to other regions, and the most important market segments in which regions compete.

In this chapter, we applied the revealed competition measure to territorial competition for foreign investments in Europe using data on greenfield investments. In light of European integration and globalisation, it is often argued that territorial competition will increase as the free movement of capital, goods and workers and the removal of economic, social and cultural barriers have made national boundaries disappear. Accordingly, MNCs often perceive European regions with similar characteristics situated in different countries as closer substitutes than dissimilar regions in the same country. This perception is, at least partly, reflected in our empirical assessment, which shows that European regions with similar locational endowments pose a fiercer competitive threat to one another than regions with different locational endowments. However, some regions are more competitive than others in that they pose a relatively higher competitive threat to other regions and at the same time face a relatively limited competitive threat from other regions. Typically, these are large, accessible regions with a skilled labour force and/or low costs of capital and labour. Regional giants such as Greater London and Ile-de-France battle against each other, but they face a low competitive threat from other regions in that they are simultaneously large and sufficiently distinctive. These regions specialise in attracting high value-added market- and strategic-asset-seeking investments in financial and business services. Perhaps paradoxically, territorial and regional competition for investments appears fiercest for those foreign investments that have the lowest value added (i.e., efficiency-seeking investments in production plants in low- and medium-tech manufacturing) and that no region really prefers. However, when the location requirements for investments are minimal, the number of regions that are included in the consideration set of a MNC is relatively large. As a MNC can choose from a wide range of locations, it can play governments against each other by asking for tax cuts or subsidies. Hence, a high degree of competition in this market as reflected by the revealed competition measure would also make sense from a substantive point of view.

The revealed competition measure presented in this chapter is not meant to replace other accounts of territorial competitiveness and territorial competition but rather should be perceived as complementary. First, the rankings of cities and regions may still be useful as indicators of territorial competitiveness, but it is important to recognise that not all relations between territories are of a competitive nature, and therefore, not all cities and regions should be compared by putting them on the same ranking list. Second, having identified the most important competitor region and its competitive advantage in attracting foreign investments, it becomes easier for regional planners and marketers to recognise the aspects of competitive advantage that should be addressed to increase the likelihood of attracting foreign investments, which facilitates more goal-directed and effective strategic planning and policy making with regards to territorial competitiveness. In this respect, regional authorities also increasingly recognise that foreign investments are not, by definition, a catalyst for economic growth and that it is best to attract investments that complement the economic structure of the region to promote sustainable development. It is not easier to attract such investments, but the probability that an MNC will become embedded in the regional economy (e.g., local labour markets, input-output structures) and not relocate will also be increased.

In addition to indicating the intensity of territorial competition, future research can utilise the revealed competition measure by linking territorial competition to territorial performance. Other aspects of in inter-regional competition based on trade (see Burger *et al.*, 2011b; Thissen *et al.*, 2011) should also be investigated. Accordingly, the focus shifts from territorial competition as a dependent variable to territorial competition as an independent variable. Naturally, new questions arise. How does territorial competition affect territorial performance? Are cities and regions that face less competitive threat from other regions more likely to grow and strengthen their position within the urban system? Can regional competition explain the decline of some regions and the growth of others? A research program in which interactions between the local and the global take centre stage unfolds.

Appendix 5A: Taxonomy of Investments by Sector

Category	Industries
Processing Industries and Natural Resource Extraction	Alternative/Renewable Energy Chemicals Coal, Oil & Natural Gas Minerals
Low-Tech Manufacturing	Beverages Ceramics & Glass Consumer Products Food & Tobacco Metals Paper, Printing & Packaging Plastics Rubber Textiles Wood Products
Medium-Tech Manufacturing	Automotive Components Automotive OEM Building & Construction Materials Engines & Turbines Industrial Machinery Non-Automotive Transport OEM
High-Tech Manufacturing	Aerospace Biotechnology Business Machines & Equipment Consumer Electronics Electronics Components Medical Devices Pharmaceuticals Semiconductors
Transport Services	Transportation Warehousing & Storage
Software and Information and Communication Technologies	Communications Software & IT Services Space & Defense
Financial Services	Financial Services
Commercial Services	Business Services Real Estate
Consumer Services	Healthcare Hotels & Tourism Leisure & Entertainment

Appendix 5B: Taxonomy of Investments by Function

Category	**Industries**
Headquarters	Headquarters
Business Services	Business Services
Research and Development	Design, Development, and Testing Research and Development
Sales and Marketing	Retail Sales, Marketing, and Support
Production	Electricity Extraction Construction Manufacturing Recycling
Support and Servicing	Customer Contact Centres Education and Training ICT and Internet Infrastructure Maintenance Shared Service Centres Technical Support Centres
Logistics	Logistics

Chapter 6:

On the Specification of the Gravity Model: Zeros, Excess Zeros and Zero-Inflated Estimation

Abstract[1]

Conventional studies of bilateral trade patterns specify a log-normal gravity equation for empirical estimation. However, the log-normal gravity equation suffers from three problems: the bias created by the logarithmic transformation, the failure of the homoskedasticity assumption, and the way zero values are treated. These problems normally result in biased and inefficient estimates. Recently, the Poisson specification of the gravity model of trade has received attention as an alternative to the log-normal specification (Santos Silva and Tenreyro, 2006). However, the standard Poisson model is vulnerable for problems of overdispersion and excess zero flows. To overcome these problems, this chapter considers modified Poisson fixed-effects estimations (negative binomial, zero-inflated). Extending the empirical model put forward by Santos Silva and Tenreyro (2006), we show how these techniques may provide viable alternatives to both the log-normal and standard Poisson specification of the gravity model of trade.

[1] This chapter has been published in *Spatial Economic Analysis*, 4(2), pp. 167-190 as "On the specification of the gravity model of trade: zeros, excess zeros and zero-inflated estimation" (with Frank van Oort and Gert-Jan Linders). It has been slightly edited to fit the format of this book.

6.1 Gravity Model of Trade and the Log-Normal Specification

Spatial interaction patterns, such as international trade, investment, migration or commuting flows, can be predicted and elucidated with an analogy to Newton's law of universal gravitation. The gravity model, which has been used in modern economics since Isard (1954), Ullman (1954), and Tinbergen (1962), hypothesises that the gravitational force between two objects is directly proportional to the product of the masses of the objects and inversely proportional to the geographical distance between them. Over the years, this model has become popular in international economics when analysing the pattern of trade flows between countries (Eichengreen and Irwin, 1998; Overman *et al.*, 2004).[2] In its most elementary form, the gravity model can be expressed as

$$I_{ij} = K\frac{M_i^{\beta 1} M_j^{\beta 2}}{d_{ij}^{\beta 3}}, \tag{6.1}$$

where I_{ij} is the interaction intensity or the volume of trade between countries i and j, K is a proportionality constant, M_i is the mass of the country of origin (in applications to bilateral trade patterns usually reflected by the country's GDP), M_j is the mass of the country of destination, d_{ij} is the physical distance between the two countries, β_1 is the potential to generate flows, β_2 is the potential to attract flows, and β_3 is an impedance factor reflecting the distance decay in trade. This basic model can easily be augmented to include other variables, such as whether countries i and j share borders, have the same language, or are member of a regional integration agreement (Feenstra, 2004).

Taking logarithms of both sides of the equation and adding a random disturbance term, the multiplicative form (equation 6.1) can be converted into a linear stochastic form, yielding a testable equation:

$$\ln I_{ij} = ln\, K + \beta_1 \ln M_i + \beta_2 \ln M_j - \beta_3 \ln d_{ij} + \varepsilon_{ij}\,, \tag{6.2}$$

where ε_{ij} is assumed to be independent and identically distributed (i.i.d.). In the trade literature, equation (6.2) is better known as the traditional or empirical gravity model (e.g., Eichengreen and Irwin, 1998) and in the field of regional science as the unconstrained

[2] See Anderson and Van Wincoop (2004) and Feenstra (2004) for the theoretical rationale behind the gravity model of trade.

gravity model (e.g., Fotheringham and O'Kelley, 1989; Sen and Smith, 1995). The terminology used in the field of regional science reflects the fact that the model does not take into account the constraints that the estimated bilateral outflows should add up to the total outflows, and that the estimated bilateral inflows should add up to the total inflows.

Recently, the international trade literature has shown a renewed interest in the theoretical foundations of the gravity model. This has resulted in formulations of the gravity model that derive from general equilibrium modelling of bilateral trade patterns (Bröcker, 1989a; Eaton and Kortum, 2002; Anderson and Van Wincoop, 2003; Feenstra, 2004). One of the key insights in the recent contributions to this field is that the traditional specification of the gravity model suffers from omitted variable bias, as it does not take into account the effect of relative prices on trade patterns. As shown by Anderson and Van Wincoop (2003), bilateral trade intensity not only depends on bilateral trade costs (affected by spatial distance, language differences, trade restrictions, and the like) but also on GDP-share average weighted multilateral trade costs indices or 'multilateral resistance terms' (affecting the prices of import-competing goods in the importing country, as well as export opportunities in the origin country). Omitting these terms from the specification may result in an omitted variables bias on the remaining parameter estimates in the gravity model. Quintessentially, this extension of the gravity model is analogous to the earlier literature in the field of regional science, which motivates singly or doubly constrained gravity models that satisfy the constraints on total country-specific inflows and outflows (e.g., Fotheringham and O'Kelly, 1989; Bröcker, 1989a).

As shown by Anderson and Van Wincoop (2003) and Feenstra (2004) and in analogy to earlier work by Bröcker and Rohweder (1990), a country-specific fixed-effects specification of the gravity equation is in line with the theoretical concerns regarding the correct specification of the model and yields consistent parameter estimates for the variables of interest. This is again in analogy to the above-mentioned regional science literature.[3] In a cross-sectional setting, this implies including country-specific exporter and importer dummy variables in equation (6.2). More formally, the log-normal fixed effects specification of the most basic gravity model (including physical distance as only resistance to trade) would look as follows:

$$\ln I_{ij} = \ln K + \beta_3 \ln d_{ij} + \gamma_i + \eta_j + \varepsilon_{ij} , \qquad (6.3)$$

[3] A similar point was motivated by econometric theory by, for example, Matyas (1998) and Egger (2005).

where γ_i is the fixed effect of the country of origin (the exporter) and η_j is the fixed effect of the country of destination (the importer). As this is commonly accepted, we will apply this estimation procedure as well.

The recent theoretical and methodological developments in the applied empirical trade literature have also increased the awareness for a different set of specification issues, that have at their heart the often implicit assumption of log-normality in the random error component, hence the double-logarithmic specification of the gravity equation to be estimated. The main catalyst of the latter development was the question of how to deal with zero-valued trade flows in estimating the gravity equation parameters (e.g., Santos-Silva and Tenreyro, 2006; Linders and De Groot, 2006; Helpman *et al.*, 2008). This issue has not reached a commonly accepted solution yet, and we will address this discussion by further investigating the (fixed-effects) specification and estimation problems related to zero-valued bilateral trade flows.

In the remainder of this chapter, we first discuss the underlying problems of the log-normal specification in Section 2. Section 3 discusses the Poisson specification as alternative technique to estimate gravity models, as is common in count data applications, and raises a number of potential pitfalls of this specification in trade flow applications. We propose to contrast the standard Poisson solution against alternative members of the Poisson family: the zero-inflated Poisson model and other modified Poisson models that can correct for the potential problems associated with the standard Poisson model. Section 4 provides an empirical application of these different econometric specifications to the analysis of bilateral trade patterns. Using this specific context, we compare the modified Poisson estimators to standard Poisson outcomes as well as to a more conventional OLS benchmark, both in terms of model fit and ability to control for specification problems. In doing so, we contribute to the methodological discussions on the correct specification of the trade gravity model by further investigating the fixed effects specification and estimation problems related to zero-valued bilateral trade flows. Section 5 concludes this chapter and provides directions for further research.

6.2 Problems with the Log-Normal Specification of the Gravity Model

Until now, the log-normal formulation of the gravity model has been one of the most commonly used economic tools to investigate international bilateral trade flows. However, from a methodological point of view, there are some serious problems with this gravity model specification. Flowerdew and Aitkin (1982) specifically point to (1) the bias created by the logarithmic transformation, (2) the failure of the assumption that all error terms have equal variance, and (3) the sensitivity of research results to zero-valued flows. These problems will be discussed in more detail below. In particular, we will focus on the problem of zero values in the log-normal gravity (fixed-effects) model.

First, the logarithmic transformation has an effect on the nature of the estimation process, as the log-normal model generates estimates of $\ln I_{ij}$ but not of I_{ij} As Haworth and Vincent (1979) have shown, the antilogarithms of these estimates tend to be biased, which in turn can lead to under-predicting of large trade flows and total trade flows (Flowerdew and Aitkin, 1982). Although it is well known in economics that Jensen's inequality implies that $E\ (\ln I_{ij}) \neq \ln E(I_{ij})$ and that the concavity of the log function should create a downward bias when using OLS, insufficient attention has been paid to this drawback of the log-normal model in the study of bilateral trade (see also Santos Silva and Tenreyro, 2006).

Second, the log-normal model is based on the questionable assumption that the error terms all have the same variance for all pairs of origins and destinations (homoskedasticity). Hence, it is assumed that an observed flow of 1 in relation to an expected flow of 2 is as probable as an observed flow of 1000 in relation to an expected flow of 2000 (Flowerdew and Aitkin, 1982). Especially when there are a large number of cases in which the observed and expected flows are small, small absolute differences before performing a logarithmic transformation of the dependent and independent variables may lead to large differences in the log-normal estimation of the model (Flowerdew and Aitkin, 1982). In the presence of such heteroskedasticity, not only the efficiency but also the consistency of the estimators is at stake (Santos Silva and Tenreyro, 2006).

Third, the log-normal model cannot deal well with zero-valued trade flows, since the logarithm of zero is undefined. Frankel (1997) argues that the most obvious reason for the occurrence of zero-valued trade flows is the lack of trade between small and distant countries, which can at best be explained by large associated variables and fixed costs.

Rauch (1999) further points out the low levels of GDP per capita and the lack of cultural and historical links as possible explanations for the absence of trade between countries, while Ghazalian *et al.* (2007) point to the influence of policies. This list of possible reasons for the existence of zero-valued trade flows becomes even longer if the volume of trade *in a specific good*, rather than the volume of overall trade, between two countries is considered. All countries do not produce all available goods, nor do they all have an effective demand for all available goods. Using bilateral trade data from 1990 from the World Trade Database (WTDB), Haveman and Hummels (2004) reported that in 58% of the cases, trade in a specific good originates from fewer than 10% of all countries. Similar patterns could be observed in other years and in other bilateral trade data, such as the UN COMTRADE dataset. On a similar note, Haveman and Hummels (2004) found that almost all countries (99.4%) bought goods from less than half of the 438 distinguished sectors. According to Haveman and Hummels (2004), a major weakness of the specification of the gravity model is therefore that it implies trade among all countries in all goods.

By tradition, the most common strategies to circumvent the 'zero problem' in the analysis of trade flows are to omit all zero-valued trade flows or arbitrarily add a small positive number (usually 0.5 or 1) to all trade flows in order to ensure that the logarithm is well-defined (Linders and De Groot, 2006). But by deleting all zero-valued flows, important information on low levels of trade is left out of the model (Eichengreen and Irwin, 1998). Particularly, when these zero-valued flows are non-randomly distributed, this can lead to biased results. Hence, a truncation of the sample should be avoided at all means. Likewise, the strategy of substituting zeros by a small positive constant can be regarded as inadequate. As Linders and De Groot (2006) remark, the choice of this number to be added is usually arbitrary and lacks both theoretical and empirical justification. What's even worse, Flowerdew and Aitkin (1982) find that even small differences in the selected constant can distort research results seriously. Varying the constant between 0.01 and 1, they show that the predicted interaction intensity significantly declines with the size of the constant, while the values of the regression coefficients generally decrease. In fact, King (1988) demonstrates that you can generate any parameter estimate to your liking by playing around with the size of the constant.

6.3 Poisson and Modified Poisson Specifications of the Gravity Model

From a Log-Normal to a Poisson Specification

Given the problems with the log-normal specification, the use of alternative regression techniques could be more appropriate in the context of the gravity model. However, despite repeated warnings from the related fields of quantitative geography and regional science (e.g., Senior, 1979; Flowerdew and Aitkin, 1982; Lovett and Flowerdew, 1988; Fotheringham and O'Kelley, 1989; Bohara and Krieg, 1996), international economics has only recently begun to take this issue seriously (e.g., Haveman and Hummels, 2004; Linders and De Groot, 2006; Santos Silva and Tenreyro, 2006; Helpman *et al.*, 2008). Following the increasing resistance against using the log-normal model in bilateral trade analysis, attention has been given to the possible use of Poisson and modified Poisson models (e.g., Santos Silva and Tenreyro, 2006).[4] This family of models originally derives from the analysis of count data. However, as indicated by Wooldridge (2002), the Poisson estimator can also be applied to non-negative continuous variables. In this chapter, we will focus on the application of negative binomial and zero-inflated models (Long, 1997) in gravity trade models, which can be considered modified Poisson models. As will be shown later in this chapter, this class of models is, from both a theoretical and empirical point of view, a viable alternative to standard Poisson and its log-normal counterpart.

By applying the Poisson specification to the fixed effects specification of the gravity model of trade (Andersen and Van Wincoop, 2003), we state that the observed volume of trade between countries i and j has a Poisson distribution with a conditional mean (μ) that is a function of the independent variables (equation 6.4). As I_{ij} is assumed to have a non-negative integer value, the exponential of the independent variables is taken, so as to ensure that (μ_{ij}) is zero or positive. More formally,

$$\Pr[I_{ij}] = \frac{\exp(-\mu_{ij})\mu_{ij}^{I_{ij}}}{I_{ij}}, (I_{ij} = 0, 1 \dots) \quad (6.4)$$

Here, the conditional mean μ_{ij} is linked to an exponential function of a set of regression variables, X_{ij}: $\mu_{ij} = \exp(\rho_0 + \beta' X_{ij} + \gamma_i + \eta_j)$, where ρ_0 is a proportionality constant,

[4] An early exception to the use of the log-normal specification is Bröcker and Rohweder (1990), who found a creative solution to reconcile trade flows with count data models, and used a Poisson estimator.

X_{ij} is the 1 x k row vector of explanatory variables with corresponding parameter vector β, which represent the different dimensions of transactional distance (cf. Obstfeld and Rogoff, 2000) between countries (e.g., physical distance, language and institutional distance). γ_i is an effect specific to the country of origin (an exporter-specific effect), and η_j is an effect specific to the country of destination (an importer-specific effect). The fixed-effects estimation in the model controls for country-specific fixed effects related to importers and exporters. Note that the Poisson model assumes equidispersion, as the conditional variance of the dependent variable should be equal to its conditional mean.

In contrast to the log-normal specification, the Poisson specification of the gravity model does not face the problems outlined in the previous section. First, the linking function is log-linear instead of log-log. Hence, the Poisson regression model generates estimates of I_{ij} and not of ln I_{ij}, thereby avoiding underpredicton of large trade flows and the total volume of trade. In addition, as the Poisson regression model is estimated by a maximum likelihood method, the estimates are adapted to the actual data, which means that the sum of the predicted values is virtually identical to the sum of the input values. Second, Poisson regression estimates are consistent in the presence of heteroskedasticity and are reasonably efficient, especially in large samples (King, 1988). Third, because of its multiplicative form, the Poisson specification provides a natural way to deal with zero-valued trade flows.

Overdispersion and the Negative Binomial Specification

An important condition of the Poisson model is that it assumes equidispersion. However, the conditional variance is most often higher than the conditional mean, which means that the dependent variable is overdispersed. According to Greene (1994), an important reason why we frequently find more variation than expected is the presence of unobserved heterogeneity not taken into account by the Poisson regression model. In fact, the Poisson regression model only accounts for observed heterogeneity, where different values of the predictor variables result in a different conditional mean value. Unobserved heterogeneity, however, originates from omitted variables. Not correcting for over- or underdispersion normally results in consistent, yet inefficient, estimation of the dependent variable, which is exemplified by spuriously large z-values and spuriously small p-values due to downward biased standard errors (Gourieroux *et al.*, 1984; Cameron and Trivedi, 1986).

In order to correct for overdispersion, a negative binomial regression model (equation 6.5), which belongs to the family of modified Poisson models, is most frequently employed. This can be regarded as a modification of the Poisson regression model (Greene, 1994). The expected value of the observed trade flow in the negative binomial regression model is the same as for in Poisson regression model (Long, 1997), but the variance here is specified as a function of both the conditional mean (μ) and a dispersion parameter (α), thereby incorporating unobserved heterogeneity into the conditional mean. In other words, an additional error term has been added to the negative binomial regression model. By allowing the dispersion parameter to take on other values than 1, overdispersion can be taken care of by explicitly modelling between-subject heterogeneity. More formally,

$$\Pr[I_{ij}] = \frac{\Gamma(I_{ij}+\alpha^{-1})}{I_{ij}!\Gamma(\alpha^{-1})}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu_{ij}}\right)^{\alpha^{-1}}\left(\frac{\mu_{ij}}{\alpha^{-1}+\mu_{ij}}\right)^{I_{ij}}, \tag{6.5}$$

Where $\mu_{ij} = \exp(\rho_0 + \beta' X_{ij} + \gamma_i + \eta_j)$, Γ is the gamma function, and α is a parameter that determines the degree of dispersion in predictions, hereby allowing the conditional variance to exceed the conditional mean. The larger α is, the larger the degree of overdispersion in the data. A likelihood ratio test of α can be employed to test whether the negative binomial distribution is preferred over a Poisson distribution (Cameron and Trivedi, 1986). If α is approximately zero, the negative binomial regression model reduces to the Poisson regression model.

Excess Zeros and the Hurdle and Zero-Inflated Specification

A related problem stems from the excessive number of zeros in the data, meaning that the number of zeros is greater than the Poisson or negative binomial distribution predicts. Although an excessive number of zeros may 'masquerade' as overdispersion, it is, according to Greene (1994), important to separate these two issues into different processes underlying the deficiencies of the Poisson model. Whereas overdispersion is induced from unobserved individual heterogeneity, excess zeros derive from 'non-Poissonness' (cf. Johnson and Kotz, 1969) through an overabundance of zeros (Greene, 1994). Although both the Poisson model and the negative binomial regression model can, unlike the log-normal model, technically deal with zeros, they are not well suited to handle the situation in which the number of observed zeros exceeds the number of zeros predicted by the model. The most important cause of 'non-Poissonness' is that some zeros in the data are produced by a different process than the remaining counts (including some of the other zeros), e.g., the complete lack of trade between pairs of countries because of a lack of resources (in which case the trade probability is identically zero by definition), compared to the lack of trade between pairs of countries due to the distances and differences in preferences and specializations (in which case the trade probability is theoretically different from zero).

The zero-inflated model (Lambert, 1992; Greene, 1994; Long, 1997) considers the existence of two latent groups within the population: a group having strictly zero counts and a group having a non-zero probability of having counts other than zero. Correspondingly, the estimation process of the zero-inflated Poisson model consists of two parts (equations 6.6.1 and 6.6.2). The first part (6.6.1) of the zero-inflated model contains a logit (or probit) regression of the probability that there is no bilateral trade at all. The second part contains a Poisson regression (6.6.2) of the probability of each count for the group that has a non-zero probability or interaction intensity other than zero. Unlike the negative binomial model, zero-inflated models can change the mean structure of the original Poisson model by explicitly modelling the origin of zero counts (Long, 1997). More formally,

$$\Pr\left[I_{ij}\right] = \varphi_{ij} + (1-\varphi_{ij})\exp(-\mu_{ij}) \qquad (6.6.1)$$

$$\Pr\left[I_{ij}\right] = (1-\varphi_{ij})\frac{\exp(-\mu_{ij})\mu_{ij}{}^{I_{ij}}}{I_{ij}} \qquad (6.6.2)$$

in which $\mu_{ij} = \exp\left(\rho_0 + \beta' X_{ij} + \gamma_i + \eta_j\right)$, and φ_{ij} is the proportion of observations with a strictly zero count $\left(0 \le \varphi_{ij} \le 1\right)$, which is determined by a logit model. Note that when φ_{ij} is 0, the zero-inflated Poisson model reduces to the Poisson model. The zero-inflated negative binomial regression model (6.7.1 and 6.7.2) is defined in a similar fashion:

$$\Pr\left[I_{ij}\right] = \varphi_{ij} + (1-\varphi_{ij})\exp\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu_{ij}}\right)^{\alpha^{-1}} \qquad (6.7.1)$$

$$\Pr\left[I_{ij}\right] = (1-\varphi_{ij})\frac{\Gamma(I_{ij}+\alpha^{-1})}{I_{ij}!\Gamma(\alpha^{-1})}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu_{ij}}\right)^{\alpha^{-1}}\left(\frac{\mu_{ij}}{\alpha^{-1}+\mu_{ij}}\right)^{I_{ij}} \qquad (6.7.2)$$

For both the zero-inflated Poisson model and the zero-inflated negative binomial regression model, the Vuong statistic (Vuong, 1989) can be employed to test whether a zero-inflated model is favoured above its non-zero inflated counterpart by examining whether significant evidence for excessive zero counts exists. The likelihood ratio test of overdispersion can be used to test whether the negative binomial specification or the Poisson specification.

A zero-inflated model may be more appropriate to model trade flows, both when viewed from a methodological and a theoretical point of view. For example, there is a difference between scientists who do not write any papers or and hence do not receive citations, and scientists who do write papers but are still not cited. Similar to the latter situation, zero-inflated trade models take into account that not all pairs of countries have the potential (or are at risk) to trade because of trade embargos or a severe mismatch between demand and supply. On a similar note, the geographical or cultural distance between countries may simply be too large for trade to be profitable. Hence, the profitability of trade, which reflects the trade potential, can be separated from the volume of trade as stemming from two different processes. Although both processes may depend on the same variables, as the profitability will generally rise if the potential size of trade gets larger (and vice versa), this does not imply that profitability only reflects the potential size of the flow. In fact, some variables may be more important in determining the profitability of bilateral trade rather than the potential volume of bilateral trade.

In this respect, the zero-inflated model resembles the hurdle Poisson regression model (Mullahy, 1986). However, the hurdle Poisson model would only distinguish whether or not trade between countries occurs and, given that two countries are trading, how large a volume of trade takes place. The zero-inflated model considers two different kinds of zero-valued trade flows: countries that never trade and countries that do not trade now, but potentially could trade in the future (based on the latent probability to trade according to manifest dimensions like distance, institutional proximity, etc.). Hence, a distinction can be made between pairs of countries with exactly zero probability of trade, pairs of countries with a non-zero trade probability who still happen not to be trading in a given year, and pairs of countries that are trading. As the zero-inflated model supersedes the hurdle model (Long, 1997) in that it accounts for unobserved heterogeneity in the population with a zero count, we do not further estimate or interpret the hurdle logit-Poisson model or the hurdle logit-negative binomial model here (see Linders *et al.*, 2008, for a hurdle Poisson model of bilateral trade patterns).

On a similar note, the zero-inflated Poisson and negative binomial models bear resemblance to the Heckman selection model (Bikker and De Vos, 1992; Linders and De Groot, 2006; Helpman *et al.*, 2008), which also corrects for the probability of trade in the gravity equation. In the Heckman selection model (Heckman, 1979), the selection equation determines whether or not bilateral trade between two countries in the sample is observed, while the regression model determines the potential size of bilateral trade. However, compared to the Heckman Selection model, the zero-inflated Poisson and negative binomial models are less restrictive, as they do not rely on stringent normality assumptions, nor do they require an exclusion restriction or instrument for the second stage of the equation (regression on the volume of trade). In the Heckman selection model, as seen in the context of the gravity trade model, this instrument should reflect a variable that influences the absence of trade but is unrelated to the volume of trade. Such an instrumental variable is often hard to find. In addition, despite the fact that the Heckman selection model also provides a natural way to deal with zero counts, the bias created by the logarithmic transformation in the regression part of the model still poses a problem. Because the modified Poisson family provides alternatives to deal with overdispersion and excess zero flows, we do not consider the Heckman log-normal specification in our comparison (see Linders and De Groot (2006) for a comparison of the Heckman selection model to other log-normal solutions to the problem of including zero flows).

6.4 Empirical Example: Determinants of Bilateral Trade

Data and Variables

To compare the different specifications, we focus on trade patterns for a set of 138 countries in the period 1996-2000 (UN COMTRADE database; Feenstra *et al.*, 2005). These are all listed in Appendix 6A. Excluding domestic trade, there are potentially 138x137 = 18906 individual trade flows between the 138 countries of origin (the exporters) and the 138 countries of destination (the importers). We use averagely yearly exports expressed in millions of US dollars as an indicator of the bilateral trade volume, such that each pair of countries yields two observations, each country being both an exporter and importer. We use reported exports rather than reported imports, as the former provides a better coverage. As can be derived from Figure 6.1, the frequency distribution of the volume of trade across trade flows strongly deviates from normality (skewness=37.57, kurtosis=1906). In fact, over 50% of all bilateral trade flows takes the value zero.

Figure 6.1: Distribution of Trade Volume (in millions of year 2000-dollars)

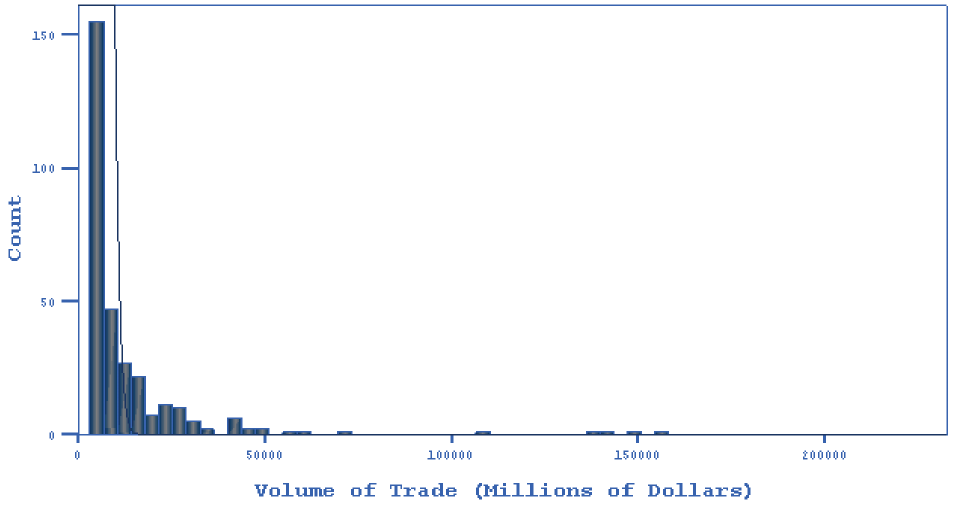


Table 6.1: Statistics of Variables used in the Gravity Equation (N=18906)

	Mean	Std. Dev.	Min.	Max
Yearly average volume of trade (1996-2000)	270.1	2884	0	189000
Geographical distance (ln)	8.685	0.800	4.01	9.90
Contiguity dummy	0.012	0.140	0	1
Common language dummy	0.132	0.339	0	1
Common history dummy	0.023	0.151	0	1
Free trade agreement dummy	0.054	0.226	0	1
Institutional distance	2.014	1.931	0	11.14
Sectoral complementarities	2.000	1.590	0	15.71

Despite the fast growth in world trade during the past decades, barriers of physical distance, culture, institutional frameworks and economic policy still yield considerable costs to international trade (Anderson and Van Wincoop, 2004). We have included a variety of explanatory variables in the gravity equation, which affect trade patterns by increasing or decreasing the transactional distance between countries. More specifically, we distinguish between tangible and intangible trade barriers (Andersen and Van Wincoop, 2004; Linders et al., 2008). First, tangible barriers obstruct trade. These barriers are directly observable in terms of their effect on the costs or quantities of trade. Examples are transport barriers and trade policy barriers (tariffs and import and export quota). Second, we can identify intangible trade barriers, which cannot be observed directly in terms of a monetary or quantitative restriction. Intangible trade barriers include barriers of incomplete information, cultural barriers (including language and history), and institutional barriers (institutional distance) across countries (e.g., Andersen and Van Wincoop, 2004). Table 6.1 provides summarized statistics of the variables included in the gravity equation. See Appendix 6B for a full description of these variables and their sources.

Empirical Results

In this section, we include zero flows in the gravity equation using the different specifications that we distinguished above. First, we present results for the log-normal specification, estimated by OLS. We discuss a naïve extension of the log-normal model to include zero flows. After that, we move on to discuss the standard Poisson model, as a more natural way to include zero flows. Finally, we show the results for modified Poisson models that can correct for overdispersion and excess zeros.

Model 1 in Table 6.2 show the results of the estimation of the log-normal model, including fixed effects and using the White estimator to obtain cluster-robust standard errors[5], in which the zero-valued flows have been omitted from the sample. Overall, it can be inferred that, in line with the trade literature, most variables have the expected sign and are highly statistically significant. The volume of trade decreases with geographical distance: an increase in distance by 1% leads to a decrease in trade by 0.84%. This is consistent with the average estimate of distance decay of –0.9 found in the trade literature (Disdier and Head, 2008). The variables describing cultural and economic proximity of countries, such as common language, having ever been in a colonial relationship, and having a free trade agreement, all positively affect the volume of bilateral trade.

Taking into account the possible bias created by the exclusion of zero-valued flows, Models 2a-2e in Table 6.2 show the results of the estimation of the log-normal model, including fixed effects and using the White estimator to obtain cluster-robust standard errors, in which the zeros in the sample have been substituted by a small positive value in order to avoid sample selection bias. This small positive value ranges here between 0.01 (Model 2e) to 1 (Model 2a). Compared to Model 1, in which the zero values had been excluded, the effects of the tangible and intangible barriers on the volume of bilateral trade are of the same sign, except for the effect of sectoral complementarities.

---

[5] Here we assume that the unobserved variation is not independent across trade links and that observations are clustered within countries of origin (see also Black (1992) on spatial network autocorrelation). Similar results were obtained by clustering by countries of destination.

Table 6.2: OLS and Average Yearly Trade from 1996-2000

	(1) T_{ij}	(2a) $T_{ij}+1$	(2b) $T_{ij}+0.5$	(2c) $T_{ij}+0.1$	(2d) $T_{ij}+0.05$	(2e) $T_{ij}+0.01$
Geographical distance	-0.841 (.052)**	-0.451 (.031)**	-0.508 (.033)**	-0.637 (.039)**	-0.692 (.041)**	-0.817 (.048)**
Contiguity dummy	0.615 (.129)**	0.553 (.140)**	0.543 (.147)**	0.507 (.168)**	0.489 (.177)**	0.448 (.200)**
Language dummy	0.421 (.061)**	0.229 (.038)**	0.300 (.043)**	0.479 (.056)**	0.559 (.061)**	0.746 (.077)**
History dummy	0.988 (.097)**	0.529 (.121)**	0.573 (.130)**	0.654 (.153)**	0.684 (.164)**	0.753 (.190)**
Free trade agreement	0.534 (.093)**	0.609 (.102)**	0.528 (.107)**	0.306 (.121)*	0.203 (.128)	-0.041 (.150)
Institutional distance	-0.052 (.015)**	-0.092 (.014)**	-0.083 (.014)**	-0.055 (.016)**	-0.041 (.017)*	-0.009 (.020)
Sectoral complementarities	0.028 (.033)	-0.032 (.017)	-0.039 (.018)*	-0.058 (.020)**	-0.067 (.022)**	-0.087 (.025)**
Observations	9128	18906	18906	18906	18906	18906
Importer Fixed Effects	YES	YES	YES	YES	YES	YES
Exporter Fixed Effects	YES	YES	YES	YES	YES	YES
-2 Log likelihood	13779	27344	29102	33938	35288	37481
SJ Goodness-of-Fit	0.860	0.809	0.782	0.769	0.765	0.761

*p<0.05, **p<0.01; Cluster-robust errors between parentheses.

However, the obtained effect sizes differ substantially between the model without zeros and the various transformed models with zeros. The choice of the positive constant that enables zero flows to be included in the log-normal specification heavily affects regression outcomes. By varying this constant (1, 0.5, 0.1, 0.05, and 0.01) in Models 2a-2e, we find that the values of the regression coefficients greatly vary with the constant selected, as differences of 50% or more are not uncommon. Following King (1988), it indeed seems that you can generate any parameter estimate to your liking, which is typically an undesirable property of the OLS estimation of the log-normal transformed gravity model. Given that omitting the zero values gives biased results and the choice of the constant has a strong effect on the parameter values, alternative estimation techniques that avoid these problems are desirable.

Because the logarithmic transformation of the gravity model suffers from Jensen's inequality, potentially severe bias due to unobserved heterogeneity, and cannot deal with zero values in a straightforward way, alternative estimation techniques may be more appropriate. In particular, Poisson estimation enables us to move away from the need of a logarithmic transformation of the gravity model. Table 6.3 presents models that use Poisson and modified Poisson estimation techniques.

Specification (3) uses the Poisson pseudo maximum likelihood (PPML) estimator introduced by Santos Silva and Tenreyro (2006). The fixed-effects Poisson regression is estimated using the White estimator of variance as a first attempt to account for unobserved heterogeneity. From specification (3) in Table 6.3, it can be inferred that the parameter estimates tend to be lower compared to the OLS specifications in specification (1), Table 6.2. Although the direction of the observed effects in general remains the same, the PPML estimates point out that the elasticities of common language and history are smaller than indicated by the OLS estimates. On a similar note, the border effect, the free trade agreement effect, and the sectoral complementarities effect appear to be significantly larger under PPML. The parameter of institutional distance is not significant in this model.

To control for unobserved heterogeneity and excess zeros, which may otherwise lead to biased and inefficient results, the PPML estimator was tested against the negative binomial pseudo maximum likelihood model (NBPML), the zero-inflated Poisson pseudo maximum likelihood model (ZIPPML), and the zero-inflated negative binomial pseudo maximum likelihood model (ZINBPML). The zero-inflated models generate two sets of parameter estimates: one set for the logit model, which identifies members of the group of pairs of countries always having zero values (pairs of countries that never trade), and one set for the Poisson and negative binomial parts, which predict the probability of a count belonging to the group of countries that have theoretically non-zero trade flows. As can be derived from Model 5 and 6 in Table 6.3, the signs of the coefficients in the logit model are usually opposite those in the Poisson and negative binomial parts. With respect to the ZIPPML model (5), we find that geographical distance, common language, and institutional distance in particular affect the *probability* of trade, which can be derived from the logit part of the model. If the geographical distance between countries increases by 1%, the trade probability of country pairs belonging to the never-trading group increases by 1.05%. Likewise, if the institutional distance between countries increases by 1%, the trade probability of countries belonging to this group increases by 0.19%.[6] Having a common language decreases the odds of never trading by 73%. Although common language and institutional distance both affect the trade probability according to the ZIPPML outcomes, these variables were not found to have an effect on the expected *volume* of trade. Looking at the Poisson part of the model, it appears that in particular physical distance, having a common border, a common history, free trade agreements, and being specialized in different economic sectors increase the expected volume of trade when holding all other variables constant. Hence, it can be inferred from the ZIPPML outcomes that whether and to what extent countries trade are related to different factors.

The ZINBPML model can be interpreted in a similar fashion. Compared to the PPML estimator, the regression coefficients estimated by ZIPPML in the Poisson part of the model are similar, while the regression coefficients estimated by NBPML and ZINBPML differ substantially from the effects under PPML. More specifically, the effects of geographical distance, common language, and common history are substantially larger under NBPML and ZINBPML, while the effects of free trade agreements are substantially smaller. Surprisingly, there is even a negative effect of having a free trade agreement on the expected volume of trade under NBPML. In addition, the parameter estimates generated by NBPML and ZINBPML deviate more from the OLS coefficients than the estimates generated by PPML and ZIPPML.

---

[6] Institutional distance enters the link function of the Poisson model (i.e., the gravity equation for conditional expected trade) linearly, not log-linearly. We compute an average effect of varying institutional distance from its mean by using the sample standard deviation given in Table 6.1. The effect on the probability of zero trade becomes: $e^{0.088*1.931}-1 = 0.19\%$

Table 6.3: Poisson and Modified Poisson PML on Average Yearly Trade from 1996-2000

	PPML (3) T_{ij}	NBPML (4) T_{ij}	Zero-Inflated PPML (5) T_{ij}		Zero-Inflated NBPML (6) T_{ij}	
			Logit	Poisson	Logit	Neg. Binomial
Geographical distance	-0.556 (.042)**	-1.058 (.061)**	1.051 (.098)**	-0.549 (.042)**	0.663 (.123)**	-0.989 (.060)**
Contiguity dummy	0.686 (.108)**	0.709 (.163)**	0.401 (.252)	0.686 (.107)**	0.406 (.260)	0.780 (.160)**
Language dummy	0.109 (.072)	0.741 (.102)**	-1.312 (.135)**	0.099 (.072)	-0.160 (.227)**	0.424 (.078)**
History dummy	0.234 (.093)*	1.227 (.155)**	0.110 (.355)	0.240 (.090)**	0.486 (.272)	1.299 (.138)**
Free trade agreement	0.548 (.075)**	-0.036 (.129)	-0.090 (.262)	0.568 (.076)**	0.360 (.329)	0.398 (.101)**
Institutional distance	0.001 (.020)	-0.043 (.021)*	0.088 (.034)**	-0.012 (.021)	-0.026 (.024)	-0.038 (.016)*
Sectoral complementarities	0.164 (.043)**	-0.007 (.040)	0.044 (.053)	0.170 (.043)**	0.069 (.099)	0.002 (.045)
Observations	18906	18906	18906		18906	18906
Importer Fixed Effects	YES	YES	YES		YES	YES
Exporter Fixed Effects	YES	YES	YES		YES	YES
-2 Log pseudolikelihood	848112	49384	807636		47685	
Overdispersion (α)		1.748**			1.132**	
Vuong (z)			12.98**		19.36**	
AIC	1696788	99334	1616401		96239	
BIC	1699001	101554	1620827		99644	
S&J Goodness-of-Fit	0.887	0.052	0.886		0.563	

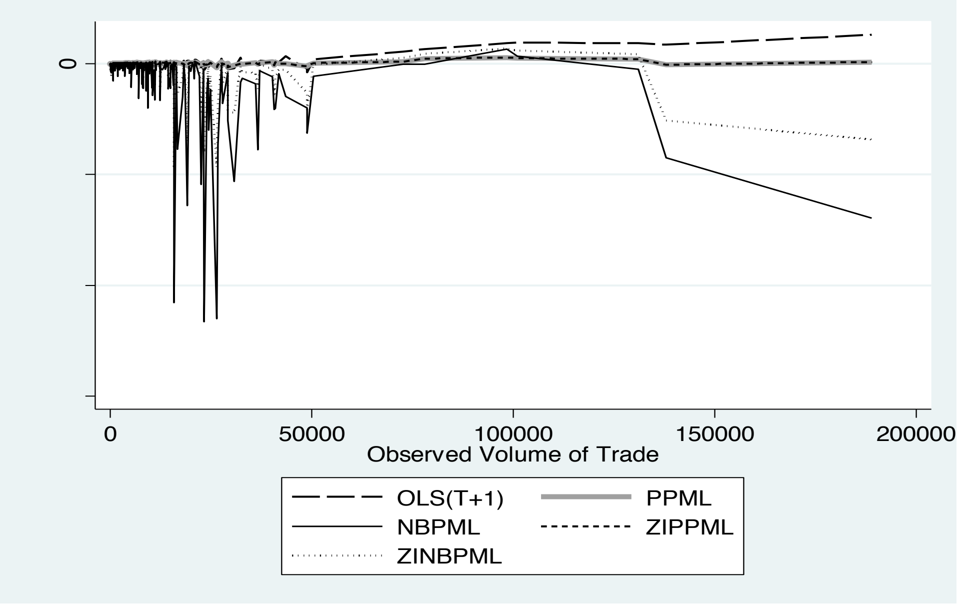
*p<0.05, **p<0.01 cluster-robust standard errors between parentheses.
All models are estimated using Newton-Raphson (NR) algorithm. For overdispersion, the alpha value is displayed, for the Vuong test the z-score.

Model Comparison among OLS, Poisson and Modified Poisson Estimations

After comparing the effect size estimates between OLS, Poisson and modified Poisson estimators, we want to assess the choice of correct model specification explicitly. The comparative performance of the OLS, Poisson and modified Poisson specifications can be examined on the basis of different measures of goodness-of-fit (see Long, 1997). As the use of the log-normal specification can be refuted on theoretical grounds, and as the available goodness-of-fit statistics to compare the OLS with the Poisson and modified Poisson specifications are rather limited, we predominantly focus on the comparison between the Poisson and modified Poisson estimations. The correct model choice within the Poisson family of estimators also depends on the extent to which overdispersion and excess zeros are empirically relevant.

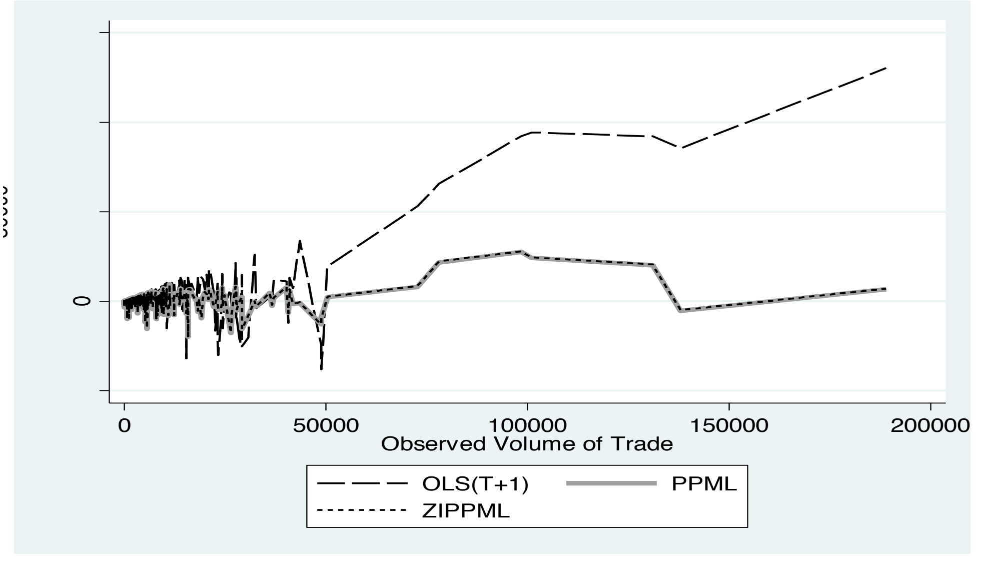
Probably the most popular way to compare the goodness-of-fit of different models is by comparing the estimated and observed values of the dependent variable (e.g., Bergkvist and Westin, 2001; Martinez-Zarozo *et al.*, 2007). Figures 6.2A and 6.2B show the residuals (the observed minus the estimated volume of trade) against the observed volume of trade. From Figure 6.2A, it is clear that the NBPML and ZINBPML perform the worst in terms of out-of-sample forecast. In particular, the NBPML and ZINBPML estimators tend to overpredict the volume of medium and large trade flows. In contrast, PPML and ZIPPML perform relatively well, as the estimated volume of trade does not deviate much from the observed volume of trade for neither small nor large trade flows. In this respect, PPML and ZIPPML do not only outperform NBPML and ZINBPML, but also OLS (see Figure 6.2B). In particular, OLS tends to underpredict large trade flows. On the one hand, the good performance of PPML and ZIPPML can be explained by the fact that these models puts more weight on observations for which the predicted level of trade is high compared to OLS, NBPML and ZINBPML (Head *et al.*, 2009). On the other hand, negative binomial regression models are also less appropriate when applied to continuous dependent variables as results are to at least some extent contingent on the scale of measurement that is used (e.g., thousands, millions or trillions of dollars) (Bosquet and Boulhol, 2010).

Figure 6.2A: Comparison of the Estimated Trade Volume and the Observed Trade Volume of Trade by Specification



The good performance of PPML and ZIPPML based on the comparison between the linearly predicted volume of trade and the observed volume of trade is also reflected in the Stavins and Jaffe Goodness-of-Fit statistic (Stavins and Jaffe, 1990; see also Martinez-Zarozo *et al.*, 2007). The Stavins and Jaffe goodness-of-fit statistics are based on the Theil inequality coefficient (Theil's U), which usually ranges from 0 to 1 (Theil, 1958). If the forecast is perfect, the Stavins and Jaffe statistic takes on the value 1. As can be derived from Tables 6.2 and 6.3, the value of the Stavins and Jaffe goodness-of-fit statistic obtained from the PPML and ZIPPML models is significantly higher than the values obtained from the NBPML and ZINBPML models. Moreover, the Stavins and Jaffe statistic is higher for PPML and ZIPPML than for all (truncated) OLS estimations. This would indeed confirm that the PPML and ZIPPML models provide a more accurate forecast. This is contrary to the findings of Martinez-Zarzoso *et al.* (2007), who find that the out-of-sample forecasts for OLS (estimated by taking the natural exponent of the predicted value) generally outperform the out-of-sample forecasts for PPML. However, results may of course vary across data sets, and more research is definitely needed on this topic.

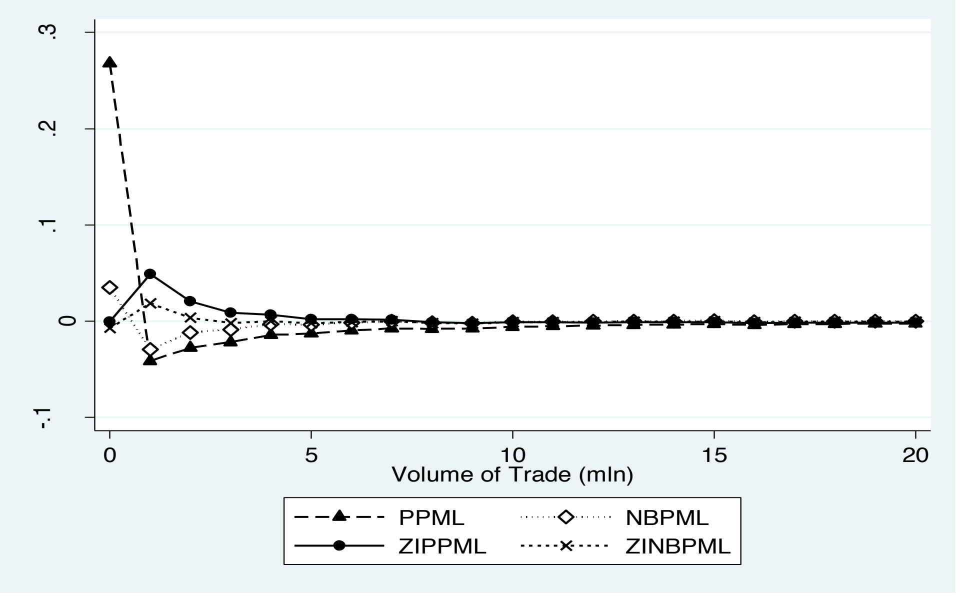
Figure 6.2B: Comparison of Estimated Trade Volume and Observed Trade Volume by Specification



A drawback of comparing the goodness-of-fit on the basis of observed versus estimated values is that this '*measure of goodness-of-fit solely based upon the expected value is unable to address the improvement achieved by a model with less restrictive variance assumptions'* (Liu and Cela, 2008: 4). The modified Poisson models such as the NBPML, ZIPPML and ZINBPML have the advantage of imposing fewer restrictions on variance and allowing more heterogeneity. We are also interested in these aspects for the choice of specification. In particular, we argued that overdispersion and excess zeros are probably relevant in the context of bilateral trade flows. An alternative way to take this into account and compare model fit of the different Poisson and modified Poisson models is to examine the probability distribution and compare the expected probabilities to the observed probabilities for each specification. Figure 6.3 shows these for PPML, NBPML, ZIPPML, and ZINBPML for all observed bilateral trade between 0 and 20 million (about 75% of the sample). The points above the x-axis represent an overprediction of the probability of observing that volume of trade, while the points below the x-axis represent an underprediction. From Figure 6.3, it becomes clear that ZINBPML performs the best, followed by NBPML and ZIPPML, which do about equally well. Moreover, the

ZINBPML and ZIPPML specifications predict most accurately the number of zero-valued trade flows in the data set. PPML in particular tend to overpredict low volumes of trade.

Figure 6.3: Observed versus Estimated Probability of the Volume of Trade



Examining more formal statistics concerned with comparing the observed and predicted distributions (see Table 6.3), the likelihood ratio test of overdispersion (α) and the Vuong test indicate that (1) NBPML is favoured over PPML, (2) ZIPPML is favoured over PPML, and (3) ZINBPML is favoured over NBPML, ZIPPML and PPML. Neither the Vuong nor the likelihood ratio test of overdispersion (α) can be used to compare NBPML and ZIPPML. However, both the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) indicate that the NBPML should be preferred over the ZIPPML. Although AIC and BIC can also be obtained for the OLS models, these values do not directly compare with values of the AIC and BIC in the Poisson and modified Poisson models, as OLS uses a different dependent variable (the natural logarithm of the volume of trade instead of the volume of trade itself).

To summarize, the different goodness-fit statistics do not all point to the same conclusion. On the one hand, PPML and ZIPPML perform the best when comparing the expected and observed values of the dependent variable. They even outperform OLS in our example. On the other hand, NBPML and ZINBPML perform the best when comparing the expected and observed probabilities, thereby taking into account the model improvement by introducing less restrictive variance assumptions (Liu and Cela, 2008). Overall, it can be inferred that ZIPPML performs the best on average, as rated by both criteria. It has a reasonable fit of estimated trade, can include zero flows, and accounts for different types of zero flows, correcting for excess zeros and the overdispersion that results from that.

6.5 Discussion and Conclusion

The renewed and extended interest in the correct econometric specification of the gravity model of trade fosters the discussion on the estimation techniques applied (Santos Silva and Tenreyro, 2006; Martinez-Zarzoso *et al.*, 2007). Three problems often encountered when analyzing bilateral trade data using the conventional log-normal specification of the gravity model of trade are (1) the bias created by the logarithmic transformation (Jensen's inequality), (2) the failure of the homoskedasticity assumption, and (3) the way zero-valued trade flows are treated. These problems normally result in biased and inefficient estimates.

To overcome these problems, this chapter considers Poisson and modified Poisson fixed-effects estimations (negative binomial, zero-inflated), extending the empirical model put forward by Santos Silva and Tenreyro (2006). This class of models is hypothesized to be a viable alternative to its log-normal counterpart, both from a theoretical and empirical point of view. In contrast to the log-normal specification, these specifications of the gravity model do not bring about the problems mentioned. First, the linking function is log-linear instead of log-log. Hence, the Poisson and modified Poisson regression models avoid underpredicting large trade flows or the total volume of trade. Second, the Poisson and modified Poisson regression estimates are consistent in the presence of heteroskedasticity and reasonably efficient, especially for large samples. Third, because of its multiplicative form, the Poisson and modified Poisson specifications provide a natural way to deal with zero-valued trade flows. Particularly, the zero-inflated model theoretically considers two different kinds of zero-valued trade flows: countries that never trade and countries that do not trade now but potentially could, based on the latent trade probability determined by manifest dimensions like geographical separation, institutional proximity, etc.).

Empirically, we compare OLS estimates (leaving the zero-valued flows out or replacing them by a small constant) with Poisson and modified Poisson models using the same trade data between countries (UN COMTRADE data with more than 50% of bilateral relations showing no trade). Using these models yields mixed results regarding the tangible and intangible trade barriers. In line with the trade literature, most variables have the expected sign and are highly statistically significant. The volume of trade decreases with geographical distance. The variables describing cultural and economic proximity of countries, such as common language, having ever been in a colonial relationship, and having a free trade agreement, all positively affect the volume of bilateral trade. Also, more traditional explanations of trade patterns, such as tangible policy barriers (embodied by an FTA variable and bilateral import tariffs), comparative advantages, and factor proportion differences, are important for explaining trade patterns.

The magnitudes of many coefficients differ considerably in the various specifications applied. Our analyses confirm that leaving out the zero-valued flows leads to seriously biased results, as the omitted zeros are non-randomly distributed across the importing and exporting countries. Moreover, in OLS models in which the zero-valued flows have been replaced by a small constant, we find that the values of the regression coefficients greatly vary with the value of the constant selected.

We show that the Poisson and modified Poisson (negative binomial, zero-inflated) modelling techniques applied may provide a viable alternative to the log-normal specification of the gravity trade model. From a theoretical point of view, these specifications of the gravity model do not bring about the problems of the log-normal formalism, and zero-inflated models allow for the possibility to detach the trade probability from the trade volume.

To further motivate the choice of econometric specification, we compare the model fit of the different specifications. The different goodness-of-fit statistics applied to the gravity models do not all lead to the same conclusion, though. On the one hand, the Poisson model (PPML) and the zero-inflated Poisson model (ZIPPML) perform the best when comparing the estimated and observed values of the dependent variable, and even outperform OLS in our example. On the other hand, the negative binominal model (NBPML) and the zero-inflated negative binominal model (ZINBPML) perform better when comparing the expected and observed probabilities, which takes into account the model improvement by introducing less restrictive variance assumptions. If we consider model fit and the relevance of excess zeros, the zero-inflated Poisson model (ZIPPML) on average scores best. Zero-inflated models, furthermore, allow for the possibility to detach the probability to trade from the volume of trade. This implies that we get additional information on the determinants of the probability of different types of zero flows. Zero-inflated estimation controls the parameters in the flow part of the gravity model for sample selection effects. Still, further investigation is needed to more robustly compare the forecast accuracy of these models and to value the trade-offs and criteria on which the models should be optimally evaluated.

Appendix 6A: Countries included in the analysis

Albania	Gabon	Norway
Algeria	Gambia	Oman
Angola	Germany	Pakistan
Argentina	Ghana	Panama
Australia	Greece	Papua New Guinea
Austria	Guatemala	Paraguay
Azerbaijan	Guinea	Peru
Bahamas	Haiti	Philippines
Bahrain	Honduras	Poland
Bangladesh	Hungary	Portugal
Barbados	India	Qatar
Belarus	Indonesia	Republic Moldova
Belgium-Luxembourg	Iran	Romania
Belize	Ireland	Russian Fed
Bermuda	Israel	Rwanda
Bolivia	Italy	Saudi Arabia
Bosnia Herzegovina	Jamaica	Senegal
Brazil	Japan	Singapore
Bulgaria	Jordan	Slovakia
Burkina Faso	Kazakhstan	Slovenia
Burundi	Kenya	South Africa
Cameroon	Korea Rep.	Spain
Canada	Kuwait	Sri Lanka
Central African Republic	Laos	Sudan
Chad	Latvia	Suriname
Chile	Lebanon	Sweden
China	Libya	Switzerland-Liechtenstein
Colombia	Lithuania	Syria
Congo	Macau	Tanzania
Costa Rica	Madagascar	Thailand
Cote D’Ivoire	Malawi	Togo

Croatia	Malaysia	Trinidad and Tobago
Cuba	Mali	Tunisia
Cyprus	Malta	Turkey
Czech Rep	Mauritania	Uganda
Denmark	Mauritius	Ukraine
Djibouti	Mexico	United Kingdom
Dominican Republic	Morocco	United Arabian Emirates
Ecuador	Mozambique	Uruguay
Egypt	Netherlands Antilles	USA
El Salvador	Netherlands	Uzbekistan
Estonia	New Caledonia	Venezuela
Ethiopia	New Zealand	Vietnam
Fiji	Nicaragua	Yugoslavia
Finland	Niger	Zambia
France-Monaco	Nigeria	Zimbabwe

Appendix 6B: Data

To compare the ability of the traditional OLS specification with that of the Poisson and modified Poisson estimation methods when dealing with zero-valued flows, we focus on trade patterns in 2000 for a set of 138 countries, all listed in Appendix 6A. In the analysis, we use both country-specific and bilateral data from various sources. The GDPs of the exporting and importing countries are examples of country-specific variables, while geographic distance, adjacency, and common language, among others, are examples of bilateral characteristics for each pair of countries. In this appendix, a more detailed description of the data and sources used can be found.

Dependent variable

- The yearly average volume of trade between countries (1996-2000) in millions of dollars was obtained from the UN COMTRADE database. We use bilateral exports as dependent variables, such that each country pair yields two observations, with each country being both an exporter and an importer.

Independent variables: bilateral data

The bilateral variables in a gravity equation merely reflect the distance between two countries. These variables do not necessarily reflect the geographical distance or adjacency but can also be economic (free trade area) and cultural in character (common language and history).

- In line with previous research, geographic distance is measured as the straight distance between countries ('as the crow flies'), using the capital of each country as its centre of gravity. This implies that the distance between the two centers of gravity of neighboring countries is likely to overestimate the average distance of trade between them.
- The Boolean border dummy variable takes the value of one if two countries are adjacent. Adjacency requires either a land border or a small body of water separating the two countries. Both measurement error in the distance variable and the effect of historical relations between adjacent countries are captured by this dummy variable.

- To assess whether two countries have the same official language, we use a database collected by Haveman that distinguishes fourteen languages. This data has been expanded using CIA's World Factbook to cover more countries and languages. A Boolean language dummy variable reflects whether or not two countries have a common language.
- The ***Boolean history dummy variable*** takes the value of one if the two countries had, or have, a colonial relationship, or if they were ever part of the same country. This variable is constructed on the basis of CEPII data.
- Whether pairs of countries take part in a common regional integration agreement has been determined on the basis of OECD data on major regional integration agreements. A Boolean dummy variable (FTA) indicates whether or not the importing and exporting country are both members of the same free trade area.
- Our measure of ***institutional distance*** is based on Kaufmann's six dimensions of governance quality (Kaufmann *et al.*, 2004). These dimensions include voice and accountability, political stability, effectiveness of government, quality of regulation, rule of law, and control of corruption. All these indicators are constructed on the basis of factor analysis and reflect different aspects of the quality of governance. A more detailed description of these dimensions can be found in Kaufmann *et al.* (2004). We measure the institutional distance between pairs of countries by using the index developed by Kogut and Singh (1988):

$$ID_{ij} = \frac{1}{6}\sum_{k=1}^{6}\frac{(I_{ki} - I_{kj})^2}{V_k},$$

where I_{ki} indicates the i^{th} country score on the k^{th} dimension, and V_k is the variance of this dimension across all countries. Institutional distance reflects the fact that a higher difference in institutional effectiveness raises adjustment costs and may decrease bilateral trust (De Groot *et al.*, 2004).[7] Traders from countries with very different

[7] Though conceptually helpful for highlighting the importance of less tangible dimensions of trade barriers, it is sometimes hard to separate tangible and intangible barriers empirically. Institutional barriers are identified as intangible trade barriers, although in principle some of the costs related to institutions are directly observable (for example, legal costs). Most of the transaction costs related to institutions are not directly observable in the market, such as contracting costs, monitoring costs, regulatory costs, expropriation risks and other uncertainties, and adjustment costs related to differences in the quality of the institutional settings.

levels of guaranteed property rights and the enforceability of contracts are frequently unfamiliar with the other country's formal or informal procedures for doing business.

- To more precisely capture the theory of trade concerned with the traditional factor proportions, we also include differences in production structure in our model, which we label ***sectoral complementarities***. These are estimated much like the institutional distance is, but with the Kogut-Singh index (equation 3) estimated using the share differences from six broad sectors in the total economy of countries *i* and *j* (agriculture, manufacturing, construction, wholesale, transport and services). Information on the production structure of the countries used in the sample was obtained from the UNCTAD database.

Chapter 7:

Functional Polycentrism and Urban Network Development in the Greater South East UK

Abstract[1]

In contemporary literature on changing urban systems, it is often argued that the traditional central place conceptualisation is outdated and should be replaced by a network view that emphasises the increasing criss-crossing pattern of interdependencies between spatial units. This chapter tests for urban network development by looking at commuting patterns in the Greater South East UK. The analysis is based on census commuting interaction data for three points in time during the past three decades (1981-2001). Although the empirical results indicate that the Greater South East UK can still not be characterised as a polycentric urban region or integrated urban network, there is some evidence for urban network development at the local, intra-urban, level as well as a decentralisation of the system at the regional, inter-urban, level.

[1] This chapter has been published in *Regional Studies*, 44(9), pp. 1149-1170 as 'Functional polycentrism and urban network development in the Greater South East, United Kingdom: evidence from commuting patterns, 1981-2001' (with Bastiaan de Goei, Frank van Oort and Michael Kitson). It has been slightly edited to fit the format of this book.

7.1 Whither urban networks?

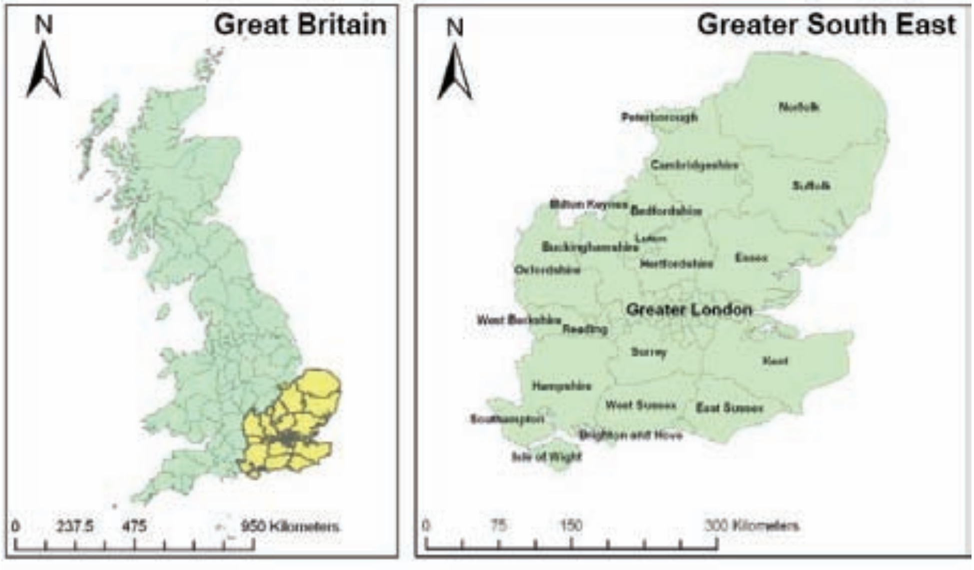
Regional planners in the Netherlands, Belgium, Germany, and the United Kingdom increasingly view the development of urban networks as a method to stimulate local and regional economic development and growth (Albrechts and Lievois, 2003; Meijers, 2005; Hall and Pain, 2006). This view has also been embraced by the European Union ministers for spatial and regional planning (CSD (Committee on Spatial Development), 1999)[2]. In particular, urban networks are promoted to take advantage of positive externalities associated with large agglomerations, such as an enlarged labour market and major facilities like air- and seaports, while avoiding the negative externalities of urban sprawl and congestion (Bailey and Turok, 2001; Parr, 2004). In addition, the city and its surrounding region, is considered as the new loci of international territorial competition (Romein, 2004). This has increased the desire of policymakers to promote their city-regions as one entity, in order to position them more strongly at the international stage (Meijers, 2005). In the United Kingdom, the Greater South East – the conurbation around the city of London and extending from Southamption in the south-west to Peterborough in the north (Figure 7.1) – is perceived as a mega-city region which is increasingly evolving into an urban network (Hall *et al.*, 2006; Allen and Cochrane, 2007; Pain, 2008).

The debate on urban networks is fuelled by a large literature on the changing spatial organisation of cities at the intra-urban and inter-urban scales (Batten, 1995; Kloosterman and Musterd, 2001). In this literature, it is often argued that recent advances in transport and communication technology, the increasing connectivity of economies worldwide (globalisation), and the individualisation of production have had a significant impact on the spatial configuration of urban regions. At the local or metropolitan intra-urban scale, cities are developing from a monocentric urban city towards a more polycentric urban configuration. The traditional city has a strict city-hinterland separation, with a city centre creating demand for labour and surrounding suburban areas providing the labour supply. However, it can be conjectured that suburban areas increasingly emerge into local centres that develop their own economic activities and demand for labour. Consequently, these 'new' local centres start competing with the original urban core (Garreau, 1991). Concurrently, the geographical scope of social and economic processes (such as

[2] Although the European Spatial Development Perspective (ESDP) is not a product of the European Community, The European Commission has been involved in preparing it. Being published in all official European languages, the ESDP is arguably the most international planning text that exists (Faludi & Waterhout, 2002, p.IX)

commuting, inter-firm relations, and business to consumer relations) is continuously increasing (Van der Laan, 1998; Frandberg and Vilhelmson, 2003; Urry, 2004). The latter results in an increasingly complex formation of functional linkages between historically separated urban regions at the regional inter-urban scale. Hence, it is often argued that the traditional central place conceptualisation of urban systems, characterised by local urban hierarchies, is outdated and should be replaced by a regional urban network view that emphasises the criss-crossing pattern of interdependencies between spatial units at the intra-urban (local) and inter-urban (regional) scales (Kloosterman and Musterd, 2001).

Figure 7.1: The Greater South East of the United Kingdom



The academic literature and the policy discourse on urban networks are rich in their analytical descriptions of polycentric regions and urban networks. However, only a few empirical studies have quantitatively assessed how well the urban network model fits the reality of contemporary urban systems (Davoudi, 2003). Moreover, these studies suffer from two major difficulties. First, most of the available empirical evidence is based on node characteristics. Consequently, researchers use methods such as location quotients, rank-size relations, sufficiency indices, and employment-to-work ratios, rather than methods based on flow characteristics (Limtanakool *et al.*, 2007). This is partly due to a lack of data regarding the network between cities. However, the focus on node characteristics is unsatisfactory in that it can only yield a proxy of spatial interaction; it cannot account for the actual spatial organisation of urban systems (Irwin and Hughes, 1992; Sohn, 2004). The existence of multiple centres in close proximity to each other does not necessarily mean that there are strong functional linkages between these centres (Lambooy, 1998; Albrechts, 2001). Indeed, most of the theoretical foundations for the central place and urban network model are based on *flows* linked to the physical movement of goods, people and services (Hall, 2001; Limtanakool *et al.*, 2007). Hence, polycentrism is addressed in the present chapter by looking at functional networks between cities, rather than by looking at the mere existence of multiple centres within one area (see Meijers, 2008).

Second, the few studies on the configuration of urban systems using flow characteristics (for example, Van der Laan, 1998; Hall and Green, 2005; Van Oort *et al.*, 2010) have predominantly assessed the central place model versus the network model at one point in time. Notable exceptions are recent studies by Nielsen and Hovgesen (2008), Limtanakool *et al.* (2009), and Burger *et al.* (2011a). As a consequence, the ways in which the present situation is changing remain ambiguous. As Bertaud (2004) correctly observes, cities are not born polycentric, but they may evolve in that direction. Instead, a dynamic model based on flow characteristics is a more accurate approach to examining the existence and functioning of urban networks, while allowing for an investigation into the evolution of the structure of the urban system over time.[3]

The main contribution of this chapter is to overcome some of the aforementioned limitations by providing an empirical assessment of changing urban systems, using flow data on commuting and looking at urban network development over time. Building on the POLYNET research outlined by Hall and Pain (2006) and Cattan (2007), the focus in the present chapter is on urban network development in the Greater South East of the United Kingdom in the period 1981-2001. The representation of the Greater South East as an urban network is based on the assumption that there is considerable regional cohesion in personal, occupational and corporate relationships of people, organisations and firms that transcends the boundaries of traditional metropolitan areas. Commuting patterns are useful

[3] It should be noted that looking at the network structure is only one way to evaluate the existence of an urban network. In a broader literature, the network model refers to more characteristics, such as the existence of complementarities between cities (see Batten, 1995; Meijers, 2007; Van Oort *et al.*, 2010). Herein, it is assumed that cities in a network fulfil different but mutually beneficial roles (Hague and Kirk, 2003). For example, a city specialized in financial services provides these services to (firms in) a city specialized in labour-intensive industry, and vice versa. In another chapter (Van Oort *et al.*, 2010), we address this issue in more detail.

data when investigating the development of urban networks, as journey-to-work trips constitutes the majority of all trips, both at the inter- and intra-urban scales (White, 1988; Clark and Kuijpers-Linde, 1994).

The remainder of this chapter is organised as follows. The next section (7.2) provides an overview of the theory on the evolution of the urban system in relation to economic and social changes. In Section 7.3, the case-study, the dataset, and research methods are introduced and an empirical model is employed to test the validity of the urban network concept. Section 7.4 contains an overview of the main empirical results, followed by a Discussion and Conclusion in Section 7.5.

7.2 The Dynamics of Urban Systems

Urban systems are in constant flux. This section gives a brief overview of the literature on changing urban systems at the intra-urban and inter-urban scales. Specifically, it considers the literature on *how* urban systems change and what developments are *driving* these changes. In particular, attention is given to changing urban systems with respect to commuting in the Greater South East.

From a Monocentric City to a Polycentric Region

In urban systems theory, urban systems are generally referred to as functionally interdependent sets of cities (Berry, 1964; Pred, 1977). However, the structure of these urban systems can range from those that are fully monocentric to those that are fully polycentric. Also, the dominant structure can differ at various spatial scales (Batten, 1995). Yet, the traditional starting point for a treatment of the theory on urban systems is Burgess' concept of the monocentric city (Burgess, 1925), later extended by Alonso (1964) and Muth (1961). The concept of the monocentric city involves a central unit, the central business district, surrounded by a circular residential area whereby land is allocated according to its most profitable use. The general idea of the monocentric city is that most economic activities are based in the urban core, whereas suburbs only fulfill a residential function. Hence, the relationship between the urban core and its suburbs in the monocentric model is hierarchical-nodal or centralised in the sense that relatively speaking most commuting flows are directed from the suburban areas towards the principal cities. As indicated by Parr (2008), the monocentric city model can be perceived as a special case of the central place-based Löschian city-region (Lösch, 1944) at the intra-urban scale. Like the monocentric city, the traditional city-region is perceived as a nodal area in which the principal city is characterised by a deficit labour supply and the territory surrounding the principal city by a deficit labour demand (Parr, 1987; 2005). Accordingly, journey-to-work flows are directed from the surrounding territory to the principal city. A graphical representation of the monocentric city-region is given in Figure 7.2-A1.

However, the conceptualisation of urban systems as monocentric city-regions is becoming increasingly problematic (Clark and Kuijpers-Linde, 1993; Kloosterman and Musterd, 2001; Meijers, 2007). For a variety of reasons (i.e., cheaper land, a low level of amenities in the city centre, decreasing transportation costs), firms and households may increasingly choose to locate themselves in secondary employment centres, despite the advantages of the principal city. As a result, suburban areas in the surrounding territory are emerging into local centres that develop their own economic activities (Anas *et al.*, 1998). The result is the development of city-regions with multiple centres, or polycentric city-regions, at the intra-urban scale (see Figure 2-A2) (Kloosterman and Musterd, 2001). In such a polycentric city-region, commuting is no longer centralised, but reciprocal in the sense that commuting is now not only directed from the surrounding territory to the principal city, but also from the principal city to the surrounding territory. In transport geography this phenomenon is better known as exchange commuting.

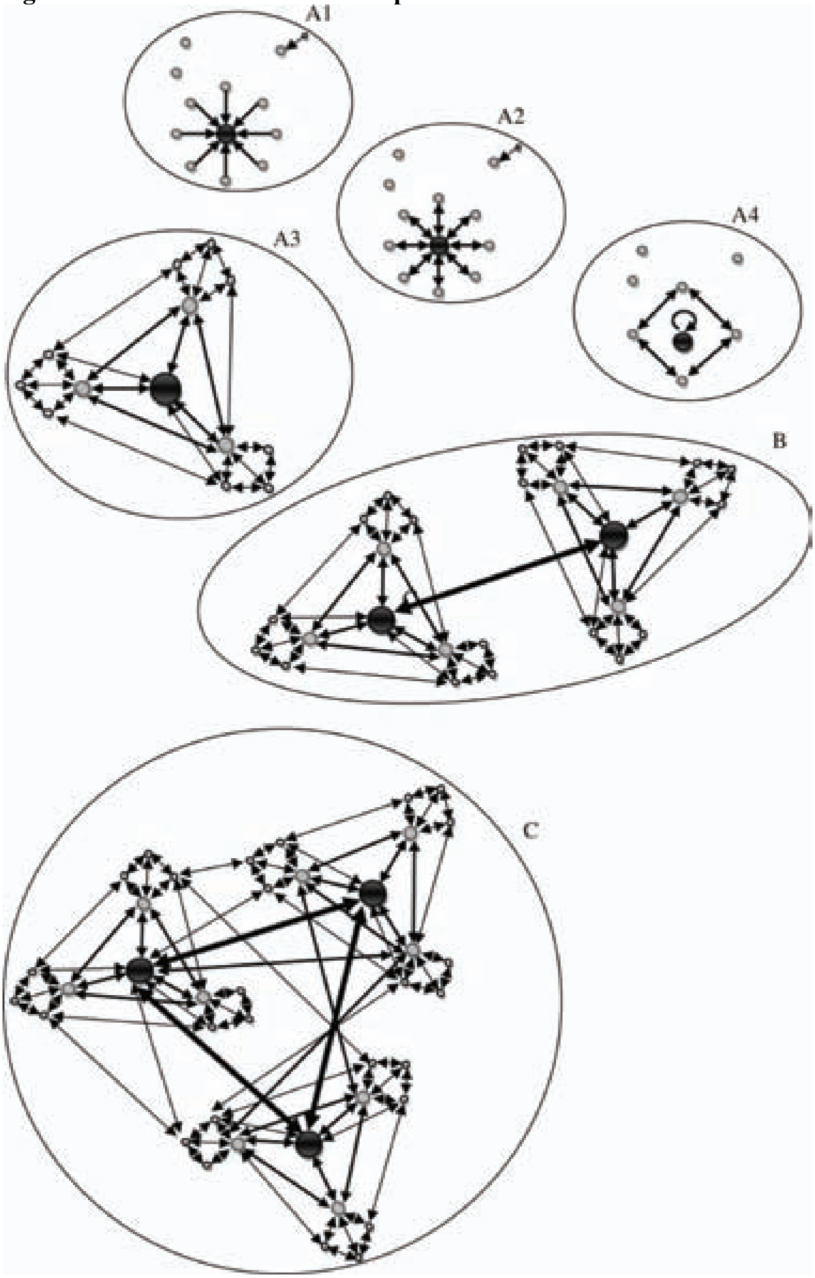
Moreover, the surrounding territory becomes increasingly self-contained in the sense that many suburban residents are employed in the suburban area in which they live. These sub-centres may grow in importance over time, as people start relocating to these sub-centres in order to follow their employer, or for the benefit of cheaper land (Van der Laan, 1998). As such, a territorial competition emerges between the original core and the new sub-centres, changing the image of the city to a *network-city* proper, as displayed in Figure 2-A3. In this situation, the principal city has lost its pure primacy. Flows of goods, services and people become decentralised as the number of workers commuting between different parts of the surrounding territory and bypassing the old urban core increases. Hence, in this state the functioning of the metropolitan area is not only dependent on the principal city but also on the functioning of its suburban areas. In fact, one location may be regarded as 'central' in terms of one particular function, while other places might be central in terms of different functions. Finally, there is a third type of polycentric city-region, which consists of multiple, *self-contained* centres (see Figure 7.2-A4); many suburban residents are employed in the suburbs and many urban residents are employed in the urban core (Schwanen *et al.*, 2004). In this fashion, transportation costs are minimised. However, according to Bertaud (2004), such polycentric urban structure, in which there is only network formation between the suburbs, is a utopian planning concept only and is hardly observed in reality.

The focus of the contemporary debate on changing urban systems has increasingly shifted from the intra-urban scale to the inter-urban scale (Kloosterman and Musterd, 2001).[4] Due to further advances in transportation and communication technologies, it is expected that significant functional linkages are formed at increasingly higher levels of scale than those of the 'traditional' city (Van Oort *et al.*, 2010). As a result, the catchment areas of different urban regions start to overlap. Metropolitan areas lose significance as an independently functioning 'daily urban system' and could, instead, be perceived as forming part of an urban network. Much of the current literature is focused on this development; that is, the development of the Polycentric Urban Region (PUR). The PUR can be represented as an *urban network* of historically and spatially separate metropolitan areas comprising a region (see Figures 7.2 B and C) (Dieleman and Faludi, 1998; Kloosterman and Musterd, 2001; Parr, 2004). These metropolitan areas can be network-cities themselves, but this is not necessarily the case (i.e., the Urban System can be dominated by a polycentric structure at the inter-urban level and a monocentric structure at the intra-urban level or vice versa). Likewise, urban network formation at the *inter*-urban scale is not necessarily the next evolutionary step after the network-city (Parr, 2004).

The degree of urban network formation differs between PURs. First, the distinction between *nodal urban networks* and *fully integrated urban networks* is important. Nodal urban networks (Figure 7.2-B; e.g., Batten, 1995) are characterised by urban network formation between the old urban cores of different metropolitan areas. In contrast, fully integrated urban networks also have functional linkages between (1) the suburbs and urban cores of different metropolitan areas, and (2) suburbs of different metropolitan areas (see Figure 7.2-C). Secondly, at the inter-urban level the urban spatial structure can be characterised either as centralised, exchange, or decentralised, depending on the existence or non-existence of a regional hierarchy of the different metropolitan relations. In the fourth section of this chapter, we introduce formal tests for this.

[4] Following the typology by Kloosterman and Musterd (2001), the intra-urban scale corresponds here to commuting flows that remain within the urban region. Likewise, the inter-urban scale corresponds to commuting flows between urban regions. More specifically, intra-urban dependencies refer to those interactions in an urban region where only one urban core is involved (Figure 2: A1, A2, A3, and A4). Inter-urban dependencies *additionally* refer to interactions between districts in different urban regions (Figure 2-B and 2-C). In Figure 2, types B and C urban systems are blended in terms of intra- and inter-urban relations, in which *intra*-urban relations refer to core-periphery relations in which the 'own' core and periphery districts are involved, and in which *inter*-urban relations refer to relations between core and peripheral districts in different urban regions.

Figure 7.2: Urban Network Development on the Intra-urban and Inter-urban Scales



(A) Network formation at the intra-urban sale; (B) Nodal urban network at the inter-urban scale; (C) Fully integrated urban network at the inter-urban scale.

Adapted from: Van der Knaap (2002) and Schwanen *et al.* (2004)

The Driving Forces behind Changing Urban Systems

Before discussing the specific conditions under which an urban system can be characterised as a PUR (section 7.3), a brief overview of the drivers behind changing urban systems is considered. The reasons given in the literature for changing urban systems can be broadly grouped under three different headers: (1) the increased spatial mobility and flexibility of firms, (2) the increased spatial mobility and flexibility of households, and (3) local and regional policies.

<u>Increased Flexibility and Mobility of Firms</u>

The effect of increasing flexibility and mobility of firms on the urban system is known as the restructuring hypothesis. The central theme of the restructuring hypothesis is that trends in urban system dynamics are driven by changes in the spatial distribution of employment opportunities (Renkow and Hoover, 2000). These changes in the spatial distribution of employment opportunities are both caused and made possible by key advancements in information and communication technology (ICT) and are enhanced by the economic change of most western economies from being dominated by manufacturing to being dominated by services (Aoyama and Castells, 2002). There is a considerable academic debate on the precise spatial and economic effects of ICT. Some authors predict that developed economies will make a complete shift to a services and information economy, unbounded by physical distance, leading to a complete spatial disintegration of the economy (Gillespie and Williams, 1988; Cairncross, 1997). Other authors claim that ICT can be well integrated in production economies and physical goods are still bounded by physical distance despite vast improvements in transport technologies (Castells, 2000). Moreover, service firms are also physically constrained by the necessity of face-to-face contact, usually locationally bounded to the 'old' CBD (Couclelis, 2000). As such, the old cores maintain strong contacts with the suburban areas, creating an ever more complex integrated urban network (Geyer, 2002).

<u>Increased Flexibility and Mobility of Households</u>

The effect of increasing flexibility and mobility of people on the urban system is also known as the deconcentration hypothesis. The deconcentration hypothesis holds that urban system dynamics are the result of widespread changes in residential preferences (Renkow and Hoover, 2000). Where the increasing flexibility of firms has changed the nature of the *demand* for labour, the same advances in transport and communication technologies changed the nature of the *supply* of labour too (Clark and Kuijpers-Linde 1994; Van der Laan 1998). To some extent, these residential preferences are influenced by enhanced mobility and the increasingly flexible workplace (Hall, 2001). Even more profound are the changes in residential preferences, caused by developments within the demography of most developed economies; which have an impact on the urban structure through their effect on the choices of lifestyle and attitudes of households (Champion, 2002).The full realm of the demographic changes mentioned are comprehensively summarized by Hall and White (1995) and include the locational preferences of two-earner households, the increasing number of women working, a higher life expectancy, a markedly lower fertility, and an increasing number of single-person households. The common factor in these demographic developments is that they have changed the residential wishes of large groups of people, changing residential patterns and causing disorder to the traditional monocentric urban system (Van Ham, 2002).

Local and Regional Policy

Local and regional policies can have the explicit intention of economic deconcentration and urban network formation, but are most commonly an unintended by-product. A well-known example of an *intentional* policy towards economic deconcentration was the 'growth pole concept' introduced by Perroux (1955) and Boudeville (1966). The aim of this policy was to create economic development in peripheral areas by moving (semi-) governmental departments to, or by encouraging the establishment of industrial growth centres ('counter-magnets') in the periphery. Ultimately, this should have led to the development of the hinterlands of these growth centres, in turn spreading the benefits of economic development over a larger area. Similarly, by embracing the urban network concept, policymakers and urban planners attempt to actively develop suburban areas, with the objective of spreading economic prosperity (Meijers and Romein, 2003). Romein (2004) states that a regional urban network perspective of planning where cities and communities actively work together, will strengthen the territorial competitiveness of these systems. However, Capello (2000) argues planners should not automatically assume that cooperation within regional urban networks stimulates growth in each participating city.

Paradoxically, it is suggested that those policies with urban network formation as an unintended by-product are the most efficient. In particular, restrictions on urban development have had a profound impact on the development of the urban structure

(Cullingworth and Nadin, 1997). Governments of many countries have introduced strict land-planning policies, mainly aimed against urban sprawl. The Town and Country Planning Act 1947 in the United Kingdom is perhaps one of the best examples of such land-planning policies (Best, 1981). Better known as the Abercrombie Plan, the core of this particular planning act was the formation of a 'Green Belt' around London and several smaller cities in the countryside, whereby new construction was only possible within the set city boundary, or at other designated key settlements (Champion, 2002). It is apparent that the economic pressures on cities like London to grow did not stop after these laws were implemented. Consequently, much of the population and employment growth has been restricted to settlements beyond the Green Belt (Longley *et al.*, 1992). These settlements have maintained a very strong link with the original core, and combined with the developments previously mentioned; this has resulted in the development of PURs.

7.3 Urban Network Formation in the Greater South East UK

The Greater South East as Policy Initiative

Researchers and policymakers increasingly identify the Greater South East in the UK as an integrated urban network. Hall (2006) states that the Greater South East region of England is a prime example of a global mega-city region in the same fashion as Jean Gottman's Megalopolis on the north-eastern seaboard of the United States (Gottmann, 1961). The agglomeration (see Figure 7.1), which comprises the three Governmental Office regions of London, South East and East of England[5], has approximately 21 million inhabitants and generates an annual gross domestic product of $900 billion. The concept of the Greater South East features prominently among the British Regional Development Agencies to encourage cooperation in several areas (for example, the 2012 Olympic Games) (SEEDA, 2005). The development of the Greater South East reflects London's need for more space; the Green Belt policy ensured that the population and employment growth leapfrogged

[5] Yet, there is considerable academic debate on the exact dimensions and urban structure of the Greater South East. Buck *et al.* (2002) take the Functional Urban Area of London, measured by the London Metropolitan Area, as the dimension of the Greater South East, though they acknowledge that this might come across as a conservative definition. A more relaxed definition would take Cambridgeshire and Northamptonshire into account as well (Buck *et al.*, 2002). Perhaps the largest drawback of the conservative definition is that it does not fit within the current policymaking framework. Gordon (2003) makes a strong case for taking the three Governmental Office Regions (GOR) of the South East, London, and the East of England as the dimensions of the Greater South East. Since this definition is more congruent with political reality, it will be the definition of the Greater South East as used in this chapter.

over the belt, and a well-developed transport network and technological advances facilitated commuting and the mobility of firms (Gordon, 2004; Hall and Green, 2006).

An important question is what are the dynamics of the spatial organisation of the Greater South East? Given the size of London, one would perhaps automatically assume that the Greater South East is a prime example of a monocentric mega-city-region. Yet, the Greater South East is perceived as an increasingly spatially integrated 'super-region' characterised by a network of multiple centres with their own complementary specialisations that strengthen the economic power of the super-region as a whole (Gordon, 2004). In this, Hall (2006) argues that London should be characterised in a as being functionally polycentric and spatially integrated, and not morphologically polycentric. Indeed, a region may geographically consist of more than one centre. However, this in itself does not provide evidence that there are social and economic interactions between firms and people residing in these centres (Lambooy, 1998; Albrechts, 2001; Meijers, 2008). Hall and Green (2006) and Hall and Pain (2006) both state that in South East England only limited functional relations are not related to London. This suggests a relatively high degree of spatial integration and complementarity between centres, especially compared to other polycentric regions in Europe (e.g., the Rhein-Ruhr region in Germany and Randstad Holland in the Netherlands) (Hall and Pain, 2006). Results from recent research on data from the European Union Communication Innovation Survey offer support for this conjecture. Simmie *et al.* (2002) found that the innovative capacity of the Greater South East is well above the European Union average but that this is largely due to high concentrations of innovative activity outside London (for example, Cambridge, and Oxford). Yet, the crucial assets on which the companies in these concentrations rely (that is, finance and skilled labour), tend to originate from organisations and institutions located at the regional, rather than at the local, scale. Likewise, Pain (2008) reports a high degree of interaction between different offices of advanced producer services firms in the Greater South East. These intra-firm network relationships vary from formal meetings to joint working and inter-office support.

Many UK policymakers seem quicker than most researchers to embrace the idea of the Greater South East as a PUR. The East of England Development Agency states that *'it is clearer than ever that the East of England doesn't stand alone. Instead it is part of a highly integrated Greater South East'* (Finch and Marshall, 2007, p. 4). Likewise, the South East Development Agency identifies twenty-one towns and cities creating a network of centres of economic activity (SEEDA, 2006). A whole array of different local and regional initiatives has been employed to promote the Greater South East as an integrated polycentric region (Allen and Cochrane, 2007; ODPM, 2003). These growth sub-regions, for instance the London-Stansted-Cambridge-Peterborough corridor, cut across the official regional boundaries promoting the integration of the Greater South East Region (for a summary of the different Greater South East growth centres and corridors proposed by different agencies, see Table 7.1). The Regional Development Agencies of the three GORs also recently published a joint study titled "*The UK's engine for growth and prosperity: A case for targeted investment in the Greater South East*" (SEEDA, 2005). In addition, the boards of the three different Regional Development Agencies have decided to intensify their communication with each other and have started an annual Greater South East Regional Development Agency boards meeting (LDA, 2007).

Table 7.1: Growth Centres and Gateways in the Greater South East

Greater Norwich	South Hampshire
Greater Peterborough	Sussex Coast
Greater Cambridge	East Kent / Ashford
Haven Gateway	Western Corridor
Aylesbury / Milton Keynes / South Midlands	Central Oxfordshire
London Arc (London Fringe)	Gatwick Area
Kent / Thames Gateway / South Essex	Greater London

Visualising Commuting Linkages in the Greater South East Region

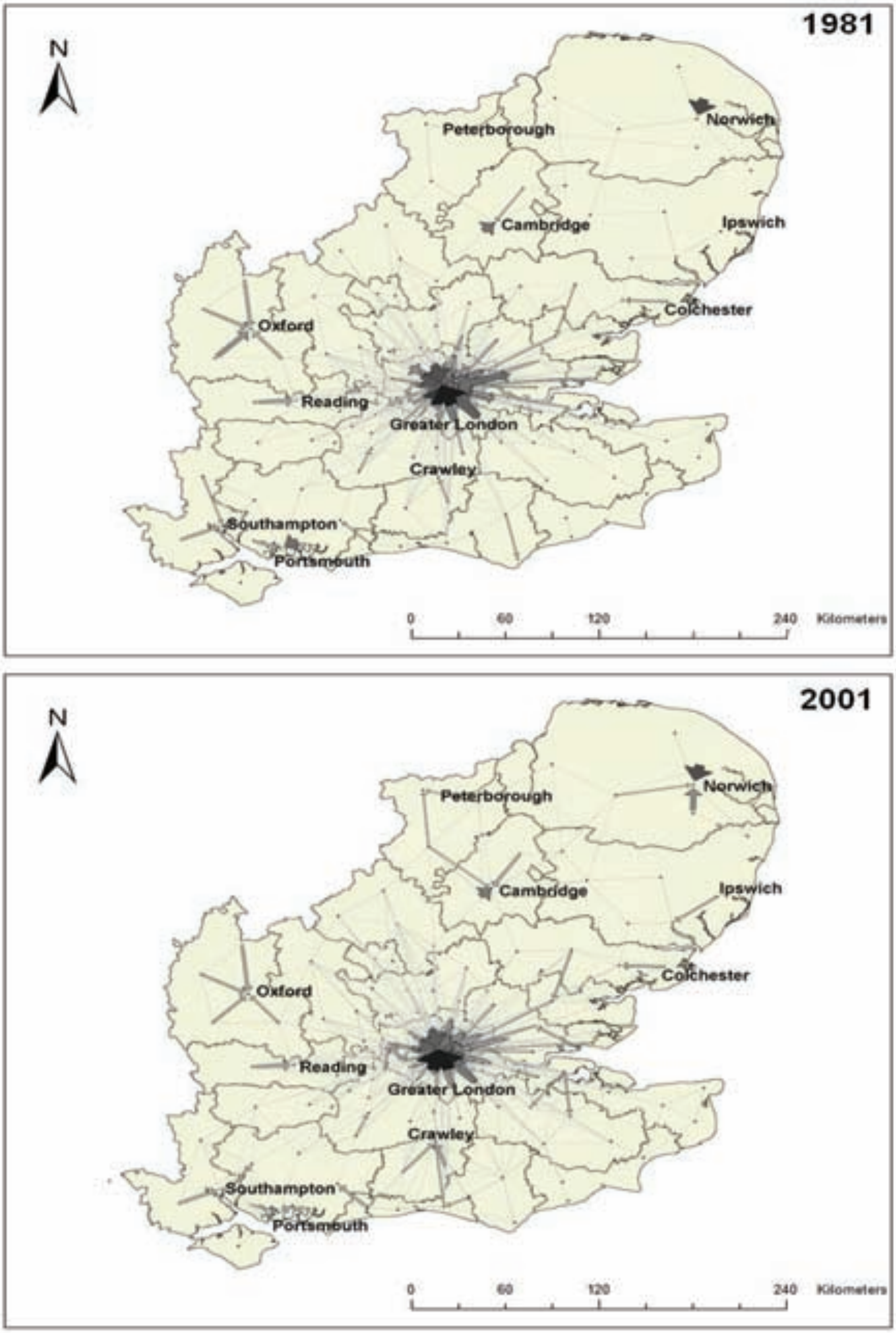
Increasingly, research on urban systems shifts from the physical appearance of a city-region (morphological polycentricity) to analysing the functional flow characteristics between nodes in an urban system. Thus, in the contemporary economy the dominance of cities is primarily determined by '*what flows through them instead of what is fixed within them'* (Limtanakool *et al.*, 2007). Focusing on linkages rather than nodes also facilitates the policy debate concentrated on the spatial integration of regions. For the analysis of the development of spatial linkages in the Greater South East, commuting interaction data between districts for the past twenty years (1981, 1991, and 2001) are used. These data were obtained from the Special Workplace Statistics (Set C) in the British census.[6] The

[6] Census output is Crown copyright and is reproduced with the permission of the Controller of HMSO and the Queen's Printer for Scotland. Sources: 1981 Census: Special Workplace Statistics (Set C) (re-estimated for 1991 boundaries), 1991 Census: Special Workplace Statistics (Set C), and 2001 Census: Special Workplace Statistics (Level 1)

'CIDS 1991/2001 Common Geography' was used to avoid potential problems with the changes of district-boundaries over the past twenty years (Boyle and Feng, 2001). Using the common geography, the Greater South East can be divided into urban areas; the urban area here is a slightly adapted version of the conventional NUTS-III definition (see Appendix 7A). Using these boundaries, there are a total of 146 districts in the Greater South East that account for 27 Urban Areas, each with 1 core-district (for more details, see Appendix 7B).

Figure 7.3 depicts the net commuting flows in 1981 and 2001 (flows above fifty commuters). Despite the obvious absolute increase in commuting numbers over the investigated twenty-year period, the relative net flows indicate that people still commute within their own urban region. Moreover, the commuting intensity between urban areas is primarily directed towards the London region, creating a hub-and-spoke system. In fact, there appears to be little activity between urban regions located in the Southeast England and East of England regions. Apart from changing local intensities (e.g., increasing around Norwich and Crawley and decreasing around Oxford and Portsmouth), no major changes in the period 1981-2001 can be visually observed from the data. Hence, at first sight, the data give little evidence for the existence of an urban network and its development over time. However, an obvious criticism of such a visual analysis is that it does not allow for differences in the absolute sizes of districts (in terms of population) and the physical distances between them. Green (2007) and Hall and Pain (2006) did not address this issue the POLYNET research framework. For example, the London area is relatively small and densely populated. Probably, the large number of commuters within the London area is largely due to the large population of London, compared to other areas in the Greater South East, and the relatively small road distances and travel times compared to distances between other urban regions. Put more formally, the likelihood of a commuting flow directed to a large city with many jobs is larger than one directed to a smaller district with fewer jobs. Likewise, the likelihood of a commuting flow between two districts in close proximity to each other is larger than one between districts located far from each other (Van Oort *et al.*, 2010). Fingleton (2003) argues that all locations and regions in the modern economy interact to some extent. Therefore, it is impossible to make robust inferences about (the development of) the urban system in the Greater South East through simple visualisation. Therefore, it is important to use a model that controls for mass and physical proximity.

Figure 7.3: Commuting Interactions in the Greater South East, 1981 and 2001



7.4 Methodology

A Gravity Model of Commuting

In this section, a formal model is introduced to test the structure in spatial interaction patterns of commuting relations in the Greater South East. The objective is to investigate whether the Greater South East consists of network cities at the intra-urban scale and whether the adjoining districts form a fully integrated, larger-scale urban network. The fully integrated, larger-scale urban network can be viewed as the most extreme form of a PUR at the inter-urban level. In general, it could be concluded such a form exists when there is no effect of spatial context on commuting network intensities, other than the mass of sending and receiving localities and the physical distance between them. If the Greater South East functions as a spatially integrated cluster (from an economic point of view), the inter-urban network structure of commuting relations should be solely determined by these variables. Although this strict definition of an integrated network of commuters being randomly distributed over space is very demanding, we can test whether the interactions evolve over time towards this situation.

A gravity model (Haynes and Fotheringham, 1984) is employed to test for these conditions. In this model, Sir Isaac's Newton's law of universal gravitation is used to explain the interaction between spatial units, in the present case commuting flows between districts. The contemporary use of the gravity model in geography and regional science originates from the work of Stewart (1948) and Ullman (1954).[7] Such models hold that the gravitational force between two spatial units is directly proportional to the product of the mass of the spatial units and inversely proportional to the physical distance between them. More formally, the gravity model can be expressed by (7.1):

$$I_{ij} = K \frac{M_i^{\beta_1} M_j^{\beta_2}}{d_{ij}^{\beta_3}} \tag{7.1}$$

where I_{ij} is the interaction intensity, or the number of commuters between areas i and j, K a proportionality constant, M_i the mass of the district of origin, M_j the mass of the district of

[7] Even earlier applications can be found in the 19th century work of Carey (1858) and Ravenstein (1885) on, respectively, the analysis of human interaction patterns and migration flows.

destination, d_{ij} the physical distance between the two areas, β_1 the potential to generate commuting flows, β_2 the potential to attract commuting flows, and β_3 an impedance factor reflecting the rate of increase of the friction of physical distance. In the present estimations, the physical distance between districts is measured as the actual road distance between districts *i* and *j*. The road distance is based on the road network in the Greater South East in 2005 and is obtained by linking an origin-destination cost matrix to the road network, where the cost was set to distance.[8] However, the overall average road distance between neighbouring districts is likely to be overestimated, as it measures the distance between the two centres of gravity. A dummy reflecting contiguity is included in order to correct for this measurement error in calculating the relevant road distances.

Modified Poisson Specification of the Gravity Model

Commuting data should be handled as count data, as they 'count' the number of times something has happened; in our case flow frequencies (number of commuters) between and within districts. Although equation (1) is often estimated here using Ordinary Least Squares (OLS), the application of the linear regression model here can lead to inefficient, inconsistent and biased results (Long, 1997), as the underlying assumptions of normal distribution and homoskedasticity are often not satisfied. For this reason, the use of alternative regression techniques is more appropriate (Burger *et al.*, 2009a). Probably the most common regression model applied to count data is the Poisson regression.

Using a Poisson model specification (Flowerdew and Aitkin, 1982; Long, 1997), the multiplicative form (7.1) can be converted into the following testable equation (7.2), in which the probability of observing the value of I_{ij} is expressed as:

$$\Pr[I_{ij}] = \frac{\exp(-\mu_{ij})\mu_{ij}^{I_{ij}}}{I_{ij}!}, \left(I_{ij} = 0,1...\right), \tag{7.2.1}$$

where the conditional mean μ_{ij} is linked to an exponential function of a set of regression variables.

---

[8] Intra-district distances were calculated by means of the formula $d_{ij} = \frac{2}{3}\sqrt{\frac{Ai}{\pi}}$, in which the intra-municipal distance d_{ii} is two thirds of the radius of the presumed circular area Ai (see Bröcker (1989b) for the exact derivation of this and an overview of the considerations involved).

$$\mu_{ij} = \exp(K + \beta_1 \ln M_i + \beta_2 \ln M_j + \beta_3 \ln d_{ij}) \qquad (7.2.2)$$

Equation (7.2.2) is an unconstrained gravity model. This terminology reflects that the model does not take into account the constraints that the estimated number of commuters entering and leaving the district should be equal to the observed number of commuters. In order to satisfy this condition and because of primarily interest is the estimation of the effects of the different interdependencies on the volume of commuting between and within districts, equation 7.1 is estimated including origin and destination fixed effects. Such *doubly constrained gravity model* ensures that the total number of observed commuters equates the total number of expected commuters and yields consistent parameter estimates for the variables of interest (Bröcker 1989a, Fotheringham and O'Kelley, 1989). In equation (7.2.2), this implies the inclusion of district-specific origin and destination dummy variables. More formally, the fixed effects specification of the most basic gravity model (including physical distance) would look as follows:

$$\mu_{ij} = \exp(K + \beta_3 \ln d_{ij} + \eta_i + \gamma_j) \qquad (7.3.3)$$

Where η_i is an effect specific to the district of origin (a residential-district specific effect) and γ_j is an effect specific to the district of destination (a work-district specific effect). These fixed-effects terms replace the mass variables in equation 7.2.2 and control also for other district-specific characteristics.

It is important to recognize that the aforementioned Poisson model assumes equidispersion, for which the conditional variance of the dependent variable should be equal to its conditional mean. If not, the dataset displays overdispersion. In addition, the dependent variable is modelled as having a Poisson distribution. However, often an excessive number of zero counts is observed, which means that the incidence of zero counts is greater than is expected for the Poisson or negative binomial distribution. In order to correct for this, a negative binomial (in case of overdispersion), zero-inflated Poisson regression (in case of excess zeros) or zero-inflated negative binomial regression (in case of overdispersion and excess zeros) can be employed. These modified Poisson regression models can be perceived as an extensions of the Poisson model. Not correcting for overdispersion and/or the excess zero count normally results in incorrect and biased estimates (Cameron and Trivedi, 1986; Gourieroux *et al.*, 1984).[9] For more detailed discussion of extensions of the Poisson regression model, see Greene (1994), Long (1997), and Burger *et al.* (2009a).

Modelling Urban Network Conditions and Change over Time

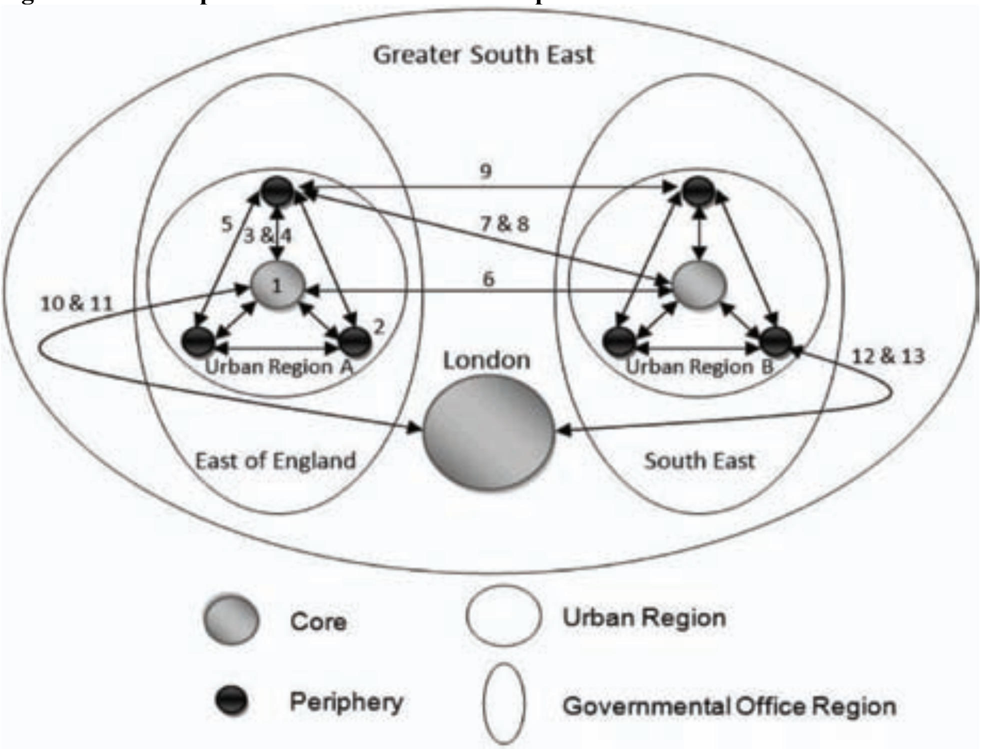
The model presented above is the gravity model in its most basic form. It can be extended to include other variables. In our model, dummy variables that express the spatial-functional context of the commuting interactions between different types of districts are included to examine the spatial structure of the commuting network in the Greater South East. These spatial-functional contexts are formally called regimes and build up the degree of spatial integration in the region. As outlined above, twenty-seven principal city districts can be distinguished, each with their own suburban districts. A distinction is made between thirteen different regimes (types of relations) at the intra-urban and inter-urban scales. These regimes are displayed in Figure 7.4 and convey the spatial context of flows between districts.

At the intra-urban scale, an urban area can be characterised as a monocentric city when – controlling for the sizes of districts and the distance between them – the within principal city interdependencies and the periphery-core interdependencies between suburban districts and their 'own' principal city are strongest [see Figure 7.2-A1]. In contrast, the separate districts in the Greater South East can be characterised as network cities when, ceteris paribus, the within principal city dependencies are not stronger than all other intra-urban interdependencies [see Figures 7.2-A2 and A3}. Moreover, no observable hierarchy in the different types of intra-urban interdependencies should be present.

At the inter-urban scale, the Greater South East can be characterised as an urban network when – again controlling for mass and distance – the interdependencies between districts within urban areas in the Greater South East are not stronger than interdependencies between urban areas across these urban areas. In order to be classified as a fully integrated urban network, no observable hierarchy in the different types of inter-urban interdependencies should be present. In addition, one can distinguish between different types of regional interdependencies based on the presumption of a regional hierarchy. The Greater London region is here depicted as the centre in an inter-urban hub-and-spoke model. Hence, one can distinguish between four types of regional interdependencies (interdependencies 10 – 13 as displayed in Figure 7.4).

[9] In this, a likelihood ratio test of overdispersion (Cameron and Trivedi, 1986) is employed to test whether the negative binomial distribution is preferred to a Poisson distribution, while the Vuong statistic (Vuong, 1989) provides evidence whether a zero-inflated model is favoured above its non-zero inflated counterpart.

Figure 7.4: Conceptualisation of Urban Interdependencies



(A) Intra-urban commuting *within* districts in the South East and East of England (1) Within principal cities dependencies that remain entirely within a principal city district (2) Within suburbs dependencies based on relationships that remain entirely within a suburban district
(B) Intra-urban commuting *between* districts *within* urban areas in the South East and East of England (3) Intra-urban core-periphery interdependencies between the principal cities and one of their 'own' suburban districts (4) Intra-urban periphery-core interdependencies between the suburban districts and their 'own' principal city (5) Criss-cross interdependencies between the suburban districts within a given urban region.
(C) Inter-urban commuting *between* urban regions in the South East and East of England (6) Inter-urban inter-core interdependencies between the principal cities of the different urban regions (7) Inter-urban core-periphery interdependencies between the principal cities and one of their non-'own' suburban districts. (8) Inter-urban periphery-core interdependencies between suburban districts and one of their non-'own' principal cities. (9) Inter-urban criss-cross interdependencies between suburban districts that are not situated in the same urban region.
(D) Inter-urban commuting *between* urban regions and London (10) Inter-urban interdependencies between principal cities in the South East and East of England and London. (11) Inter-urban interdependencies between suburban districts in the South East and East of England and London. (12) Inter-urban interdependencies between London and principal cities in the South East and East of England. (13) Inter-urban interdependencies between London and suburban districts in the South East and East of England.

In summary, if the Greater South East can be characterised as a fully integrated decentralised urban network consisting of network cities at the intra-urban level, the network structure of commuting flows should be solely determined by the masses of the districts and the physical distances between them. Controlling for mass and size, commuting trips should be randomly distributed. Hence, there should be no significant relationship of the degree of interaction with any of the thirteen types of interactions identified. There should be no evidence for a regional hierarchy at the inter-urban scale. However, this can be considered the ultimate form of a PUR or urban network proper. As Bertaud (2004) correctly observes, no region is fully monocentric or fully polycentric. In the subsequent analyses, the urban structure that fits the Greater South East best is examined.

Besides testing the structure of the network, the aim of the analysis is also to examine in which direction the urban system evolves over time. By including time dummies and slope dummies in the gravity equation, changes of the relative strengths of the different spatial regimes (urban interdependencies) over time can be assessed (Cameron, 2005). In other words, the change in the relative strengths of the different spatial regimes over time is captured by an interaction between the time variable and spatial regime variables (the different urban interdependencies).

7.5 Empirical Model

Changing Urban Systems at the Intra-Urban Scale

The results for model 1 (displayed in Table 7.2) test for the spatial structure in the South East and East of England at the intra-urban scale using a negative binomial regression. As expected, distance has a marked inverse correlation with commuting intensity. The coefficients can be interpreted as elasticities: when physical distance increases by 1%, commuting is predicted to decrease by 1.36%. Likewise, the volume of commuting between two districts that border each other is expected to be 3.85 times as high as the volume of commuting between districts that do not border each other.[10] Taking intra-nodal dependency (the flows that remain entirely within a district) as the reference category (as it

[10] The coefficients on contiguity and the interdependencies are semi-elasticities. To interpret the impact of e.g., contiguity on the interaction intensity by the estimate of equation (2.3) in terms of an elasticity, we assume that a district pair moves from being contagious to being non-contagious. The interaction intensity is then multiplied by a factor $e^{1.348} = 3.85$ where 1.349 is the coefficient reported in Model 1 (Table 7.2).

is conceptually the strongest type of urban interdependency), it is possible to compare the relative strength of the different types of urban interdependencies while controlling for the masses of districts and the distance between them.

Table 7.2: Negative Binomial Regression on Commuting between Districts in the Greater South East UK at the intra-urban scale 1981-2001

	General Structure 1981-2001 (1)	**Change over time 1981-2001 (2)**
Intercept	-2.50 (.988)*	-2.40 (1.18)*
Road Distance (ln)	-1.36 (.049)**	-1.36 (.049)**
Contiguity	1.34 (.040)**	1.35 (.040)**
Urban Interdependencies		
Within principal city	•	•
Within suburban areas	-0.21 (.182)	-0.29 (.354)**
Suburbs → Principal City	-1.63 (.286)**	-1.75 (.229)**
Principal City → Suburbs	-1.56 (.330)**	-1.85 (.337)**
Suburbs → Suburbs (Criss-Cross)	-2.22 (.237)**	-2.51 (.376)**
Time Trend		
Within principal city * T		•
Within suburban areas * T		-0.01 (.098)
Suburbs → Principal City * T		0.13 (.095)
Principal City → Suburbs * T		0.22 (.094)*
Suburbs → Suburbs * T		0.20 (.089)*
Origin fixed effects	YES	YES
Destination fixed effects	YES	YES
Time fixed effects	YES	YES
Overdispersion (α)	0.30 (.009)**	0.29 (.010)**
Log pseudolikelihood	-11204	-11191
Akaike's Information Criterion	11.13	11.12
Observations	2052	2052

*p<0.05, ** p<0.01
• = Reference Category, robust errors between parentheses

Looking at the average spatial structure at the intra-urban scale in the period 1981-2001, it appears that the spatial structure of urban regions within the Greater South East (intra-urban scale) is best described by *a mixture between the monocentric city model and the polycentric city model*. Some of the results strongly point to the monocentric model: the within principal cities dependencies in the Greater South East are significantly stronger than interdependencies between districts situated in the same urban region. Furthermore, holding everything else constant, the predicted commuting intensity within principal cities is about five times as high as the predicted flow between suburban districts (criss-cross commuting) and between principal cities and suburban districts (core-periphery relations) within the same urban region. In addition, holding everything else constant, the predicted commuting intensity between principal cities is about nine times as high as the predicted flow between suburban districts (criss-cross commuting). Finally, testing for the equality of coefficients by means of a Wald test reveals that the periphery-core interdependencies are significantly stronger than the criss-cross interdependencies (χ^2=12.05, df=1, p<0.01). However, not all conditions of the monocentric model hold. First, the periphery-core interdependencies are not significantly stronger than the core-periphery interdependencies (χ^2=0.03, df=1, p=0.85). Second, and most importantly, the within suburban areas dependencies are not weaker than the within principal cities dependencies. From this it can be inferred that many districts classified as 'suburban' are largely self-contained; many suburban residents are employed in the suburban area in which they live. Thus, many of those districts classified as suburban (those surrounding larger, principal cities and forming their hinterland) in principle are not suburban in character, but self-contained. These are strong arguments to suggest, at least to some extent, that urban areas in the Greater South East are polycentric spatial entities.

Looking at the estimated linear trend over time (1981-2001) in Model 2 (Table 7.2) suggests some development toward a more polycentric urban form at the intra-urban scale can be observed. The coefficients should be interpreted as the shift in the relative strength of the different urban interdependencies vis-à-vis within principal cities dependencies, over a period of 10 years. In 1981, holding everything else constant, the within principal cities dependencies are about 6.4 times as strong as the core-periphery urban interdependencies. This number has decreased to 4.1 times in 2001. Likewise, the within principal cities dependencies are in 1981 about 12.2 times as strong as the core-periphery urban interdependencies, while in 2001 this has dropped to about 8.2 times. However, even if this trend continued, it would take at least another 80 years before one could speak of a network city at the intra-urban scale. Additional evidence for decentralisation of the urban system at the intra-urban scale is shown by the significant increase in the relative strength of core-periphery and criss-cross interdependencies relative to the within-suburb dependencies and periphery-core interdependencies. Additionally, the periphery-core interdependencies also increase in strength relative to the within-principal cities dependency over time (although not significantly so).

Changing Urban Systems at the Inter-Urban Scale

The results for Model 3 (Table 7.3) show the average spatial structure of the Greater South East in the period 1981-2001 at the inter-urban scale using a zero-inflated Poisson regression. Recall that the Greater South East can be characterised as an urban network if the interdependencies between districts *within* (intra-) urban areas in the Greater South East are not stronger than interdependencies *between* (inter-) urban areas. Overall, it can be concluded that the dependencies within urban regions in the South East and the East of England are stronger than the dependencies between urban regions. Holding mass and physical distance constant, the predicted flow between districts within the same urban region in the South East and the East of England is, on average, twice as large as the inter-district flows that exceed the level of the urban regions. Examining the different types of inter-urban interdependencies between urban regions in the South East and the East of England, the presence of a hierarchy can be observed in the sense that the different types of interdependencies significantly differ in their relative strength. In general, the between principal cities interdependencies are stronger than the inter-urban principal city-suburb, inter-urban suburb-principal city and between suburbs interdependencies. From this, it can also be concluded that although the degree of urban network formation is marginal, it is mainly occurring between the core districts of the separate urban areas (Figure 7.2B).

Stronger evidence for urban network formation at the inter-urban scale can be found in the interdependencies between the urban regions of the South East and the East of England (origin), on the one hand, and the London area (destination), on the other hand, as they are stronger than the dependencies within urban regions in the South East and the East of England (compare Hall and Pain, 2006). Controlling for mass and distance, the interaction intensity between the South East and the East of England areas and the London area is, on average, not significantly smaller than within urban regions in the South East and the East of England. Looking at the interaction intensity between London and the South East and the East of England, it can be concluded that the urban network formation is one-sided. Overall, there are many employees travelling from the South East and the East of England to London, but relatively few employees travelling from London to the South East and the East of England.

Table 7.3: Zero-Inflated Poisson Regression on Commuting between Districts in the Greater South East UK at the inter-urban scale 1981-2001

	General Structure 1981-2001 (3)	**Change over time 1981-2001 (4)**
Intercept	8.31 (.103)**	8.31 (.104)**
Road Distance (ln)	-1.93 (.018)**	-1.93 (.019)**
Contiguity	0.64 (.039)**	0.64 (.040)**
Urban Interdependencies		
Within urban region (intra-urban)	•	•
Between urban regions in SE and EoE (inter-urban)		
- Between Principal Cities	-0.46 (.099)**	-0.58 (.152)**
- Suburbs → Principal City	-0.77 (.092)**	-0.75 (.165)**
- Principal City → Suburbs	-0.78 (.084)**	-0.93 (.114)**
- Suburbs → Suburbs (Criss-Cross)	-0.67 (.064)**	-0.69 (.064)**
Between London – SE and EoE (inter-urban)		
- Greater South East Principal Cities → London	-0.08 (.328)	0.01 (.364)
- Greater South East Suburbs → London	-0.15 (.323)	-0.00 (.357)
- London → Greater South East Principal Cities	-1.88 (.150)**	-0.77 (.161)**
- London → Greater South East Suburbs	-1.62 (.141)**	-0.29 (.143)*
Time Trend		
Within urban region (intra-urban)		•
Between urban regions in SE and EoE (inter-urban)		
- Between Principal Cities * T		0.10 (.101)
- Suburbs → Principal City * T		-0.02 (.092)
- Principal City → Suburbs * T		0.13 (.063)*
- Suburbs → Suburbs (Criss-Cross) * T		0.03 (.037)
Between London – SE and EoE (inter-urban)		
- Greater South East Principal Cities → London * T		-0.06 (.046)
- Greater South East Suburbs → London * T		-0.13 (.026)**
- London → Greater South East Principal Cities * T		0.29 (.068)**
- London → Greater South East Suburbs * T		0.12 (.041)**
Origin fixed effects	YES	YES
Destination fixed effects	YES	YES
Time fixed effects	YES	YES
Vuong (z)	13.17**	12.77**
Log pseudo likelihood	-367106	-365852
AIC	12.13	12.07
Observations	60681	60681

** p<0.01, * p<0.05
• = Reference Category, cluster-robust errors between parentheses
Inflated part (not shown) estimated using road distance (ln), contiguity and interdependencies

The results from Model 4 (Table 7.3) provide evidence on the development of the urban system at the inter-urban scale over time.[11] Overall, some evidence if found for the decentralisation of the Greater South East at the inter-urban scale for the period 1981-2001. First, the interdependencies between South East/East of England and London lose relative strength, compared to dependencies within urban regions in the South East and the East of England, while the interdependencies between the South East/East of England and London gain relative strength. Second, the interdependencies between regions within the South East and the East of England do not gain any strength over the dependencies within urban regions, except for the inter-urban principal city-suburb interdependencies. This indicates that there is evidence for the decentralisation of activities in the Greater South East at the regional level, but evidence for urban network development at the inter-urban scale (between regions) over the past 20 years is lacking.

7.6 Conclusions and Discussion

There has been a plethora of research reports and policy documents on the development of urban networks worldwide and in the Greater South East, in particular. However, there are relatively few rigorous empirical assessments of the urban network concept. The shift from a location-based economy to a network-based economy can be seen as a continuum. As a consequence, the extent to which the urban network model is now a full substitute for the central place model remains unclear. There is a need for objective and quantitative assessment.

In this chapter, the structure and evolution of commuting flows in districts in the Greater South East between 1981 and 2001 were modelled with an extended version of the gravity model, incorporating functional regime dummies and time trends. The strengths of the different spatial interdependencies within the Greater South East were tested on both the intra- and inter-urban scales. The results indicate that the Greater South East does not (yet) constitutes a fully integrated urban network. However, the strength of the spatial interdependencies within suburban districts indicates that suburban nodes are increasingly operating in a manner independent of the principal city. This indicates the development of polycentric regions at the intra-urban scale. However, the time-trend analysis suggests that using the gravity approach without external shocks (opening-up of infrastructure, job

[11] In this, we only examined a linear trend. Future research should more carefully look at non-linear relationships over time.

creation and (re-)location and the creation of new housing facilities), based upon the difference in magnitude observed over the past twenty years, it would take another eighty years before the Greater South East is fully polycentric at the intra-urban scale. At the inter-urban scale, there is less indication of development towards urban network formation. The results mostly support a monocentric interpretation of the Greater South East at the inter-urban scale, which is relatively stable over time. However, the absence of a hierarchy in the interdependencies on the regional, inter-urban scale suggests that a development towards a PUR is possible; however, this would require pointed investments in infrastructure and locational employment and housing planning.

Although the model employed for this analysis is robust, a number of points should be made about the underlying data. First, commuting data is only one way to investigate the structure of urban systems. Several authors have pointed out that movements of people are not a perfect indicator for economic interaction and should be used alongside other forms of economic interaction to gain a realistic insight into the structure of urban systems (Glanzmann *et al.*, 2004). Although different groups of people exhibit various degrees of willingness to travel to work, most people prefer to live relatively close to their main place of work (Turner and Niemeier, 1997; Rouwendal 1999). A similar analysis as performed in this chapter of data on buyer-supplier interactions or innovation collaboration could potentially offer a different view that would enable one to make more detailed conclusions on the structure of the urban system in the Greater South East. However, the data on such interactions that are currently available for the Greater South East are too weak to make statistically robust inferences and are difficult to obtain (Hall *et al.*, 2006).

Second, most currently available commuting data is based on survey questions asking for daily commuting behaviour. Hence, the choice of studying commuting trips allows a focus on the 'daily urban space' of people. When considering urban network development, however, it might be more useful to assume that interactions over larger distances do not take place everyday and we should rather look at the 'weekly urban space' or 'monthly urban space' of people. Green *et al.* (1999) describe how *weekly* commutes over large distances are increasingly supplanting migration. These 'super commutes' are missing from, or disturbing, the currently available data, as people who commute weekly often have two places of residence. Green *et al.* estimate that in Britain the total number of people undertaking such super commutes is just over 1% of the total number of employed residents.

Third, and related to the previous point, it is also important that future research on functional polycentrism and urban network development concentrates on less frequent types of trips, such as leisure and business trips (see also Lambooy, 1998; Hall and Pain, 2006), in addition to other types of functional relationships between cities, such as inter-urban trade (Davoudi, 2008; Van Oort *et al.*, 2010).

Finally, the empirical results presented in this chapter have implications for policy. Our results indicate a development towards urban networks at the intra-urban scale and relatively little development at the inter-urban scale. Thus, transport planning should, therefore, pay particular attention to the intra-urban scale. This may mean that there should be more investment on improving secondary roads and other form of transport (including public transport and cycle routes) within the existing urban fabric rather than improving high-speed roads linking urban regions. Recent studies suggest that there are few urban economic and labour force complementarities between nearby cities in Western economies (Meijers, 2005). Instead, cities are increasingly trying to compete in same high-technology areas, such as knowledge intensive business services, ICT and biotechnology (Kitson *et al.*, 2004; Van Oort *et al.*, 2010). This 'place competition' may hamper a more integrated and synergetic 'urban network' approach which stresses collaboration between places. If this does not change, the spatial planning of housing and business sites should predominantly serves local demand and improve the efficiency of daily urban systems. And as the location of employment becomes more endogenous to population location within urban regions in Western counties (Boarnet, 1994) – meaning that "jobs follow people" more than that "people follow jobs" – the planning of population development becomes more important in steering the planning process

Appendix 7A: Urban Areas

In order to investigate the hypotheses further, it was necessary to define different 'Urban Areas' within the Greater South East, each with one 'core-county' and several 'periphery-counties'. The analyses performed in this chapter allow for a rather simple definition of 'Urban Areas'. In almost all instances, the most recent version of NUTS III areas was used to define Urban Areas in the Greater South East. The NUTS III geography is useful here for two reasons: first, it can be used with the *'CIDS 1991/2001 common geography'*, and second, NUTS III is a commonly accepted definition of an 'Urban Area'. However, in a number of instances the NUTS III area geography causes problems in that some counties (the unit of analysis) are a NUTS III area on their own. In these cases, another definition of an Urban Area, the Travel-to-Work-Areas (TTWA), was used to assign counties to an Urban Area (see Figures 7A1-A3). The core of each Urban Area was defined as the county with the largest city in terms of population. The rationale behind the choice for the most populous city as the core of an 'Urban Area' is based on the historical role of the city as a 'Central Place'. However, for Urban Areas located in the Greater London Area this rule does not apply as London as a whole could be considered a core. For these Urban Areas, the county (London Borough) with the highest demand for labour was chosen as the urban core. The role of the Greater London Area as a core on its own in the Greater South East urban network is investigated separately.

Figure 7A1-A3. *Creation of Urban Areas*. From left to right: GSE NUTS III areas, GSE TTWA areas, and the used Urban Areas in this chapter with their urban cores.

Appendix 7B: Districts in the Greater South East

Districts sorted by urban area (core district in bold)

Basildon	Epping Forest
	Harlow
	Thurrock
Basingstoke and Deane	Hart
	Rushmoor
Bedford	Mid Bedfordshire
	Milton Keynes
	North Hertfordshire
Brighton and Hove	Adur
	Arun
	Eastbourne
	Lewes
	Wealden
	Worthing
Cambridge	East Cambridgeshire
	South Cambridgeshire
Colchester	Braintree
	Tendring
	Uttlesford
Crawley	Horsham
	Mid Sussex
Croydon	Bromley
	Kingston upon Thames
	Merton
	Sutton
Enfield	Barking and Dagenham
	Bexley
	Greenwich
	Havering
	Redbridge
	Waltham Forest
Hastings	Rother
	Shepway
Hillingdon	Barnet
	Brent
	Ealing
	Harrow
	Hounslow
	Richmond upon Thames
Ipswich	Babergh
	Forest Heath
	Mid Suffolk
	St. Edmundsbury
	Suffolk Coastal
	Waveney
Luton	South Bedfordshire
Maidstone	Ashford
	Sevenoaks
	Tonbridge and Malling
	Tunbridge Wells
Norwich	Breckland
	Broadland
	Great Yarmouth
	King's Lynn and West Norfolk
	North Norfolk
	South Norfolk
Oxford	Cherwell
	South Oxfordshire
	Vale of White Horse
	West Oxfordshire
Peterborough	Fenland
	Huntingdonshire
Portsmouth	Chichester
	East Hampshire
	Fareham
	Gosport
	Havant
	Winchester
Reading	Bracknell Forest
	Slough
	Windsor and Maidenhead
	Wokingham
Southampton	Eastleigh
	Isle of Wight
	New Forest
	Test Valley
Southend-on-Sea	Castle Point
	Chelmsford
	Maldon
	Rochford
Southwark	Hackney
	Haringey
	Islington
	Lambeth
	Lewisham
	Newham
	Tower Hamlets
Swale	Canterbury
	Dartford
	Dover
	Gravesham
	Medway Towns
	Thanet
Watford	Broxbourne
	Dacorum
	East Hertfordshire
	Hertsmere
	St. Albans
	Stevenage
	Three Rivers
	Welwyn Hatfield
Westminster, City of	Camden
	City of London
	Hammersmith and Fulham
	Kensington and Chelsea
	Wandsworth
Woking	Elmbridge
	Epsom and Ewell
	Guildford
	Mole Valley
	Reigate and Banstead
	Runnymede
	Spelthorne
	Surrey Heath
	Tandridge
	Waverley
Wycombe	Aylesbury Vale
	South Bucks

Appendix 7C: Road Distance

Using the actual road distance rather than the more conventional air distance is especially appropriate in the case of the Greater South East. The hub and spoke structure of the road network in the Greater South East makes the distance between counties often longer than expected (see Figure C1). Though a number of roads have been upgraded (which does not affect the actual distance) over the period investigated, the overall majority of all public roads were constructed at the beginning of the 20th century (SABRE, 2007). The distances calculated on the basis of the 2005 road network are therefore valid for all three investigated periods (1980, 1991, and 2001).

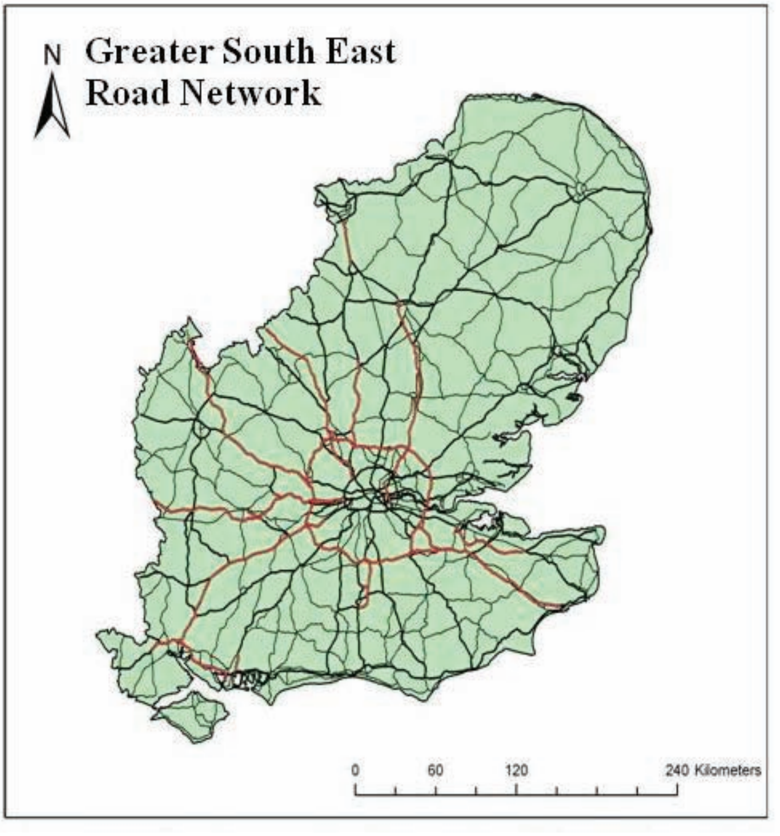


Figure 7C1. *The Greater South East Road Network in 2005.* The red lines indicate the major motorways, whereas the thick and thin black lines respectively indicate the major regional and local roads

Chapter 8:

On the Economic Foundation of the Urban Network Paradigm

Abstract[1]

Conceptually, the degrees of spatial and functional integration and urban complementarities in economic network relations are hypothesised to be important. In this chapter, data on inter-firm relations in the Dutch Randstad are used to test conditions for integration and the existence of economic complementarities. A clear hierarchy is observed in the different types of spatial interdependencies in the Randstad, in which the central place model prevails. Furthermore, no evidence is found for functional integration of municipalities in the Randstad. This also calls into question the applicability of the urban network concept in general, as the Dutch Randstad is usually seen as a prime example of an economically successful polycentric urban system.

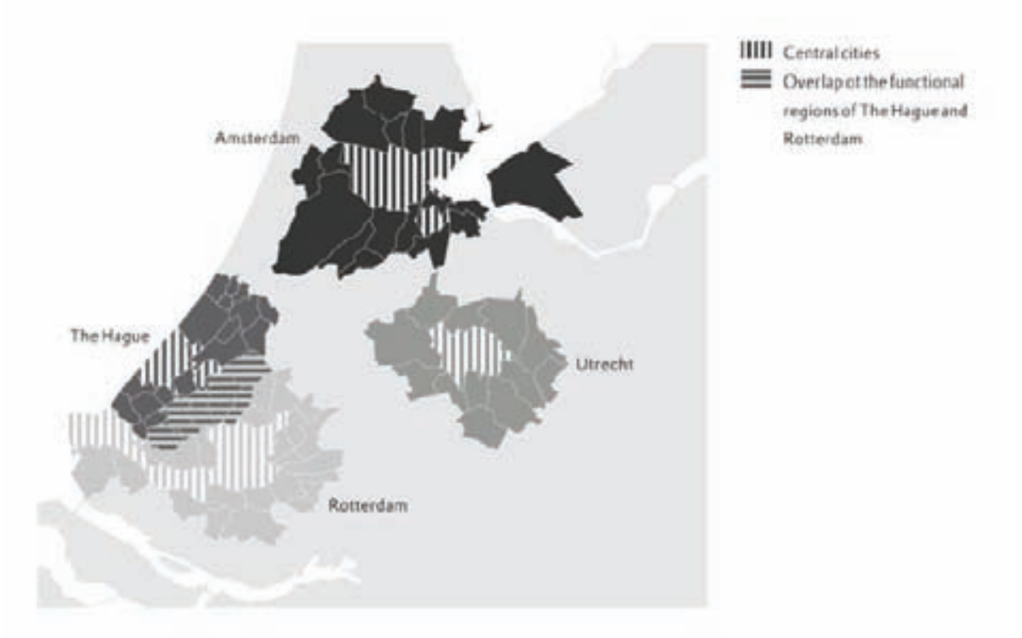
[1]This chapter has been published in *Urban Studies*, 47(4), pp. 725-748 as "On the economic foundation of the urban network paradigm: spatial integration, functional integration and urban complementarities within the Dutch Randstad" (with Frank van Oort and Otto Raspe). It has been edited to fit the format of this book.

8.1 Introduction

From a geographical point of view, the Randstad is known as the urban conurbation in the western part of the Netherlands, in which four major cities (Amsterdam, Rotterdam, The Hague, and Utrecht) and a number of smaller towns are located within close proximity of each other (see Figure 8.1). The Randstad constitutes the heart of the Dutch economy, with 50% of the gross national product being generated on approximately 25% of the country's total land area. Having a population of six million inhabitants, the Randstad houses over one third of the Dutch population. However, in the debate on spatial planning and economic policy in the Netherlands, the 'Randstad' stands for more. The name, since it includes the Dutch word for 'city' ('stad', in the singular), suggests that the Randstad is a single, contiguous urban region. Suggestions that the region functions as an integrated economic entity for basic industries, like manufacturing activities, distribution activities and business services, are numerous (see e.g., Dieleman and Musterd, 1992; Sachar, 1994; Batten, 1995; Kloosterman and Lambregts, 2001; Lambregts, 2008). Based on these suggestions, policymakers now more than ever aim at the concentrated location of (inter)national firms and businesses in this networked region in order to have optimal economic growth potentials (VROM 2008). Nevertheless, simply assigning a name, such as the Randstad, to a collection of towns and cities does not automatically meld them into a spatial and functional integrated city with economic complementarities and firms benefiting from region-wide agglomeration economies.

From the end of the 1950s onwards, the Randstad has been regarded as one of the most important urban networks or functional clusters of economic activity in Europe (Hall, 1966; Batten, 1995). It is argued that the Randstad functions as a role model for a network of cities and towns, which, given their mutually dependent specialisations and their variety, creates a favourable setting for economic production and growth (Lambregts *et al.*, 2006). In the urban geography and planning literature, it is generally contended that such cities and towns complement each other in terms of economic specialisations, each being therefore more competitive than they would be in isolation (Meijers, 2005). This representation of the Randstad as urban network is based on the assumption of a considerable regional cohesion in personal, occupational and corporate relationships of people, organisations and firms that transcends the boundaries of the traditional metropolitan areas. The general contention for different cities within an urban network to be complementary to each other requires that the cities not only be specialised in different industries but at the same time also be showing a marked degree of spatial interaction and hence integration. In this, inter-firm relationships are considered to be most fundamental to the creation and evolution of such an urban network (Sachar, 1994; Lambooy, 1998). Camagni and Capello (2004, p.496) argue that polycentric urban regions (PURs) comprise a new paradigm in spatial sciences, provided that (a) the exact meaning is defined, (b) the theoretical economic rationale is justified, and (c) the novel features of its empirical content are clearly identified and distinguished from more traditional spatial facts and processes that can be interpreted through existing spatial paradigms. Camagni and Capello (2004, p.496) further argue that "*the concept of spatial networks is sometimes merely used as a substitute for 'interaction': an exchange of goods, services, information and contacts among places and nodes. Traditional paradigms of spatial interaction can be easily utilised, unless one could demonstrate that the probability of such exchanges is mainly independent of distance and the size of nodes*".

Figure 8.1: The Randstad Research Area and the 67 Municipalities in the Survey



This chapter contributes to the discussion on economic complementarities in urban networks by analysing networked economic relations in the Randstad. To date, there has been little empirical research into the spatial and functional economic cohesion of urban-networked regions, mainly because of a lack of inter-firm relational data. We use a recently-collected dataset that stems from a large-scale survey of 1676 firm establishments that are active in the sectors industry, producer services and distribution in the Randstad to test for the presence of urban complementarities. A detailed insight into inter-firm networks is obtained by asking these firms to identify their most important business relationships with customers and suppliers in terms of physical goods, services and information. Using these data, which are representative of the entire commercial sector in the Randstad, and defining urban complementarities by the combination of spatial and functional integration between localised specialised firms, we answer three related questions on the economic foundation of urban networks:

1. To what extent does the Randstad operate as a spatially integrated entity?
2. To what extent does the Randstad operate a functionally integrated entity?
3. Do urban complementarities between municipalities in the Randstad (being the joint occurrence of spatial and functional integration) exist?

The rest of this chapter is organised as follows: Section 8.2 discusses the literature on the spatial and functional development of cities and urban systems, focusing primarily on the role of economic networks in the concepts of spatial integration, functional integration and economic complementarities. Section 8.3 offers a diagrammatic representation of the network relationships of the surveyed firms. Section 8.4 examines the degree of spatial integration of inter-firm relationships in the Randstad by means of spatial interaction models. In Section 8.5, we inspect the degree of functional integration by looking at the degrees of specialisation and diversification across municipalities in the Randstad in relation to the interactions between firms in these municipalities. Finally, in Section 8.6, we examine the presence of urban complementarities in the Randstad, conclude on our three research questions and sketch out policy implications.

8.2 The Economic Foundation of Changing Urban Systems

The Monocentric Model: Towns into Cities and Daily Urban Systems

In order to judge whether the Randstad can be classified as a single urban economic entity, a classification of urban functions in relation to the morphology of cities is necessary. Prior to the Industrial Revolution, a city could be identified as a monocentric agglomeration of people and businesses (a town), clearly separated from the countryside. What made cities most distinctive from the rural areas was their specific legal status (notably 'city rights') and their political identity. Markets and administrative places gradually "*crystallized as central places for their surrounding areas in which each center approximated the center of gravity of its service area in order to minimize transportation costs*" (Hohenberg and Lees, 1985, p. 49). From a morphological point of view, the city in the pre-industrial era was then also very concentrated and centralised, as physical distance often encumbered interactions between different areas. As a result, business relations were often restricted to the urban core.

Cities shifted their borders when mobility steadily increased and communication technology further developed. The tram, train, and telegraph in the nineteenth century and the telephone and the automobilesation in the twentieth century are examples of technology that impacted urban development (Anas *et al.*, 1998). Also, due to the existence of cheaper land outside the urban centre and rising welfare levels, households increasingly choose to locate further away from the city centre. These developments led to the rise of metropolitan areas or Daily Urban Systems (DUS), which are typically defined by the most important commuting relations (Van der Laan, 1998). The relationship between the urban core and its suburbs remained hierarchical-nodal. Most economic activity was based in the urban core, commuting flows were directed towards the principal cities, and suburbs only fulfilled a residential function. Here, the metropolitan region is characterised as a central place system with the principal city as main focus. In such monocentric city-region inter-firm business flows largely remain within urban cores (Pred, 1973, 1977), although space-consuming economic activities – like industrial and distribution activities - are hypothesised to radiantly develop out of the city centre (Smith, 1971).

However, the conceptualisation of urban regions as monocentric city-regions is becoming increasingly problematic (Clark and Kuijpers-Linde, 1993; Kloosterman and Musterd, 2001; Meijers, 2007). For a variety of reasons, firms and households may increasingly choose to locate themselves in secondary employment centres, despite the advantages of the principal city. As a result, suburban areas in the surrounding territory are emerging into local centres that develop their own economic activities (Anas *et al.*, 1998). The result is the development of city-regions with multiple centres, or polycentric city-regions, at the intra-urban scale. Functional relationships are not longer centralised, but reciprocal in the sense that commuting is now not only directed from the suburban areas to the principal city, but also from the principal city to the suburban areas. In transport geography this phenomenon is better known as exchange commuting.

Moreover, the surrounding territory becomes increasingly self-contained in the sense that many suburban residents are employed in the suburban area in which they live. These sub-centres may grow in importance over time, as people start relocating to these sub-centres in order to follow their employer, or for the benefit of cheaper land (Van der Laan, 1998). As such, a territorial competition emerges between the original core and the new sub-centres, changing the image of the city to a *network-city* proper. In this situation, the principal city has lost its pure primacy. Flows of goods, services and people become decentralised as the number of workers commuting between different parts of the surrounding territory and bypassing the old urban core increases. At the same time, economic complementarities within the daily urban system (DUS) arise, where one location may be regarded as 'central' in terms of one particular function while other places might be central in terms of other functions.

The Polycentric Urban Region

The focus of the contemporary debate on changing urban systems has increasingly shifted from the intra-urban scale to the *inter-urban* scale (Coe and Towsend, 1998; Kloosterman and Musterd, 2001; Hall and Pain, 2006; Hoyler *et al.*, 2008; Bailey and Turok, 2001). The inter-urban scale corresponds to flows *between* different urban regions. Usually, urban systems are blended in terms of intra- and inter-urban relations, in which intra-urban relations refer to relations in which the 'own' core and periphery districts are involved, and inter-urban relations refer to relations between core and peripheral districts in different urban regions. As catchment areas of different cities start to overlap, individual metropolitan areas lose significance as independently functioning daily urban systems and could instead be perceived as forming parts of an urban network. Much of the current literature is focused on this development, that is, the development of the polycentric urban region (PUR). The PUR can be represented as an urban network of historically and spatially separate metropolitan areas comprising a larger region (Dieleman and Faludi, 1998; Kloosterman and Musterd, 2001). These metropolitan areas can be network-cities themselves, but this is not necessarily the case (i.e., the urban system can be dominated by a polycentric structure at the inter-urban level and a monocentric structure at the intra-urban level or vice versa).[2] In a PUR, there is no obvious leading city, considerable spatial

[2] Likewise, urban network formation on the inter-urban level is not necessarily the next evolutionary step after the

interaction between the cities, and each city is specialised in different economic activities (Champion, 2001; Parr, 2004; Green, 2007). In The spatial integration of formerly independently functioning urban regions is supposed to create a favourable setting for economic growth, especially when the cities and towns in such an urban network complement each other's economic specialisations. These developments coincide conceptually with the identification of the paradigm shift suggested by Camagni and Salone (1993), Batten (1995), and Meijers (2007): from a central place model to an urban network model.

The Economic Foundations of Urban Networks

The conceptualisation of urban network formation is predominantly tested by interaction patterns of people. Previous research has focused on the effect of the increasing flexibility and mobility of people and their changing residential preferences on the urban system (Renkow and Hoover, 2000; Van Ham, 2002). To some extent, these residential preferences are mutually influenced by enhanced mobility, the increasingly flexible workplace and choices of lifestyle and attitudes of households, including the locational preferences of two-earner households, the increasing number of working women, and an increasing number of single-person households (Hall, 2001). Still, these trends in labour supply do not, on average, coincide with a larger labour mobility of employees: the average commuting time in the Netherlands has remained stable over the last 20 years at approximately 25 minutes (Van der Burg and Dieleman, 2004). Only a limited number of higher-educated professionals have become more mobile over time.[3]

Instead, *firms* are argued to have become the most mobile and flexible over the recent years. This would implicate that urban networks form an enlarged home base for firms in terms of market potential, diversity and quality of available knowledge, infrastructure, institutions and subcontracting possibilities (Pred, 1977). This microeconomic (business) foundation of urban networks is hinted at in the literature (Kloosterman *et al.* 2001; Lambregts *et al.*, 2006), but that has not been researched much in the urban geography and planning literature. This is not surprising, since urban economists have for some time fuelled a burgeoning empirical literature that examines whether spatial circumstances give rise to agglomeration economies – external economies from which firms can benefit

(intra-urban) network-city (Parr, 2004).

[3] Over the last 20 years, the average distance of shopping activities of consumers has not grown significantly in the Netherlands, either (Ritsema van Eck et al., 2006).

through co-location and local network creation – that endogenously induce localised economic growth (Glaeser *et al.*, 1992; Combes, 2000; Rosenthal and Strange, 2003). In their survey of the empirical literature on the benefits of agglomeration, Rosenthal and Strange (2004) point out that the elasticity of productivity to city and industry size typically ranges between 3% and 8%. However, the effects of agglomeration economies on localised economic growth differ across sectors, time and space (Rosenthal and Strange, 2004; Van Oort, 2007). Concerning the latter, there is a growing interest in this debate on agglomeration economies in the networked structure of (systems of) cities (Anas *et al.*, 1989; Meijers and Burger, 2010).

At the micro level, the relation between the morphology of urban systems and economic performance is conceptualised by the increasing flexibility and mobility of firms. The hypothesis is that trends in urban system dynamics are driven by changes in the spatial distribution of employment and growth opportunities (Renkow and Hoover, 2000). Aoyama and Castells (2002) argue that these changes are facilitated by key advancements in transport technology and in information and communication technology (ICT), by globalisation and flexible specialisation in production and by the economic change of most western economies from a production to a services-dominated economy. There is considerable academic debate on the precise spatial and economic effects of these developments. Concerning ICT, for instance, in one view – the substitution view – it potentially influences the production of new products and the location of their production by substituting for production factors such as manual labour or traditional means of transport. This then leads to higher efficiency and productivity in firms. In substituting physical transport by ICT – mainly relevant for services – a reduction in time and transaction costs can be achieved. A liberalising or centrifugal effect then occurs, in the literature summarised as the 'death of distance' or the 'weightless economy', in which economic value is transmitted across physical space at zero marginal costs (Horan et al, 1996; Kolko, 2002). The so-called complementary view on the other hand stresses inertial and concentrated growth patterns. In this conceptualisation, spatial economic dynamics occur within the limits of the spatial interaction patterns laid down in the past in processes characterised by cumulative causation. Moreover, firms are also physically constrained by the necessity of face-to-face contact (Geyer, 2002). Functional and trust relations thus limit the morphological layout of urban agglomeration to that of the (polycentric) region (Nooteboom, 1999). Comparable discussions concern the (spatial) flexibility thesis of firms. It is argued that to compete in the network economy, firms have to make production processes more flexible with respect to time, place, contracts and job content (Scott, 1988). Increasing uncertainty in markets and differentiation in consumer demand in terms of varieties, brands and quality force firms to run small-scale production batches. The outsourcing of economic activities that do not directly belong to the core activities of the company is stimulated, and vertical cooperation with firms active within the same industry becomes more important. This flexibilisation of business processes and the functional division of tasks between companies create opportunities for a spatial division of labour, and different spatial settings or locations become suitable for different economic functions. The result is often argued to be a polycentral and multi-nodal structure, in which flows of goods, services and people are not one-sided, but two-sided and criss-crossed (Curran and Blackburn, 1994).

Integration and Complementarities in Local and Regional Policy

Local and regional policies often have the explicit intention of economic deconcentration and urban network formation. A well-known example of an intentional policy towards economic deconcentration is the 'growth pole concept' (Parr, 1999). The aim of this policy is to create economic development in peripheral areas by encouraging the establishment of industrial growth centres in the periphery. Ultimately, this should have led to the development of the hinterlands of these growth centres, in turn spreading the benefits of economic development over a larger area. Similarly, by embracing the urban network concept, national as well as local policymakers and urban planners attempt to actively develop suburban and adjacent areas, with the objective of spreading economic prosperity and enhancing territorial competitiveness of urban regions (Glaeser, 2007). Also in the Netherlands, the urban network paradigm is embraced by policy in this vein. In recent policy memoranda by the Ministry of Economic Affairs (*Peaks in the Delta 2005*), the Ministry of Housing, Spatial Planning and the Environment (*Spatial Memorandum 2004*), and the Ministry of Transport (*Mobility Memorandum 2004*), the concept takes in a prominent place. Three key concepts within the present-day academic as well as policy conceptualisation of urban networks are spatial integration, functional integration and urban complementarities. Spatial integration between the towns in an urban network (for instance in the Randstad) results from the improved opportunities for mobility and communication, which facilitate larger transport and information flows and stronger relationships between the individual urban agglomerations. An urban network can be classified as a functionally integrated entity if alongside more spatial integration there is differentiation between the municipalities in terms of urban economic functions. In an economic sense, this would require that the municipalities that make up an urban network (the Randstad) be specialised in different economic sectors, hereby fulfilling different economic roles (Meijers, 2005). For example, a city specialised in business services provides these services to a city specialised in labour-intensive industry, and vice versa (Lambregts *et al.*, 2006). In sum, differences in relative specialisations (functional integration) together with a large degree of interaction between economic agents (spatial integration) economically define an urban network that is characterised by economic complementarities.

In earlier days, integration and complementarities bundled in one town or city, but with the increasing flexibility and mobility of firms, their goods and services and the division of labor, it is suggested that these processes are now embedded in regionally-defined networks. Despite the fact that both the academic literature as well as policy documents on urban networks use the concepts of spatial and functional integration and economic complementarities, only few empirical studies have qualitatively assessed how well the network model fits the reality of contemporary urban systems (Davoudi, 2003; Capello, 2000). Unfortunately, most of the available empirical evidence is based on node characteristics, by which (inter-firm) interaction patterns can be mainly explained by distance and the size of nodes, using methods such as location quotients, rank-size relations, sufficiency indices, and employment-to-work ratios (Limtanakool *et al.*, 2007; Camagni and Capello, 2004). In our empirical analysis, we will introduce a method based on flow characteristics that tests for the spatial structure of inter-firm relations independently of masses of nodes and the distances between them.

8.3. Inter-firm Relations in the Randstad

Data: A Survey among Firms in the Randstad

In the previous section, we defined urban complementarities as the *combination* of spatial integration and functional integration. To test whether the Randstad does indeed function as such a single economic system or urban network with complementary sub-economies, we have examined the spatial dynamics of firms' networks within the region. The network relationships involve (sub)contracting, purchasing and selling of products, services and knowledge. In our analyses, we aggregate the relationship flows into municipalities (LAU-2) of which there are 69 in the Randstad, see Figure 8.1). The survey was conducted in 2005 among more than 20,000 selected firms (establishments) with more than one employee and based in the Dutch Randstad (divided in four sub regions, see Figure 8.1). A random stratified sample, taking size, sector and regions into account, was taken from the LISA database (an employment register of all Dutch economic establishments, see Van Oort, 2007). For this research, we included firms in manufacturing, wholesale and business services. These basic sectors are not directly bound to consumers for their location as retail is, for example. The response of 1676 establishments - approximately 8% - is representative of the stratification by region, size and sector. The questionnaire focuses on the sources and destinations of an individual firm's ten most important selling and purchasing relations, which we aggregate to the municipality level in our analysis. Table 8.1 shows for each of the four sub-regions in the Randstad (Amsterdam, Rotterdam, The Hague and Utrecht) the firm population, the firm sample size, and the number of firms responding to the questionnaire. The calculation of the sample size is based on stratification by region, economic activities (by sector, 27 NACE codes in manufacturing, wholesale and business services) and firm size (6 size classes).

Table 8.1: Number of Establishments by Region and Sector

	Population	Sample	Response (%)
Amsterdam	19045	7035	574 (8.2%)
Rotterdam	10789	5668	514 (9.1%)
Den Haag	5468	3655	291 (8.0%)
Utrecht	6096	3943	297 (7.5%)
Total	41398	20301	1676 (8.3%)
Manufacturing	5322	5307	367 (6.9%)
Wholesale	10991	4807	376 (7.8%)
Business services	25085	10186	933 (9.2%)
Total	41398	20301	1676 (8.3%)

Visualisation of Network Patterns within the Randstad

Figure 8.2 shows the network of inter-firm relationships for the entire Randstad. In this figure, the respondent population is not classified by sector or size. The dots indicate the extent of relationships within an individual town or city, e.g., companies in The Hague that maintain a business relationship with other companies in The Hague. The lines represent the relationships between companies in different towns or cities. A large number of relationships can be seen within the four major cities, but there are also flows between these main centres. Moreover, a significant number of criss-crossing relationships, i.e., relationships between companies that are located outside the central cities, can be noticed. In absolute terms, the four major cities function as the centres of the urban network. Not only do companies there maintain the largest number of relationships with other firms in the same municipality, but they also are involved in a large number of flows within the larger network. This is particularly true in the case of Amsterdam, which occupies a key position in the Randstad's overall network. It should be noted, however, that Figure 8.2 is only telling half of the story: about 50% of all inter-firm relationships of firms that are located in the Randstad region transcend the boundaries of the Randstad.

Figure 8.2: Network of Inter-firm Relationships in the Randstad

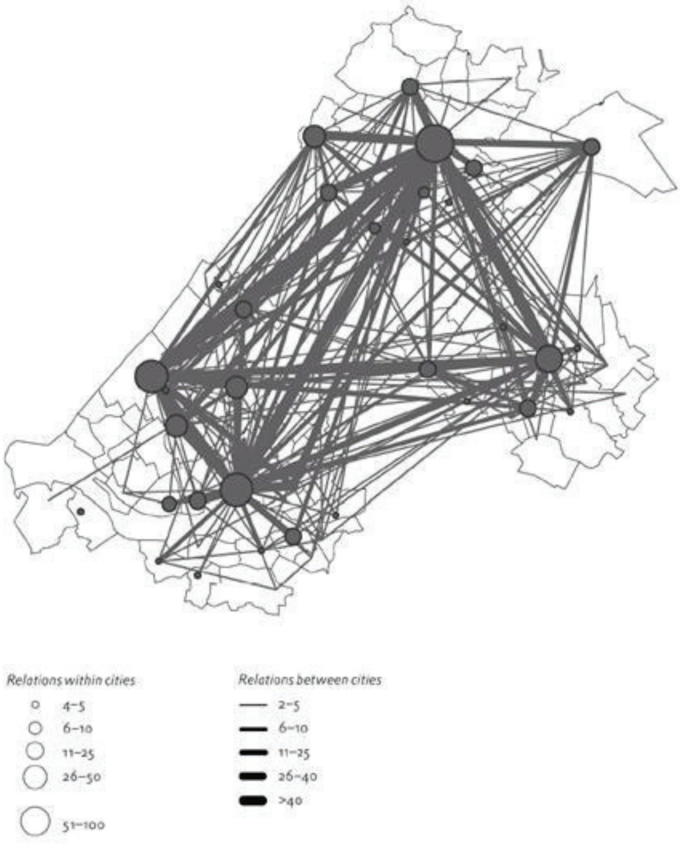


Figure 8.2 gives a descriptive account of the embeddedness of economic networks in the Randstad region. However, an obvious criticism of such a visual analysis is that it does not allow for differences in the absolute sizes of municipalities (in terms of firm population) and the physical distances between them. For example, recent empirical studies conducted within the POLYNET research framework (e.g., Green, 2007; Hall and Pain, 2006) do not address this issue. The likelihood of an inter-firm relation with companies located in a large city with many (and a sectorally varied number of) firms is larger than one directed to a smaller city with fewer firms. Likewise, the likelihood of an inter-firm relation between two cities in close proximity to each other is larger than the likelihood of one between municipalities located far from each other.

Figure 8.3: Observed versus Expected Inter-Firm Relationships in the Randstad

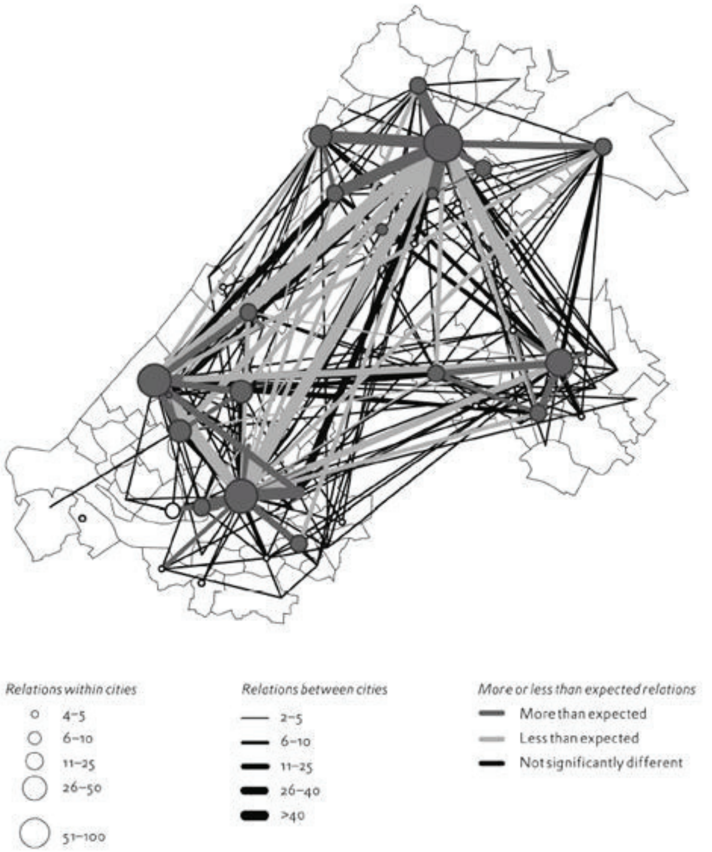


Figure 8.3 therefore shows the same map as figure 8.2, but the visualized spatial interactions are now characterized by their deviation from the number of expected relationships based on the size of the originating and destination municipalities and their mutual physical proximity. In order to compare the observed versus the expected interaction intensity between cities in the Randstad region, we made use of the likelihood ratio chi-square statistic (Agresti 2002). Where the number of actual relationships is significantly larger than the expected figure, this is shown in dark gray shading. Where the number of actual relationships is significantly smaller than the expected number, this is shown in light gray shading. Non-significant relations are shown in black. Figure 8.3 shows that inter-firm relationships within the same municipality and relationships between central cities and their direct (adjacent) hinterland are in general larger in number than projected. Inter-firm relations between the four central cities are less than expected.

All locations and regions in the modern economy interact to some extent (Fingleton, 2003). Accordingly, based on Figure 8.2 we cannot draw conclusions on the nature of the existing urban interdependencies within the Randstad region. And although figure 8.3 suggests a spatial hierarchy in more-than-expected interactions, it is not precise in the degree of this ranking and does not inform us on functional interactions. We therefore introduce an interaction model that controls for masses of cities and their mutual physical proximity to analyse spatial and functional integration more accurately.

8.4 The Spatial Economic Integration of the Randstad

Modelling Spatial Integration

In this section, we test whether the municipalities in the Randstad form a spatially integrated urban system based on inter-firm relations. In this, we use a rather strict testing system in the sense that we speak of a fully integrated network when there is no effect of spatial-functional context on inter-firm network intensities other than the economic mass of sending and receiving localities and the physical distance between them. If the Randstad functions as a spatially integrated urban system (from an economic point of view), the spatial network structure of inter-firm relations in the Randstad is solely determined by these two variables. Three related conditions for spatial integration are, therefore:

1. Intra-urban interdependency should not be stronger than interdependencies between cities within the Randstad.
2. Interdependencies between cities within one of the urban (sub)regions in the Randstad should not be stronger than interdependencies between cities across these (sub)regions.
3. No observable hierarchy in the different types of inter-municipal interdependencies should be present.

We test these conditions within the context of a gravity model. Spatial interaction patterns, such as inter-firm flows, can be predicted and elucidated in analogy with Newton's law of universal gravitation (Haynes and Forthingham, 1985; Sen and Smith, 1995). The gravity model assumes that the gravitational force between two objects (in our study, the interaction between companies, aggregated at the level of the municipality) is dependent on the mass of the objects and the physical distance between them. More specifically, the interaction intensity between two municipalities (the origin and destination) is hypothesised to be directly correlated with the masses of the municipalities and inversely correlated with the physical distance between the two municipalities. More formally,

$$I_{ij} = K \frac{M_i^{\beta_1} M_j^{\beta_2}}{d_{ij}^{\beta_3}} \tag{8.1}$$

where I_{ij} is the gravitational force, or in our case the interaction intensity between municipality i and j expressed by the number of linkages, K a proportionality constant, M_i the mass of the municipality of origin, M_i the mass of the municipality of destination and d_{ij} the physical distance between the two municipalities. β_1, β_2, and β_3 are parameters to be estimated. Here, the mass of the municipality of destination and origin are defined as the total number of inter-firm relations of each municipality, as embedded in the network. As inter-firm relationships are considered to be undirected in this study, there is no clear distinction between the municipality of origin and the municipality of destination. Hence, the natural logarithm of the product of M_i and M_j is taken together as one variable in our analysis. Distance is measured as the crow flies between cities, where intra-municipal distances are calculated by (8.2):

$$d_{ii} = \frac{2}{3}\sqrt{\frac{A_i}{\pi}} \qquad (8.2)$$

in which the intra-municipal distance d_{ii} is two thirds of the radius of the presumed circular area A_i (see Bröcker (1989b) and Frost and Spence (1995) for the exact derivation and overview of considerations of this).

Spatial interaction data should be handled as count data, as they 'count' the number of times that something has happened, which in our case is the frequency of flow (expressed as interaction intensity) between and within municipalities. Although these data are often treated as though they are continuous, the application of the conventional linear regression model here can lead to inefficient, inconsistent, and biased estimates (Flowerdew and Aitkin, 1982; Long, 1997) as the underlying assumptions of normal distribution and homoskedasticity are often not satisfied. For this reason, the use of alternative regression techniques is more appropriate. The most common regression model applied to count data is probably the Poisson regression, which is estimated by means of maximum likelihood estimation techniques. In this log-linear model, the observed interaction intensity between municipality i and j has a Poisson distribution with a conditional mean (μ) that is a function of the independent variables (8.3). More specifically,

$$\Pr[I_{ij}] = \frac{\exp(-\mu_{ij})\mu_{ij}^{I_{ij}}}{I_{ij}!}, \text{where } \mu_{ij} = \exp(K + \beta_1 \ln(M_i M_j) + \beta_2 \ln d_{ij}) \qquad (8.3)$$

In order to correct for overdispersion (where conditional variance is larger than the conditional mean) and an excessive number of zero counts in our data set (where the incidence of zero counts is greater than would be expected for the Poisson or negative binomial distribution), we make use of the zero-inflated negative binomial regression, which can be perceived as an extension of the Poisson model. Not correcting for the overdispersion and excess zero problem normally results in consistent but inefficient estimates, exemplified by spuriously large z-values and spuriously small p-values due to downward biased standard errors (Gourieroux *et al.*, 1984; Cameron and Trivedi, 1986). The zero-inflated negative binomial model considers the existence of two (latent) groups within the population: a group having strictly zero counts and a group having a non-zero probability of counts different than zero. Correspondingly, its estimation process consists of two parts (8.4.1 and 8.4.2).

$$\Pr[I_{ij}=0]=\psi_{ij}+(1-\psi_{ij})\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu_{ij}}\right)^{\alpha^{-1}} \tag{8.4.1}$$

$$\Pr[I_{ij}]=(1-\psi_{ij})\frac{\Gamma(I_{ij}+\alpha^{-1})}{I_{ij}!\Gamma(\alpha^{-1})}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu_{ij}}\right)^{\alpha^{-1}}\left(\frac{\mu_{ij}}{\alpha^{-1}+\mu_{ij}}\right)^{I_{ij}}, \tag{8.4.2}$$

In which, $\mu_{ij}=\exp(K+\beta_1\ln(M_iM_j)+\beta_2\ln d_{ij})$, ψ_{ij} is the proportion of observations with a strictly zero count $(0\leq\psi_{ij}\leq 1)$, Γ( ) is the gamma function, and α is a parameter that determines the degree of dispersion in predictions, hereby allowing the conditional variance to exceed the conditional mean. The first component of the zero-inflated negative binomial model (8.4.1) contains a logit regression of the predictor variables on the probability that there is no interaction between two given municipalities at all. The second component (8.4.2) contains a negative binomial regression on the probability of each count for the group that has a non-zero probability of count different than zero. A likelihood ratio test of overdispersion (Cameron and Trivedi, 1986) is employed to test whether the negative binomial distribution is preferred to a Poisson distribution, while the Vuong statistic (Vuong, 1989) provides evidence whether a zero-inflated model is favoured above its non-zero inflated counterpart.[4]

In order to test the three specified conditions for spatial integration of municipalities in the Randstad region using a zero-inflated negative binomial model, we introduce dummy variables in our model that reflect the spatial-functional context of the economic interactions between types of localities (regimes). These regimes build up the degree of spatial integration in the Randstad region. We distinguish four core cities (Amsterdam, Rotterdam, The Hague and Utrecht) with their suburban municipalities and introduce the

[4] A more extensive discussion of zero-inflated estimation in relation to spatial interaction models can be found in Burger et al. (2009a).

following six types of urban interdependencies that convey the spatial context of flows between municipalities:

A. Economic relations within municipalities:

1. Intra-nodal relationships that remain entirely within a particular municipality (this can be either the central city or a suburban location).

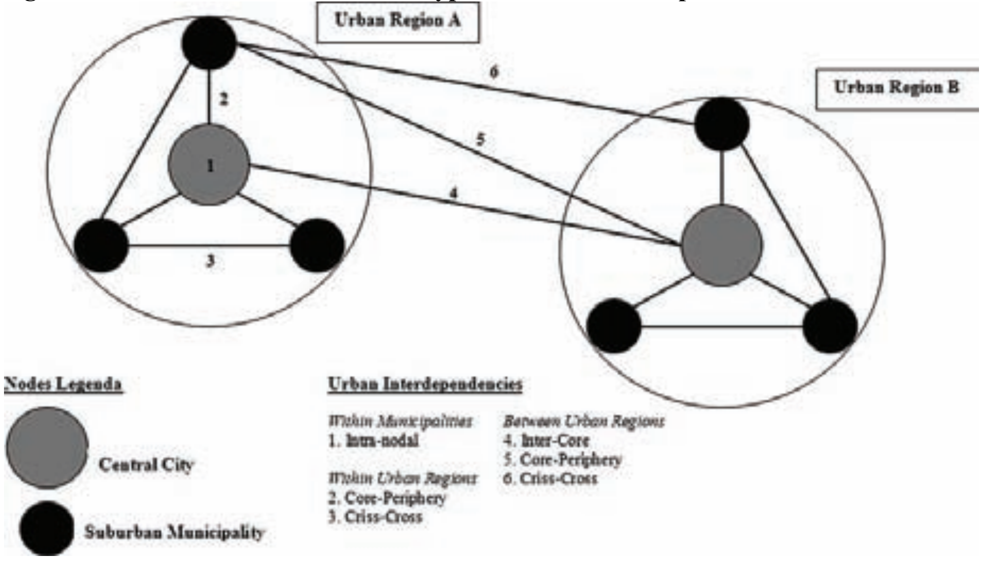
B. Economic relations within urban (sub)regions of the Randstad:

2. Core-periphery interdependencies between the central cities and one of its ‘own’ suburban municipalities.
3. Inter-periphery or criss-cross interdependencies between the suburbs within a given urban (sub)region.

C. Economic relations between urban (sub)regions:

4. Inter-core interdependencies between the central cities of Amsterdam, Rotterdam, The Hague and Utrecht.
5. Core-periphery interdependencies between the central cities and one of the non-‘own’ suburban municipalities.
6. Inter-periphery or criss-cross interdependencies between suburban municipalities that are not situated in the same urban region.

Figure 8.4: Classification of different types of urban interdependencies



The different types of urban interdependencies are displayed in Figure 8.4. Recall that if the Randstad can be characterised as a spatially integrated urban system (from an economic point of view), the regional network structure of inter-firm relations is solely determined by the masses of the municipalities and the physical distances between them; spatial context does not play any role, and there is no difference in the relative strength of the different types of interdependencies. The advantage of this testing system is that it is independent of the scale of regions and cities and can be applied in other settings (for a comparable test on urban network formation in the Greater South East UK, see De Goei *et al.*, 2010).

Empirical Results

Table 8.2 presents the estimates from the zero-inflated negative binomial regression model for the economic interaction intensity between municipalities in the Randstad region. Overall, the significance of the likelihood ratio test of overdispersion (α) and the Vuong-statistic indicate that the zero-inflated negative binomial model fits the data best, which justifies the choice of this model. As indicated above, the zero-inflated negative binomial model consists of two components. The negative binomial component corresponds to the estimates for those pairs of municipalities with non-strictly zero counts. The zero-inflated or binary component relates to the logit regression predicting whether an observation belongs to the 'always zero' or 'not always zero' group. Examining the zero-inflated component of the model, it can be observed that in three of the four models presented, only a low joint mass significantly increases the probability of belonging to the 'always zero' group. On average, an increase of 1% in the joint mass of the two municipalities decreases the likelihood of belonging to the non-strictly zero group by 0.60%, holding all other variables constant. This is in line with the finding that the largest share of non-interaction is between many small localities, where the critical mass to generate flows is lacking. In the remainder of our discussion of the empirical results, we focus on the negative binomial component of the regression model.

Model 1 in Table 8.2 represents the null or baseline model and only includes variables of the joint mass of the originating and destination municipalities and the physical distance between them. Recall that if the Randstad is functioning as one urban network, the joint mass and the physical distance between municipalities should solely determine the interaction intensity between municipalities in the Randstad. The other types of spatial interdependency should not play any role. As expected, economic mass has a marked direct correlation with the flow frequency between the municipalities, while distance has a marked inverse correlation. These values can be interpreted as elasticities: when physical distance increases by 1%, the interaction intensity of firm relations is predicted to decrease by 0.85%. Similarly, an increase in the joint mass of the two municipalities by 1% increases the predicted interaction intensity of firm relations by 0.91%.

Table 8.2: Zero-inflated negative binomial models on inter-firm linkages

	Model 1	Model 2	Model 3
Neg. Binomial Part			
Intercept	-4.86 (22.2)**	-4.66 (21.6)**	-6.18 (23.8)**
Mass (ln)	0.91 (36.0)**	0.88 (37.2)**	1.02 (41.7)**
Distance (ln)	-0.85 (23.5)**	-0.63(9.66)**	-0.58 (9.23)**
Intra-municipal		•	-
Other within Region		-0.58 (4.35)**	•
- Core-Periphery			
- Criss-cross			
Between Regions		-0.75 (3.81)**	-0.28 (2.72)**
- Inter-Core			
- Core-Periphery			
- Criss-cross			
Overdispersion (α)	-7.95**	-8.48**	-6.31**
Zero Inflated Part			
Intercept	-0.54 (0.34)	-11.6 (0.02)	-10.6 (0.03)
Mass (ln)	-0.62 (4.25)**	-0.67 (5.42)**	-0.61 (4.21)**
Distance (ln)	1.03 (2.70)**	0.70 (0.19)	0.16 (0.36)
Intra-Municipal		•	-
Other within Region		11.8 (0.02)	•
- Core-Periphery			
- Criss-cross			
Between Regions		15.6 (0.02)	13.2 (0.04)
- Inter-Core			
- Core-Periphery			
- Criss-cross			
Vuong-statistic	1.45#	2.39**	1.98*
Log Likelihood	-1575	-1556	-1400
McFadden's Adj. R^2	0.360	0.366	0.349
AIC	1.310	1.297	1.201
N	2415	2415	2346

**p<0.01, *p<0.05, #p<0.10, absolute z-values between brackets. • = benchmark
For the Overdispersion and Vuong statistic the values of the z-test are displayed.

Model 2 in Table 8.2 tests the first condition for spatial integration, which states that the intra-nodal interdependency should not be stronger than interdependencies between municipalities within the Randstad region. In other words, the degree of spatial interaction between firms that remains within municipalities should not exceed the degree of interaction between municipalities. Controlling for mass and physical distance between municipalities in our model, it appears, however, that this condition is not met. The intra-urban interdependency is significantly stronger than interdependencies between municipalities situated in the same region as well as interdependencies between other municipalities. More specifically, the predicted interaction intensity within municipalities is about 75% higher than that between municipalities within the same region. Likewise, vis-à-vis interdependencies between municipalities not situated in the same region, this figure is approximately 110% (these marginal elasticities can be obtained by taking the natural exponent of the parameter estimates).

In Model 3 in Table 8.2, the second condition for spatial integration is tested, which states that the interdependencies between cities within one of the urban (sub)regions in the Randstad should not be stronger than the interdependencies between cities across these (sub)regions. Also, this condition is not met. The interaction intensity between municipalities within the same region is predicted to be significantly higher than the interaction intensity between municipalities across urban (sub)regions. Holding mass and physical distance constant, the predicted flow between municipalities within the same urban region is over 30% larger compared to the inter-municipal flows that exceed the level of the urban region.

In Model 4 in Table 8.2, we test the third condition for spatial integration, which states that there should be no observable hierarchy in the different types of inter-municipal interdependencies present. Taking *intra-urban* criss-cross interdependencies as a reference category (as it is conceptually the weakest type of urban interdependency), we are able to compare the relative strength of the different types of the urban interdependencies, controlling for mass and distance. We conclude whether the interaction intensity significantly differed between the different types by using a Wald test to check the equality of coefficients. This way, we are able to compile a ranking list, in which the different types of urban interdependencies were ranked according to relative strength. From this analysis, we conclude that also the third condition for spatial integration is not met. Inter-core interdependencies between the four largest cities (Amsterdam, Rotterdam, The Hague, and Utrecht) and intra-urban core-periphery interdependencies are the strongest types of urban interdependencies. Inter-urban core-periphery interdependencies and inter-urban criss-cross interdependencies are the weakest types of relationships. As none of the three conditions for spatial integration is formally met in our tests, it can be concluded that the

Randstad does not (yet) function as a spatially integrated cluster. Firm-relations appear to be both regionalised within the agglomeration level of the four (sub)regions, and inter-regionalised between the four larger cities.[5]

8.5 The Functional Economic Integration of Randstad Holland

Measuring Functional Economic Integration and Urban Complementarities

Although spatial integration is one prerequisite for urban complementarities, functional integration or the existence of a spatial division of labour is the other one. Functional economic integration presupposes a differentiation between cities within the Randstad in terms of economic specialisations and functions, while at the same time a large degree of integration (the use of each other's specialisations) reflects the existence and use of an aggregated regional production system. In this section, we test whether functional integration is present in the Dutch Randstad region.

Since we simultaneously want to test for spatial integration (as defined in the previous section) and functional integration, we extend our gravity models on spatial interaction between firms with an indicator for functional integration. When firms in municipalities i and j have many mutual relations, this can be rooted in the fact that the local production structure in i is characterised by other – complementary – specialisations than that in j. For example, a city specialising in financial services provides these services to (firms in) a city specialising in labour-intensive industry, and vice versa (Lambregts *et al.* 2006). In theory, the business services specialisation in Amsterdam should lead to a large number of companies in other regions making use of these services, not least because the services are under-represented in their own immediate region. Companies outside Amsterdam are then able to specialise in another type of activity, which will then attract trading relationships from yet other regions. In this scenario, each region benefits from each other's specialisation and will still have marked interactions with each other. Hence, cities do not have to be specialised in all possible sectors but can benefit from specialisations elsewhere in the urban network (Meijers, 2005).

[5] Because agglomeration economies differ across industries (Rosenthal and Strange, 2004), we tested for the robustness of the degree of spatial integration in interaction models for manufacturing, distribution and business service activities separately. Since industrial activities are to a considerable extent also located outside the Randstad (Van Oort, 2004), the model of business services resembles the (total) model presented to a large degree. Because we are interested in functional integration by means of detailed *cross-sectoral* interdependencies (see section 5), we did not explore the three sector-specific interaction models any further.

We speak of the presence of urban complementarities if functional integration coincides with or complements spatial integration. We measure the relative specialisation of municipalities by means of location quotients in 27 different basic sectors.[6] Basic sectors are not dependent on the direct location of consumers for their location-choice[7], and hence firms in these sectors may profit from complementary specialisations in (nearby) cities. The location quotients are defined as:

$$LQ_{i,j} = \frac{E_{i,j} / \sum_{j} E_{i,j}}{\sum_{i} E_{i,j} / \sum_{i,j} E_{i,j}} \tag{5}$$

in which *E* represents the number of firms or employment in region *i* and sector *j*. A score larger than one indicates that the sector is relatively over-represented in the region when compared to the Randstad on average. A score lower than 1 indicates the relative under-representation of a sector in a municipality. The location quotient is expressed in terms of employment and in terms of number of firms. The difference between the two reflects the average firm size in sectors in locations. It is a priori not clear whether specialisations of the number of firms or specialisations in employment are related to functional urban complementarities. We therefore weigh both equally in our indicator for functional integration (FI), which for each economic interaction between origin and destination municipalities (n=2346) is defined as:[8]

$$FI_{OD} = \sum_{j} \left| LQo_j^E - LQd_j^E \right| + \sum_{j} \left| LQo_j^F - LQd_j^F \right| \quad , \tag{8.6}$$

[6] These 27 sectors are (in brackets sectoral Dutch sectoral SBI-codes): the food and beverage industry (15), the tobacco industry (16), the textile industry (17), the clothing industry (18), the leather and leather goods industry (19), the timber industry (20), the paper industry (21), the oil and coal industry (23), the chemical products industry (24), the rubber industry (25), the glass and ceramics industry (26), the primary metal industry (27), the metal products industry (28), the machine industry (29), the computer industry (30), the electronics industry (31), the audio and telecom industry (32), the medical equipment and instruments industry (33), the car industry (34), the transportation equipment industry (35), the furniture industry (36), wholesale (51), the publishing industry (22), telecommunication services (64), computer services and consultancies (72), the research & development and knowledge institutions (73), the remaining business services (74).

[7] Non-basic sectors are retail, primary education and schools, local public services like police, fire departments and healthcare, and local and regional governments.

[8] Analyses with location quotients for employment and the number of firms present in municipalities separately give similar results to those presented. Also, other (aggregated) definitions of sectors do not change the outcomes.

in which *LQo* represents location quotients of origin municipalities, *LQd* represents location quotients of destination municipalities, *E* stands for employment, *F* for the number of firms and *j* for the 27 sectors distinguished. This indicator measures and aggregates all possible functional complementarities between the 27 sectors and between the 69 municipalities in the Randstad region. Functional complementarities at first are per municipality, expressed as a weighted average of the difference in specialisations between all potential origin and destination combinations. These differences are then matched with the actual origin and destination municipalities in the measured economic interactions between municipalities.

Empirical Results

Table 8.3 presents – similar to Table 8.2 - the estimates from the zero-inflated negative binomial regression model for the economic interaction intensity between municipalities in the Randstad region, complemented with the indicator for functional integration.[9] Overall, the likelihood ratio test of overdispersion (α) and the Vuong-statistic again indicate that the zero-inflated negative binomial model fits the data best. The zero-inflated component of the model reveals similar results as those presented in Table 8.2. Model 5 in Table 8.3 represents the null or baseline model when functional integration is included along with the variables of the joint mass of the originating and destination municipalities and the physical distance between them. The results indicate that there is no significant effect of functional integration on flow frequency between cities.

Model 6 in Table 8.3 shows a negative significant interaction effect of the functional integration indicator with the mass indicator of municipalities in origin and destination municipalities. This can be interpreted as weak evidence of functional integration within a group of relative small cities and municipalities in the Randstad. As these cities are too small to inhabit all economic functions individually, functional complementarities with nearby municipalities containing other specialisations occur. Larger cities have all the specialised resources needed for firm networks available within their boundaries. Models 7 and 8 introduce spatial and functional integration variables simultaneously in the model. While all spatial interaction variables show similar relations with firm interactions as presented earlier in Models 2-4 in Table 8.2, the introduction of the indicator for functional integration is only slightly significant, again only for smaller municipalities.[10]

[9] Correlations between explanatory variables in the models are not higher than 0.4, meaning there is little risk of multicollinearity problems.

[10] For both model 6 and 8, we find no significant interaction effect of functional integration and distance. For this reason, this interaction term is omitted from our final models.

Table 8.3: Zero-inflated negative binomial models on inter-firm linkages - functional integration and urban complementarities

	Model 5	Model 6	Model 7	Model 8
Neg. Binomial Part				
Intercept	-5.47 (11.1)**	-10.8 (5.65)**	-5.17 (8.84)**	-9.68 (3.98)**
Mass (ln)	1.01 (32.8)**	1.62 (7.64)**	0.92 (21.4)**	1.42 (5.43)**
Distance (ln)	-0.72 (15.6)**	0.71 (16.1)**	0.57 (8.37)**	-0.54 (7.97)**
Intra-municipal	-	-	-	-
Other within Region				
- Core-Periphery	-	-	0.47 (3.00)**	0.48 (2.96)**
- Criss-cross	-	-	0.24 (1.53)	0.30 (1.76)#
Between Regions				
- Inter-Core	-	-	0.53 (2.52)*	0.36 (1.64)#
- Core-Periphery	-	-	0.14 (0.94)	0.14 (0.94)
- Criss-cross	-	-	•	•
Functional Integration				
- Δ Relative Specialisation	-0.10 (1.06)	1.50 (2.64)**	-0.14 (1.53)	1.15 (1.70)#
- Δ Relative Specialisation* Mass	-	-0.18 (2.89)**	-	-0.15 (1.95)#
Overdispersion (α)	-6.60**	-6.58**	-6.15**	-5.38**
Zero Inflated Part				
Intercept	0.51 (0.13)	3.00 (0.38)	4.77 (3.12)**	7.61 (0.84)
Mass (ln)	-0.68 (3.02)**	-1.34 (1.36)	-0.63 (3.00)**	-1.46 (1.33)
Distance (ln)	1.37 (2.27)*	1.01 (2.52)	-0.19 (0.46)	-13.5 (0.04)
Intra-municipal	-	-	-	-
Other within Region				
- Core-Periphery	-	-	-15.3 (0.02)	1.22 (1.24)
- Criss-cross	-	-	-2.21 (1.41)	-26.5 (0.00)
Between Regions				
- Inter-Core	-	-	-29.7 (0.00)	-0.53 (0.74)
- Core-Periphery	-	-	-0.76 (0.88)	0.30 (0.79)
- Criss-cross	-	-	•	•
Functional Integration				
- Δ Relative Specialisation	-0.61 (0.72)	-0.87 (0.41)	-0.47 (0.91)	-1.38 (0.58)
- Δ Relative Specialisation* Mass	-	0.19 (0.47)	-	0.24 (0.80)
Vuong-statistic	1.67*	1.93*	1.90*	2.13*
Log Likelihood	-1409	-1405	-1393	-1388
McFadden's Adj. R^2	0.343	0.345	0.348	0.349
AIC	1.211	1.207	1.202	1.200
N	2346	2346	2346	2346

**p<0.01, *p<0.05, #p<0.10, absolute z-values between brackets. • = benchmark
For the Overdispersion and Vuong statistic the values of the z-test are displayed.

8.6 Conclusions

In this chapter, we examined whether the Randstad can be regarded as an urban network and an integrated economic entity. There is a need for this, since a burgeoning literature suggests that the polycentric region as a spatial economic concept replaces the hierarchical, central node concept. Camagni and Capello (2004) argue that PURs only comprise a new paradigm in spatial sciences when (a) the exact meaning is defined, (b) the theoretical economic rationale is justified, and (c) the novel features of its empirical content are clearly identified and distinguished from more traditional spatial facts and processes that can be interpreted through existing spatial paradigms. The concept of spatial networks in the empirical literature is merely used as a substitute for 'interaction' (exchange of goods, services, information and contacts among places and nodes), for which traditional paradigms of spatial interaction can be utilised. For the concept of urban networks to be considered different than that of cities or urban agglomerations, the probability of inter-firm interaction should be independent of distance, the size of nodes and hierarchical relations between nodes. Functionally, the contention for different cities within an urban network to be complementary to each other requires that cities not only be specialised in different industries but at the same time also be showing a marked degree of spatial interaction and hence integration. To date, there has been little empirical research into the spatial and functional economic cohesion of urban networks, mainly because of the lack of data on inter-firm relations.

As the Randstad combines Amsterdam (cultural capital), The Hague (political capital), Rotterdam (gateway) and Utrecht (central national position), together with numerous smaller cities and a highly skilled labour force, the region is traditionally regarded as the European showcase of regional polycentricity (Lambregts *et al.*, 2006). Relationships between the cities date back centuries. No earlier empirical research tests whether this image is justified for present-day economic (inter-firm) relations. We tested for the spatial and functional integration of the Randstad and the presence of urban complementarities, relying on recently gathered data that derive from a large-scale survey of 1676 firm establishments in the region. We formulated a set of three conditions for *spatial* integration within the Randstad region. None of these three conditions for spatial integration was met. First, we found that intra-urban economic interdependencies are stronger than interdependencies between cities within the Randstad. Second, interdependencies between cities within one of the urban (sub)regions in the Randstad defined by the largest cities were stronger than interdependencies between cities across these (sub)regions. And third, an observable hierarchy in the different types of inter-municipal interdependencies in the Randstad is present in which central place relations prevail. Therefore, it can be concluded that the Randstad does not (yet) function as a fully spatially integrated network of cities. We then introduced an indicator for *functional* integration based on the differences in economic specialisations of origin and destination municipalities that are included in the firm relational network data. We found no clear evidence for functional integration over municipalities in the Randstad. Urban complementarities in the Randstad defined by spatial and functional integration between municipalities are thus currently not present. The largest cities – Amsterdam, Rotterdam, The Hague and Utrecht – are all mature nodes within their own functional economic region. Weak evidence for urban complementarities is only found for the smallest municipalities that cannot accommodate all economic functions within their boundaries.

The economic (inter-firm) dimension of urban networks has not been put to an empirical test systematically. Our research results question the many policy attempts to create and sustain polycentric economic development trajectories in Europe. When economic complementarities based on inter-firm linkages do not exceed the (monocentric) city-region in the 'archetypical polycentric' Randstad, it is doubtful that policy aiming at higher-level interaction can be justified outside of wishful thinking. Our results suggest that a focus on the daily urban systems (DUS) of the four largest cities fits the spatial-economic reality better. Recall that 50 percent of the inter-firm relations are with (inter)national regions outside the Randstad, which causes spatial and functional dependencies to transcend the DUS. However, the scale of the PUR appears to be skipped in the so-called 'local-global economic development trajectories' (Bathelt *et al.*, 2004). More comparable research in other regions should be carried out in order to confirm or confront this outcome. The testing system introduced is independent of the scale of regions and cities and can therefore be applied to this end. We think that this testing system, although strictly formulated, is advantageous for the testing of hypotheses. Less strict testing will to our opinion leave much room for speculation on the potential (policy) usage of the urban network paradigm. It is also important to repeatedly measure inter-firm relationships. Although commuting and shopping relations do not suggest a profound development towards more *intra-urban* network formation in the Randstad for the last 20 years (Ritsema van Eck *et al.*, 2006), inter-firm relations may develop in that direction over time.

Chapter 9:

Spatial Structure and Productivity in US Metropolitan Areas

Abstract[1]

Recent concepts as megaregions and polycentric urban regions emphasise that external economies are not confined to a single urban core, but shared among a collection of close-by and linked cities. However, empirical analyses of agglomeration and agglomeration externalities so-far neglects the multicentric spatial organisation of agglomeration and the possibility of 'sharing' or 'borrowing' of size between cities. This chapter takes up this empirical challenge by analyzing how different spatial structures, in particular the monocentricity-polycentricity dimension, affect the economic performance of U.S. metropolitan areas. OLS and 2SLS models explaining labour productivity show that spatial structure matters. Polycentricity is associated with higher labour productivity. This appears to justify suggestions that, compared to relatively monocentric metropolitan areas, agglomeration diseconomies remain relatively limited in the more polycentric metropolitan areas, while agglomeration externalities are indeed to some extent shared among the cities in such an area. However, it was also found that a network of geographically proximate smaller cities cannot provide a substitute for the urbanisation externalities of a single large city.

---

[1] This chapter has been published in *Environment and Planning A*, 42(6), pp. 1383-1402 as "Spatial structure and productivity in US metropolitan areas" (with Evert Meijers). It has been slightly edited to fit the format of this book.

9.1 Introduction

Slowly but steadily, the image of the city has changed dramatically over the last one and a half century. The industrial image of a city – as being composed of an urban core and a rural hinterland – has become increasingly obsolete. Advances in transport infrastructure and rising levels of car ownership have fuelled a process of decentralisation and suburbanisation, initially of people, but later followed by jobs (Boarnet, 1994). However, this trend does not stop with the establishment of new centres in the city or at its edges. We are also witnessing the 'fusion' of formerly relatively independent and distinct cities into wider metropolitan areas. Nowadays, what is 'urban' increasingly spreads out over a wider region, requiring us to think of the city as a regional phenomenon (Scott, 1988; Storper, 1997). This is reflected in the revival of the debate on city-regions (Parr, 2005) and in the conceptualisation of regionalised urban entities (Kloosterman and Musterd, 2001; Hall and Pain, 2006; Florida *et al.*, 2008). In spatial terms, the spatial structure of such regions can be characterised as a series of towns 'physically separate but functionally networked, clustered around one or more larger cities' (Hall and Pain, 2006, 3), or 'integrated sets of cities and their surrounding suburban hinterlands' (Florida *et al.*, 2008, 459). Therefore, the emerging spatial form of post-industrial urban regions is quintessentially polycentric (Hall, 2001; Kloosterman and Musterd, 2001; Phelps and Ozawa, 2003).

Essential to this debate on such regionalised urban entities is the underlying idea that external economies are not confined to a well-defined single urban core, but, instead, are shared among a group of functionally linked settlements (Phelps and Ozawa, 2003; Sassen, 2007). The basic idea of polycentricity is that multiple centres or cities, and hence multiple sources of agglomeration economies, are co-located and also interact, given the widening geographical scale of economic and social processes (Van Oort *et al.*, 2010). Such 'regionalisation' of urbanisation externalities has been conceptualised and described by several scholars (Richardson, 1995; Coe and Townsend, 1998), thereby deploying terms such as 'urban network externalities' (Capello, 2000), 'spatial externality fields' (Phelps *et al.*, 2001) or 'regional externalities' (Parr, 2002). Such concepts build on the concept of 'borrowed size', coined by Alonso (1973), who used it to explain why smaller cities that are part of a megalopolitan urban complex had much higher incomes than self-standing cities of similar size. According to Phelps and Ozawa (2003, p. 594), "*the idea of borrowed size suggests that today's examples of megalopolitan agglomeration are based predominantly on some combination of pecuniary and technological externalities open to* *service industries across a group of settlements, rather than the technological externalities available at the localised scale of discrete towns or cities*."

When external economies are increasingly conceptualised in relational terms (Gordon and McCann, 2000; Phelps and Ozawa, 2003; Johansson and Quigley, 2004; Burger *et al.*, 2009b), it would make sense to study agglomeration externalities at the scale of the regional urban system rather than the single city, as the interactions with nearby cities may also influence the presence of agglomeration externalities. However, such research is rather non-existent. It seems that empirical analysis of economic agglomeration does not correspond to the changes in the geographical scale at which agglomeration manifests itself (Phelps and Ozawa, 2003; Burger *et al.*, 2010). In analysis, the shape of the urban system is most often simply taken for granted (Scott, 2000; Kloosterman and Musterd, 2001). In equilibrium approaches, the economic organisation of space is not a concern (see Corpataux and Crevoisier, 2007).

The principal objective of this chapter is to provide some first steps to overcome the empirical deficit that characterises the current debate about the sharing of agglomeration externalities between a collection of more or less proximally located cities. Do cities actually borrow size from each other? Can a collection of close-by cities provide a substitute for the urbanisation externalities of a single larger city? These key questions are at the heart of the worldwide policy debates on the geographical scale of agglomeration, be it the megaregions in the U.S. or Asia or the somewhat smaller – in spatial terms- polycentric urban regions that have become such a popular planning concept in Europe (see Meijers, 2005).

The approach developed in this chapter to answer the question of whether cities borrow, or share, size, is to include the spatial structure of metropolitan areas into empirical analysis of agglomeration externalities. Building on previous work by Gordon and Richardson (1996), Anas *et al.* (1998) and Lee and Gordon (2007), we will not limit ourselves to the monocentricity-polycentricity dimension, but also include a centralisation-dispersion dimension. Labour productivity is used as a proxy for metropolitan performance. We extend existing production functions (notably Ciccone and Hall, 1996) with spatial variables other than the commonly used indicators as size or average density.

The remainder of this chapter is organised as follows. We synthesise the literature discussing the spatial structure of metropolitan areas in relation to their performance in Section 9.2, which results in three testable assumptions. Section 9.3 presents our measurements of the spatial structure of metropolitan areas. Section 9.4 continues with the model specification and other data used. Section 9.5 presents the estimation results. Section 9.6 concludes and discusses the implications of our findings.

9.2 Urbanisation, Spatial Structure and Metropolitan Performance

Spatial structure tends to attract increasing interest from urban geographers and planners as it is believed to affect the economic performance, environmental sustainability and social well-being of places and their inhabitants. Clear examples are the 'new urbanism' and 'smart growth' movements in urban planning circles in the U.S. Although in regional science and urban economics there is a large empirical literature which links city characteristics to urban performance, often empirical work on agglomeration does not go beyond including average density or city size ('urbanisation externalities') as a spatially relevant factor. However, neither density nor size reveals much about a region's spatial organisation.

Indicators of the spatial organisation of metropolitan areas need to address two questions (Anas *et al.*, 1998). First, how is the urban population spread over urban centres? Second, to what extent is the metropolitan population located in urban centres or dispersed? The first question refers to a monocentric-polycentric dimension, while the second question refers to a centralisation-dispersion dimension. Below, we address the relationship of size, monocentricity-polycentricity and centralisation-dispersion respectively with metropolitan performance, which results in three testable hypotheses.

Size and Urbanisation Externalities

A large strand of empirical research in regional science and urban economics focuses on the benefits stemming from the size or density of the urban economy. As a general rule, these urbanisation externalities can be regarded as external economies passed to firms as a result of savings from large-scale operation of the city as a whole. These benefits are uncontrollable and unregulable for a single firm and, above all, immobile or spatially constrained (Van Oort, 2004). Following Isard (1956), it is the availability of a large and multi-functional labour pool and the presence of a good infrastructure and public facilities in dense economic areas that are the sources of urbanisation externalities. Relatively more urbanised areas are also more likely to accommodate universities, R&D laboratories, trade associations, and other knowledge-generating institutions. Moreover, the often diverse industry mix in an economically dense area increases the odds of interaction, generation, replication, modification and recombination of ideas and applications across different sectors (Van Oort, 2004) and protects a region from volatile demand (Frenken *et al.*, 2007). Finally, the presence of a large internal market offers a larger degree of stability and lower transport costs (Siegel *et al.*, 1995). However, a high degree of urbanisation may also result in a dispersion of economic activities due to pollution, crime or high land and housing prices. In this respect, one can speak of urbanisation diseconomies, which are assumed to be negatively related to metropolitan performance. We expect to confirm the strong positive relation between size and metropolitan performance, but our main interest lies with the monocentricity-polycentricity and centralisation-dispersion dimensions of urban spatial structure.

Monocentricity and Polycentricity

Whereas metropolitan size is linked to external economies to scale, monocentricity or polycentricity, and centralisation or dispersion can be linked to some sort of external economies to structure. In the current debate on metropolitan spatial structure, the influence of monocentricity or its opposite, polycentricity, on the performance of metropolitan areas remains unclear due to a lack of empirical research, while this evidence is urgently needed (Lambooy, 1998; Kloosterman and Musterd, 2001; Parr, 2004; Turok and Bailey, 2004; Cheshire, 2006; Parr, 2008; Meijers, 2008a).

At the spatial scale of the metropolitan area, Lee and Gordon (2007) did not find that a polycentric or monocentric structure, measured by the subcentres' share of all centre employment, does affect metropolitan population and employment growth. Still, it is generally brought forward that the advantage of polycentricity at the local level is that it comes with a lack of agglomeration disadvantages (see Fujita *et al.*, 1997, Goffette-Nagot and Schmitt, 1999; Bertaud, 2004) such as fierce competition for land and workers, congestion, and pollution exposure.

Extent of Regionalisation of Urbanisation Externalities

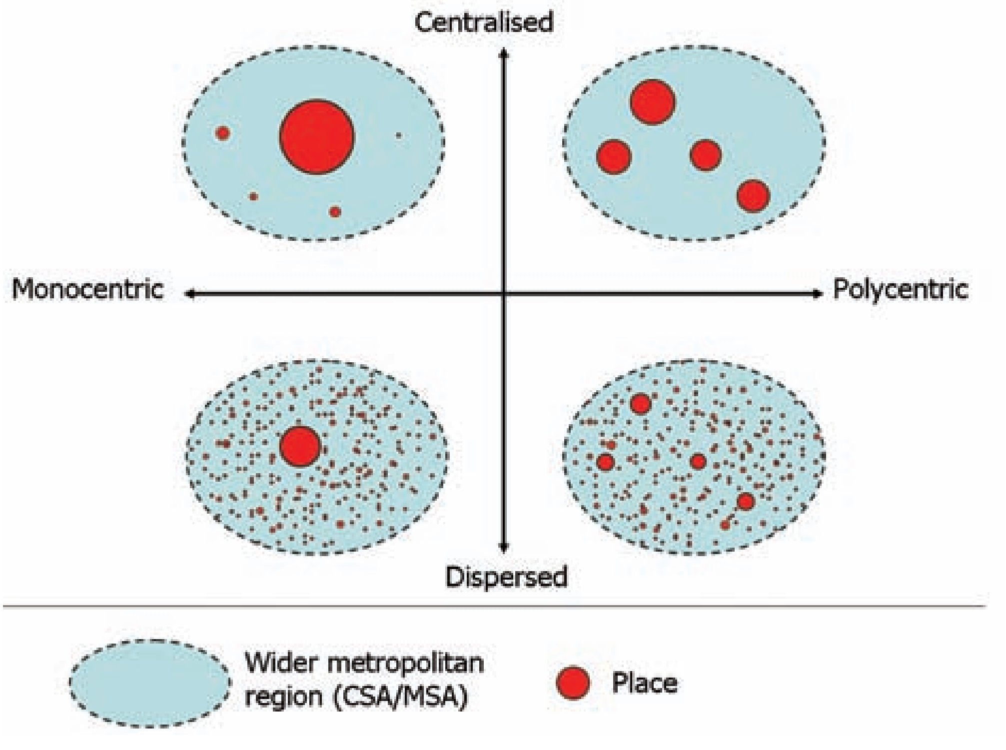
Agglomeration disadvantages appear to be largely confined to the scale of individual cities within the metropolitan area (Parr, 2002) and evidence suggests that smaller cities have a greater endogenous capacity to keep these social, economic and environmental costs under control (Capello and Camagni, 2000). When, at the same time, the idea holds that agglomeration advantages are increasingly associated with a more regionalised spatial structure (Parr, 2002; Capello and Camagni, 2000; Sassen, 2007) as networks may substitute for agglomeration (Johansson and Quigley, 2004), then polycentricity will become an increasingly strong asset of metropolitan areas. So far, however, it remains untested that a polycentric spatial structure in metropolitan areas leads to successful economic development (Parr, 2008; Parr, 2004; Lambooy, 1998). Building on the idea that agglomeration advantages have 'regionalised' to a considerable extent, while disadvantages remain local issues, we hypothesise in this chapter that a more polycentric urban structure has a direct and positive effect on metropolitan performance, as they may provide a better balance between agglomeration advantages and agglomeration disadvantages.

Despite the theoretical consensus regarding the 'regionalisation' of urban externalities, the extent to which such a 'regionalisation' may take place in a polycentric spatial structure is highly questioned. According to Bailey and Turok (2001) the idea that the integration of separate cities results in agglomeration advantages comparable to similar-sized monocentric cities is 'rather simplistic'. Parr (2004; 2008) points in this respect to the need for longer travel flows, longer commodity flows and less convenient flows of information in polycentric urban regions. Moreover, it should be noted that 'some of the advantages of urban size stem from the nature of the metropolitan environment, and are related to such factors as density, proximity, face-to-face contact, informal structures, unplanned interaction, etc.' (Parr, 2004, 236), and consequently hold less for polycentric urban regions. This is confirmed by a recent study (Meijers, 2008a) that showed that polycentric regions in the Netherlands had significantly less cultural, leisure and sports amenities than monocentric regions in which the urban population is concentrated in a single city. In this chapter we test the hypothesis that polycentricity diminishes the effect of urbanisation economies on labour productivity at the regional metropolitan scale.

Centralisation and Dispersion

A dispersed spatial structure refers to the situation in which a large part of the population is not living in centres but spread out across the territory in a non-concentrated pattern. It is not necessarily similar to urban sprawl, as this is often equated with low-density residential development, whereas dispersion concerns the issue of whether this development is taking place in centres or not, leaving aside the question of density. Whether or not dispersion negatively influences urban performance is an unsolved issue and as far as it corresponds to urban sprawl even controversial. According to a 2000 Costs of Sprawl report (Transportation Research Board, 2002), dispersed low-density development consumes more land and infrastructure, provides fewer fiscal impacts, whilst increasing housing costs, personal travel costs and automobile dependence. Critics claim that spread out, dispersed development fulfills a widespread need for safe neighbourhoods, appreciating housing values, and unrestricted use of automobiles. Glaeser and Kahn (2004) stress the association of sprawl with significant improvements in quality of life. According to the 2000 Costs of Sprawl study, the alternative is a form of centralisation that directs development to locations where it is more efficient to provide public services. This is referred to as 'smart growth'. In this study we will test the hypothesis that metropolitan areas that have a higher proportion of the population living in urban places, and hence, less dispersion, perform better in terms of labour productivity.

Figure 9.1: Dimensions of Regional Urban Form



9.3 Quantifying Metropolitan Spatial Structure

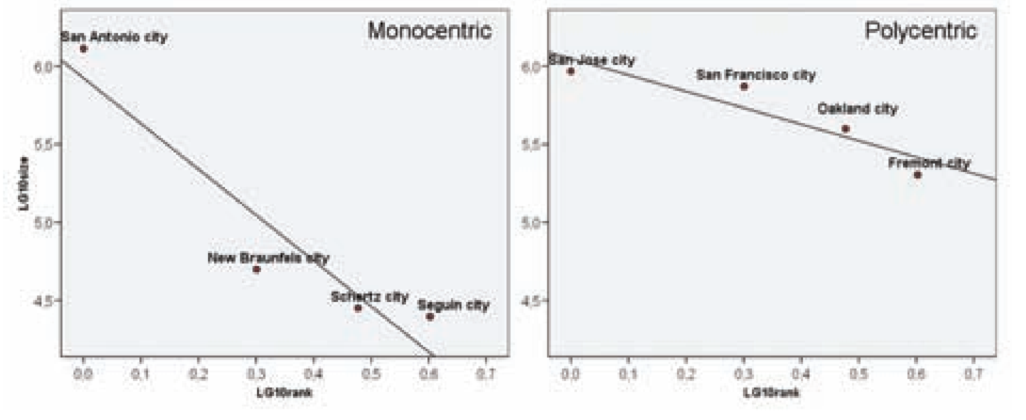
A prerequisite for testing the idea of whether urbanisation economies are dependent on spatial structure is to quantify this regional spatial structure. Next to size, we distinguished two dimensions that effect spatial concentration. Here we discuss their exact measurement. The centralisation-dispersion dimension refers to the extent to which population and employment is centralised in cities or dispersed over smaller non-urban places in the area in a non-centralised pattern. The monocentricity-polycentricity dimension reflects the extent to which urban population and employment is concentrated in one city or spread over multiple cities in the wider metropolitan area (see Figure 9.1). These two dimensions are quite similar to the two types of spatial concentration at the city-level discerned by Anas *et al.* (1998) in their classic essay on the urban spatial structure of cities (see also Lee and Gordon, 2007), although in terms of measurement we adopt them to the larger metropolitan area scale.

Monocentricity versus Polycentricity

In the literature, one finds different interpretations of what makes a metropolitan area polycentric (Meijers, 2008b). Grossly speaking, there is an approach that defines polycentricity on the basis of urban morphology (see Kloosterman and Musterd, 2001; Parr, 2004), while another approach adds relational aspects to it in the sense that a metropolitan area can only be considered polycentric when the cities are strongly functionally linked, which is sometimes referred to as 'relational polycentricity' or 'functional polycentricity' (see for instance Hall and Pain, 2006; Green, 2007; De Goei *et al.*, 2009). Here, we adhere to the first and least restrictive vision, thus studying the monocentricity-polycentricity dimension from a morphological perspective. It is important to note that polycentricity is not so much about the presence of multiple cities in a metropolitan area, but about the balance in the size distribution of these cities. The more equally sized cities in a metropolitan area (indicating the lack of a strong hierarchy) area, the more polycentric a metropolitan region is (Kloosterman and Lambregts, 2001; Parr, 2004; Meijers, 2005).

The rank-size distribution of the regional urban system provides information on this hierarchy and is therefore a useful indication of the extent of mono- or polycentricity (Spiekermann and Wegener in Nordregio *et al.*, 2004; Parr, 2004). Figure 9.2 presents the four largest incorporated places in two U.S. metropolitan areas and also the regression slope that best fits the distribution of their sizes. The flatter this slope is, the more polycentric the metropolitan area. Conversely, the steeper this slope is, the more monocentric the metropolitan area. In this example, San Antonio, TX, is obviously monocentric, while San Jose-San Francisco-Oakland, CA, is a clear example of a polycentric metropolitan area.

Figure 9.2: Rank-Size Distributions to Measure Mono/Polycentricity.



In this study we calculated the slope of the regression line of the rank-size distribution of incorporated places (cities)[2] in each U.S. metropolitan area. Following Meijers (2008b) we did so for different numbers of incorporated places per metropolitan area (2, 3 and 4) and then calculated the average of these three scores. The slopes found were normally distributed, meaning that the majority of metropolitan areas in the US cannot be considered (very) monocentric nor (very) polycentric, but are somewhere in between those extremes on the same scale. It appears that only the most polycentric metropolitan areas can be considered polycentric urban regions in the way they are usually defined.[3] Below we will refer to the position of a metropolitan area on this scale ranging from monocentric to polycentric as its ‘degree of polycentricity’; simply because higher values mean that it is

[2] Only considering incorporated places of at least 5,000 inhabitants in 2006. In cases where the second largest incorporated place in the metropolitan region did not meet this threshold, we used its actual size in order to be able to calculate a slope.
[3] Following common definitions of such regions (see Kloosterman and Musterd, 2001; Parr, 2004; Meijers, 2005), although for a definite categorization we require more knowledge on the level of specialisation and the level of interaction.

more polycentric. Otherwise, we could have equally chosen to term it the 'degree of monocentricity'.

The rank-size distribution does not provide information on the spread of cities over the metropolitan territory, but polycentricity is also about spatially distinct cities (Parr, 2004; Kloosterman and Lambregts, 2001). Therefore, we need to filter out regions that score polycentric in terms of the rank-size distribution, but in which the cities are part of the same contiguous built-up area. In the latter case, the term polycentric conurbation is more appropriate. If the two largest cities of a metropolitan area that scored polycentric belong to the same 'urban area', which is delineated by the US Census Bureau to encompass densely settled territory, we labelled these 'polycentric conurbations'. We did not include these polycentric conurbations in the analysis as it could be argued that these metropolitan areas, while scoring polycentrically, in fact resemble monocentric metropolitan areas more, the main difference being the presence of administrative boundaries dividing the built-up area (see Appendix 9A).

Table 9.1: Most Monocentric, Polycentric, Centralised and Dispersed CSA/MSA

Rank	Most monocentric	Most polycentric	Most centralised	Most dispersed
1	Lincoln, NE	Midland-Odessa, TX	El Paso, TX	Greenville-Spartanburg-Anderson, SC
2	Tallahassee, FL	Santa Barbara-Santa Maria, CA	Lincoln, NE	Portland-Lewiston-South Portland, ME
3	Jacksonville, FL	Johnson City - Kingsport - Bristol (Tri-cities), TN-VA	Phoenix-Mesa-Scottsdale, AZ	Columbia – Newberry, SC
4	El Paso, TX	Salt Lake City-Ogden-Clearfield, UT	San Diego-Carlsbad-San Marcos, CA	Pittsburgh-New Castle, PA
5	San Antonio, TX	Greenville-Spartanburg-Anderson, SC	Midland-Odessa, TX	Youngstown-Warren-East Liverpool, OH-PA

Centralisation versus Dispersion

The share of the central city in total metropolitan area population in the U.S. fell rapidly from almost 64% in 1930 to 38% in 2000 (Kim, 2007). The question then is where the majority of the metropolitan population is located; are they clustered in other urban centres or are they dispersed over the metropolitan territory in an uncentred way? In order to test the hypothesis that less centralisation and thus more dispersion limits labour productivity, we scored each case study area on a centralisation–dispersion axis, their position being dependent on the share of the metropolitan population that was not located in urban centres of at least 25,000 inhabitants in 2006.

Association of Dimensions

Both dimensions are associated in the sense that more polycentric metropolitan areas in the United States tend to be characterised slightly more often by dispersion. But, as Table 9.1 displays, there are several exceptions to this 'rule'. For instance Midland-Odessa, TX, is the most polycentric metropolitan area, while it is also among the top 5 most centralised areas.

9.4 Model, Data and Estimation Strategy

Model

In regional science and urban economics, many studies have investigated the effect of urbanisation externalities using aggregate production functions at the city level. Although different functional forms of the urban production exist, our point of departure is the models developed in Ciccone and Hall (1996) and Ciccone (2002), who use a Cobb-Douglas production function to assess the effect of agglomeration economies on localised labour productivity.

Consider the following production function of a metropolitan economy with production factors capital (K), labour (L), human capital (H), materials or intermediate inputs (M) and land (N) in which a single good is produced that is a composite of all the outputs of all producers in that metropolitan area (9.1),

$$Q = AK^{\kappa}L^{\lambda}H^{\varepsilon}M^{\mu}N^{\nu}, \qquad (9.1)$$

in which Q is the nominal output. In equation (9.1), A represents an efficiency parameter or vector of exogenous influences on the nominal output measuring Total Factor Productivity. Amongst others, the efficiency parameter A here reflects the urbanisation externalities and metropolitan spatial structure (the degree of polycentricity and of dispersion). Given constant returns to scale ($\kappa+\lambda+\varepsilon+\mu+\nu=1$), equation (9.1) can be rewritten as (9.2)

$$\left(\frac{Q}{L}\right) = A\left(\frac{K}{L}\right)^{\kappa}\left(\frac{H}{L}\right)^{\xi}\left(\frac{M}{L}\right)^{\mu}\left(\frac{N}{L}\right)^{\nu}, \tag{9.2}$$

in which the output per worker (labour productivity) is a function of the capital-labour ratio, human capital-labour ratio (or alternatively, education per worker), intermediate inputs-labour ratio, land-labour ratio, and the efficiency parameter A. By taking logarithms on both sides of equation (9.2), the multiplicative form can be converted into a linear stochastic form, to give the following testable equation (9.3):

$$\ln\left(\frac{Q}{L}\right) = \theta_0 + \kappa \ln\left(\frac{K}{L}\right) + \xi \ln\left(\frac{H}{L}\right) + \mu \ln\left(\frac{M}{L}\right) + \sigma \ln\left(\frac{N}{L}\right) + \sum_j \theta_{j+1}(\ln X_j) + r_j + \varepsilon \tag{9.3}$$

, where equation (9.3) is augmented with a set of variables X with parameters θ, which are related to metropolitan size and spatial structure and enter the production function through a higher value of A (Fogarty and Garofolo, 1988; Broersma and Oosterhaven, 2009). Here, this set includes the size of the metropolitan population, the degree of polycentricity, and the degree of dispersion. Following Ciccone (2002) census region dummy variables r_j are included to account for remaining differences in exogenous Total Factor Productivity which may moderate the relationship between agglomeration, spatial structure and labour productivity, such as relative differences in climate, price levels, and levels of technology across metropolitan areas.

Data and Variables

To estimate our production function, data was gathered for metropolitan statistical areas (MSAs), but in the many cases in which these were part of a wider combined statistical area (CSA) we used this widest possible definition of U.S. metropolitan areas, which is largely based on commuting behaviour (see Appendix 9A). The reason to principally focus on CSAs comes forward from the necessity to analyse the performance of cities in their wider spatial context and we wanted to avoid the monocentric perspective that underlies the MSA definition. For example, it was deemed necessary for this analysis to take the San Jose- San Francisco – Oakland CSA as a unit of analysis rather than the MSAs that make up this CSA separately. Data concerns those metropolitan areas located in continental U.S with a total population over 250,000 inhabitants in 2006.

Our dependent variable *Labour Productivity* is measured as the 2006 GDP in real dollars of a metropolitan area divided by the total number of jobs in the included sectors in that area in 2006. As our research underlies a market-based model and spatial externalities are most profound in sectors that lack exogenous endowments, agriculture, fishing, hunting, mining and public administration were excluded (see also Brülhart and Mathys, 2008). In addition, no figures on self-employment were available. Data on GDP by metropolitan area and sector were obtained from the U.S. Department of Commerce's Bureau of Economic Analysis (BEA). Data on the number of jobs were provided by the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor, and for individual sectors taken from the 2006 American Community Survey. The new BEA estimates enable a more direct measurement of labour productivity than previously possible, when many researchers used indirect proxies such as the mean annual wage or household income. Descriptive statistics are provided in Table 9.2. Note that corresponding specification (9.3), all non-dummy variables in our empirical analysis are log-transformed.

Table 9.2: Descriptive Statistics of Variables (N=113)

	Mean	Std. dev.	Minimum	Maximum
Labour Productivity (ln)	11.29	0.197	10.70	11.85
Capital-Labour Ratio (ln)	11.93	0.106	11.73	12.31
Land-Labour Ratio (ln)	-3.661	0.732	-5.620	-1.671
Education per Worker (ln)	-0.621	0.404	-1.650	0.418
Metropolitan Size (ln)	13.68	0.998	12.43	16.89
Polycentricity (ln)	-0.573	0.554	-1.636	2.291
Dispersion (ln)	-0.769	0.425	-2.144	-0.124
New England	0.027	0.161	0	1
Middle Atlantic	0.071	0.258	0	1
East North Central	0.177	0.383	0	1
West North Central	0.088	0.285	0	1
South Atlantic	0.159	0.368	0	1
East South Central	0.177	0.383	0	1
West South Central	0.071	0.258	0	1
Mountain	0.088	0.285	0	1
Pacific	0.142	0.350	0	1

With respect to the factor inputs, the *Capital-Labour Ratio* within a metropolitan area was measured by linking the capital-labour ratio of broad sectors, as obtained from the Annual Survey of Manufacturers, to the industrial composition within the metropolitan area (based on a division into 15 sectors). Hence, the obtained value is a weighted average of the capital-labour ratio across sectors. Although this operationalisation does not account for regional differences within sectors (e.g., capital intensity, level of technology and sub-sector specialisation), it provides a reasonable proxy to the capital-labour ratio within metropolitan areas. The *Land-Labour Ratio* is defined as the average number of acres per worker within a metropolitan area. The human capital-labour ratio or average *Education per Worker* within a metropolitan area is obtained from the American Community Survey (2006) and measured as the percentage of the metropolitan population of 25 years and older with a bachelor's degree or higher. As our output variable is Gross Domestic Product (GDP), which equals the total production minus intermediate inputs, we do not take intermediate goods into consideration (see also Broersma and Oosterhaven, 2009).

However, the main variables of interest in our research are the indicators related to the urbanisation externalities and spatial structure. Urbanisation externalities are captured by the variable *Metropolitan Size*, which is measured as the size of the metropolitan population in 2006. With respect to urban spatial structure, we include both a metropolitan area's degree of *Polycentricity* and its degree of *Dispersion* in our model. Their measurement was discussed in section 3. Finally, dummy variables based on the census divisions are included, which reflect nine broad geographic regions in the United States (New England, Middle Atlantic, South Atlantic, East North Central, East South Central, West North Central, West South Central, Mountain and Pacific; see also Lee and Gordon, 2007).[4] These dummies attempt to control for some of the unobserved heterogeneity across metropolitan areas, in particular differences in technology and price levels.

Endogeneity and Two Stage Least Squares Estimation (TSLS)

Although equation (3) can be estimated using conventional Ordinary Least Squares (OLS), this estimation technique does not account for the simultaneity between metropolitan size and structure and labour productivity. In the model specification, it is assumed that metropolitan size and spatial structure have an effect on metropolitan labour productivity. However, the causality of this relationship is far from clear. On the one hand, agglomeration is often associated with a number of benefits such as labour market pooling, accessibility to intermediate goods, knowledge spillovers, and proximity to consumers, which in turn would augment productivity. On the other hand, firms may also be attracted to economically dense areas because of the presence of higher productivity levels

[4] Using census region dummies (covering four broad geographical regions) yielded similar empirical results.

(Rosenthal and Strange, 2004). In other words, agglomeration can be regarded as both a cause and consequence of labour productivity. Likewise, metropolitan spatial structure may be regarded a consequence rather than a cause of labour productivity growth. High land and real estate prices in combination, driven by high levels of labour productivity in city centres, may disperse people and firms out of the main cities into the wider metropolitan area. In this case, it is not spatial structure that directs metropolitan performance, but metropolitan performance that directs spatial structure.

Not accounting for simultaneity can lead to inconsistent estimates as it violates one of the underlying assumptions of OLS, namely that the independent variables are uncorrelated with the disturbance term of the dependent variable. In other words, the independent variables should not be affected by the dependent variable. Probably the most common technique to deal with this (potential) simultaneity bias is to isolate the effect that runs from agglomeration and urban spatial structure to labour productivity by means of a two stage least squares (TSLS) estimation (see also, Ciccone and Hall, 1996; Ciccone, 2002; Combes *et al.*, 2008). In order to do so, we need instruments, or variables that are correlated with the endogenous independent variables but not with the dependent variable. Hence, they should be 'relevant', but at the same time 'exogenous'. Based on Ciccone and Hall (1996), we used five historical variables that are not related to labour productivity today, as production 60-150 years ago was organised in a very different way than nowadays, but that did significantly contribute to today's metropolitan size and spatial structure:

1. The metropolitan population in 1950
2. The degree of polycentricity in 1950
3. The degree of dispersion in 1950
4. Presence or absence of a railroad in the metropolitan area in 1860 (Stover, 1961).
5. Agricultural land use, measured as the density of employment in agriculture outside the urban areas.

The 1950 variables are constructed in exactly the same way as our 2006 variables and their inclusion as instrumental variables is obvious. With respect to our railroad variable, it is assumed that the presence or absence of railroads in 1860 was not driven by modern productivity differences (Ciccone and Hall, 1996), but are important in explaining agglomeration at the end of the 19th century and the development of other places through suburbanisation in the early 20th century. Finally, the agricultural land use variable is used as an instrument of dispersion: more extensive agricultural land use outside the urban areas increases relative land rent as competition for land intensifies (Brueckner, 2001). This in turn, slows down the development of housing and offices outside the urban area compared to metropolitan areas in which non-urban land is relatively cheap. Agricultural land use is however not related to our dependent variable as this sector was excluded in the measurement of the labour productivity of metropolitan areas.

9.5 Empirical Results

Testing for Endogeneity of Metropolitan Size and Spatial Structure

Although there may be a problem of recursive causality from a theoretical point of view, this does not necessarily mean that there is a problem from an econometric point of view (Combes *et al.*, 2008). If indeed the independent variables of interest can be treated as exogenous, then OLS, which is a more efficient estimator, should be preferred over the TSLS estimator (Woolridge, 2006). In order to conduct such a test, the instruments need to fulfil two general conditions: they should be relevant (not weak) and valid (exogenous).

Table 9.3 shows the test results on the relevance and validity of the instruments as well as the endogeneity of metropolitan size and structure. The endogenous variables were tested both separately and simultaneously. In other words, we ran three regressions in which we instrumented metropolitan size, polycentricity or dispersion and one regression in which we instrumented the three variables simultaneously. We included more instruments than endogenous independent variables in each specification in order to conduct an overidentification test to assess the validity of the instruments. On the basis of the Anderson canonical correlation, Cragg-Donald F-statistic and Shea Partial R^2 statistics, we can conclude that our instruments are relevant.[5] With respect to testing the validity of the instruments, both the Sargan and Basmann test indicate that our instruments are valid.[6]

Table 9.3: First Stage Results of TSLS on Metropolitan Labour Productivity

	Metropolitan Size	**Polycentricity**	**Dispersion**	**All**
Instruments	Population '50 Railroad	Polycentricity '50 Railroad	Dispersion '50 Agr. land use	Population '50 Polycentricity '50 Dispersion '50 Railroad Agr. land use
Relevance				
Anderson canon. corr.	79.28**	44.63**	35.13**	36.89**
Cragg-Donald F-test	114.05**	31.66**	22.11*	9.31**
Critical value CD (10% relative bias)	19.93	19.93	19.93	6.06
Shea Partial R^2				
- Metropolitan size	0.70			0.75
- Polycentricity		0.40		0.43
- Dispersion			0.31	0.33
Validity				
Sargan statistic	0.29	0.08	0.00	1.00
Basmann statistic	0.25	0.07	0.00	0.86
Exogeneity				
Wu-Hausman F-test	4.78*	0.71	0.02	1.85
Durbin-Wu-Hausman Chi-Square test	5.31*	0.83	0.02	6.24
Observations	113	113	113	113
Regressors	14	14	14	14
Instruments	15	15	15	16
Excluded Instruments	2	2	2	5
**p<0.01, *p<0.05				

[5] The Anderson canonical correlation statistic is significant in all four specifications, meaning that the instruments used in these specifications are adequate to identify the equation. The Cragg-Donald F-statistic tests whether we face a weak-instrument problem. A set of instruments is defined as weak if the bias of the TSLS estimator, relative to the bias of the OLS estimator, exceeds the threshold of 10% (Stock and Yogo, 2005) at the 5% confidence level. As can be obtained from Table 9.3, this is the case for all specifications as the value of the Cragg-Donald F-statistic exceeds the critical values provided by Stock and Yogo (2005). These results are reinforced by the Shea partial R^2 statistic, which is reasonably high for all specifications. In particular, metropolitan size appears to be well instrumented.

[6] In this, it is tested whether the instruments for metropolitan size and spatial structure are uncorrelated with the disturbance term. As these overidentification test statistics were non-significant for all four specifications, we cannot reject the null hypothesis that the instruments are uncorrelated with the disturbance term of the dependent variable and can be considered valid.

Finally, we tested whether the endogenous independent variables included are also econometrically endogenous. In this, the Wu-Hausman F-test and Durbin-Wu-Hausman Chi-Square test assess the null-hypothesis that the instrumented variables are exogenous by comparing the TSLS estimates with the OLS estimates. From these tests it can be concluded that metropolitan spatial structure, defined by monocentricity-polycentricity and centralisation-dispersion can be treated as exogenous. In line with Lee and Gordon (2007), this is not surprising because spatial restructuring can be considered a long-term process. However, for the specification in which metropolitan size is instrumented the Durbin-Wu-Hausman test rejects the hypothesis at a 5% confidence level (p=0.021). The estimation of this equation using the OLS estimator would therefore not yield inconsistent results. Examining the specification with multiple endogenous regressors, we cannot reject the null-hypothesis that metropolitan size and metropolitan spatial structure are exogenous. As both the Wu-Hausman F-test and Durbin-Wu-Hausman Chi-Square test indicate that there is no evidence for an endogenous relationship between labour productivity and metropolitan size and structure, OLS estimation should be used, given the fact that our instruments are relevant and valid and OLS more efficient. However, we test for robustness of our results by comparing the OLS estimates with the estimates from the TSLS specification in which only metropolitan size is treated as endogenous.

Labour Productivity, Urbanisation Externalities and Spatial Structure

Model 1 in Table 9.4 shows the results of the OLS estimation of metropolitan size and spatial structure on labour productivity, controlling for capital-labour ratio, land-labour ratio, education and including census division fixed effects. The White-Koenker test indicates that the null-hypothesis that the residuals are homoskedastic cannot be rejected, while the Ramsey RESET test shows that we do not face an omitted variable bias problem. The VIF statistics indicate no multicollinearity problems. In general, the model fits the data well, explaining about two-thirds of the variance in labour productivity across American metropolitan areas.

Turning to the main results, we find a positive and significant effect of the capital-labour ratio (elasticity of 0.75) and no effect of the proportion of the workforce with a bachelor's degree or higher on metropolitan labour productivity. However, our main interest lies in examining the effect of metropolitan size and structure on urban performance. In line with the existing empirical work on agglomeration, we find a positive and significant effect of urbanisation externalities on metropolitan labour productivity. A doubling of metropolitan size increases metropolitan labour productivity by over 10%. This is slightly higher than the consensus view that a doubling of city size increases productivity by between 3 and 8% (Rosenthal and Strange, 2004) and the average of 5.4% found by Melo *et al.* (2009) in a meta-analyses of such estimates.

Table 9.4: OLS and TSLS on Metropolitan Labour Productivity

	Model 1 OLS	**Model 2 TSLS[a]**
Intercept	11.4 (.110)**	11.3 (.110)**
Capital-Labour Ratio (ln)	0.75 (.232)**	0.84 (.222)**
Land-Labour Ratio (ln)	0.01 (.032)	-0.01 (.032)
Education per Worker (ln)	-0.01 (.050)	-0.01 (.047)
Metropolitan Size (ln)	0.11 (.020)**	0.08 (.023)**
Polycentricity (ln) [b]	0.06 (.023)*	0.05 (.022)*
Dispersion (ln) [c]	0.02 (.039)	0.03 (.036)
Census division dummies	YES	YES
Number of Observations	113	113
F-statistic	13.48	12.01
R^2 (OLS) / Centred R^2 (TSLS)	0.66	0.65
Root MSE	0.12	0.12
White-Koenker (OLS) / Pagan-Hall test (TSLS)	22.7	19.8
Ramsey RESET test	0.83	0.03

**p<0.01, *p<0.05
Standard errors between parentheses; all non-dummy variables are mean-centred
[a]Instruments used in the first stage of the regression for the endogenous variable metropolitan population
[b] The higher the value, the more polycentric. The lower the value, the more monocentric,
[c] The higher the value, the more dispersed. The lower the value, the more centralised.

With respect to metropolitan spatial structure, we find mixed results, in the sense that we find a positive and significant effect of the degree of polycentricity on metropolitan labour productivity, but no effect of the degree of dispersion. We had expected that dispersion would have a negative effect on labour productivity, but this is not the case. However, the positive effect of the degree of polycentricity on metropolitan labour productivity confirms our theoretical expectation. A doubling of the degree of polycentricity, increases the metropolitan labour productivity by 5.5%. This means that the labour productivity in metropolitan areas in which the urban population is relatively evenly spread over multiple places in the metropolitan area leads to higher labour productivity than in metropolitan areas in which the urban population is concentrated in one large city, holding everything else constant. We will elaborate on this important finding in the concluding section.

Table 9.5: OLS and 2SLS on Metropolitan Labour Productivity– Interaction Effects

	Model 3 OLS	**Model 5 TSLS[a]**
Intercept	11.3 (.110)**	11.3 (.108)**
Capital-Labour Ratio (ln)	0.75 (.229)**	0.82 (.216)**
Land-Labour Ratio (ln)	0.00 (.031)	-0.02 (.031)
Education per Worker (ln)	0.02 (.049)	0.02 (.045)
Metropolitan Size (ln)	0.09 (.021)**	0.07 (.023)**
Polycentricity (ln)	0.04 (.023)	0.03 (.022)
Dispersion (ln)	0.04 (.039)	0.05 (.037)
Metropolitan Size*Polycentricity	-0.06 (.021)**	-0.06 (.020)**
Metropolitan Size*Dispersion	-0.01 (.024)	-0.02 (.023)
Census division dummies	YES	YES
Number of Observations	113	113
F-statistic	13.48	12.11
R^2 (OLS) / Centred R^2 (TSLS)	0.68	0.68
Root MSE	0.12	0.11
White-Koenker (OLS) / Pagan-Hall test (TSLS)	21.11	20.32
Ramsey RESET test	0.07	1.09

**p<0.01, *p<0.05
Standard errors between parentheses; all non-dummy variables are mean-centred
[a]Instruments used in the first stage of the regression for the endogenous variable metropolitan population

Comparing the OLS and TSLS estimator (Model 2 in Table 9.4), it can be seen that the urbanisation externalities effect is over 25% less when estimated using TSLS (elasticity of 0.078), while the effect of the capital-labour ratio is larger. The parameter estimates of polycentricity and dispersion do not significantly differ across the models.

Examining the two interaction effects between metropolitan structure and urbanisation externalities (Model 3 and 4 in Table 9.5), the only negative effect we found is for the interaction between metropolitan size and polycentricity on metropolitan labour productivity. The negative and significant interaction term can be interpreted as the fact that urbanisation externalities are larger in monocentric cities. This confirms our theoretical assumption that polycentricity diminishes the effect of size on labour productivity. We will discuss the important theoretical implications of this finding further in the next section. Similarly, it can also be interpreted as that the benefits of polycentricity hold more for smaller regions than for large regions (in terms of population).

9.6 Conclusion and Discussion

Recent theoretical interest of geographers has turned to post-industrial forms of urban agglomeration. The industrial image of a metropolitan area as being composed of an urban core and a rural hinterland is in many cases becoming obsolete and appears to be being replaced by increasingly polycentric metropolitan areas that spread over larger territories, thereby including multiple cities that together constitute a metropolitan network of cities. The 'city' is becoming a regional phenomenon and calls have been made that this should also manifest itself in the study of agglomeration economics as these seem to be associated also with wider, and more polycentric, forms of metropolitan agglomeration rather than being confined to a single urban core (Alonso, 1973; Kloosterman and Musterd, 2001; Phelps and Ozawa, 2003; Cheshire, 2006; Parr, 2008). Despite these calls, however, several of these scholars have suggested that empirical research on agglomeration externalities in relation to the regional urban systems is rather non-existent, contrary to the more local scale of polycentric cities (Lee and Gordon, 2007). An important reason for this empirical deficit is that many existing empirical analyses of agglomeration still originate from definitions of metropolitan areas that depart from a single nodal perspective. By this, we mean that the vast majority of countries defines functional urban areas as being one central city and its hinterland, thereby ignoring the possibility of having multiple core cities. Moreover, particularly in urban economics, spatial structure is hardly an issue and often approximated by general indicators such as just size or density, which, however, do not reveal much detail of the spatial structure within regions.

This chapter takes up this empirical challenge by analysing how different spatial structures affect the development of agglomeration externalities in U.S. metropolitan areas in 2006 with over 250,000 inhabitants. Externalities were measured in terms of labour productivity. The widest official delimitation of metropolitan areas was used (CSAs), and these were supplemented with MSAs that do not form part of such CSAs.

As regards spatial structure, we assumed that, next to size, two dimensions are important as these affect urban concentration within the region: 1) the monocentricity-polycentricity dimension that indicates to what extent the urban population is concentrated in one urban centre (monocentricity), or spread over multiple urban centres in a metropolitan area in a balanced way (polycentricity); and, 2) the centralisation–dispersion dimension, which indicates the extent to which the metropolitan population is concentrated in centres. In addition to these indicators relating to spatial structure we controlled for the capital-labour ratio, land-labour ratio and human capital. The empirical analysis in this chapter resulted in four findings about the relationship between a region's spatial structure and its economic performance in terms of labour productivity.

(1) Metropolitan areas with more dispersion do not perform worse in terms of labour productivity.

Whether a large part of the population is concentrated in urban centres or lives outside of these centres in the non-urban part of the metropolitan area was not found to influence labour productivity. Thus we found no evidence for the expectation that dispersion is harmful to labour productivity.

(2) Metropolitan areas that are more polycentric show higher labour productivity.

We found a positive and significant direct effect of the degree of polycentricity on labour productivity. The more evenly the population is spread across the different places in a metropolitan area, the higher the labour productivity in the metropolitan area. As labour productivity proxies the balance between agglomeration economies and diseconomies, we can conclude that this balance is better in the more polycentric metropolitan areas. This can be explained by the assumption that urbanisation diseconomies are less in the more polycentric areas and the idea that urbanisation economies have 'regionalised' to some extent, while 'urbanisation diseconomies' appear to be confined to the city boundaries. So, this result appears to confirm ideas that agglomeration externalities spread over larger distances, and may interact in regions where multiple urban places and hence multiple sources of agglomeration externalities are co-located. As such, it confirms that agglomeration economies need to be conceptualised in relational terms. Thus, as Phelps and Ozawa (2003) proposed, external economies are not confined to a single urban core, but instead, appear to be shared among a group of functionally linked settlements. The latter appears to be the case for the relatively more polycentric metropolitan areas. Finding 3, however, qualifies the extent to which this 'regionalisation' of agglomeration economies takes place.

(3) <u>The effect of metropolitan size decreases as metropolitan areas are more polycentric</u>
Metropolitan size tends to reflect the presence of urbanisation externalities. It was found that the degree of polycentricity has an indirect effect on labour productivity as urbanisation externalities are fewer in the more polycentric metropolitan areas. Put differently, the productivity gains of size diminish as the metropolitan area becomes more polycentric. These results are in line with the conclusion of Meijers (2008a), who found that the more polycentric a region was, the less cultural, leisure and sports amenities were present. It also confirms the doubts raised by Parr (2004; 2008) and Bailey and Turok (2001) that the magnitude of urbanisation externalities in a polycentric metropolitan area is less compared to a monocentric metropolitan area. From a theoretical perspective, we cannot expect the advantages based on density, proximity and the easy and sometimes unplanned exchange of information to be equally present in a metropolitan area in which population is spread over multiple smaller cities as in one where the population is concentrated in a single large city. This result means that a collection of cities does not provide a substitute for the urbanisation externalities of a single large city, even though the size of the population in both metropolitan areas is similar.

(4) <u>Polycentricity appears to be more beneficial in smaller (population) metropolitan areas</u>
Our findings on the interaction-effect could also be interpreted as that the positive effect of having a relatively more polycentric spatial structure on labour productivity found here decreases as the population size of the metropolitan area increases. A possible reason for polycentricity being relatively more beneficial in smaller metropolitan areas is that perhaps cities in smaller polycentric metropolitan areas are more functionally related than those in larger polycentric metropolitan areas. This needs to be tested, however.

Research Agenda

More generally, the relation between the strength and extent of functional linkages between cities in a metropolitan area and their performance as a regional urban system deserves further exploration. Also external linkages between more distant metropolitan regions require our attention. The idea that such external linkages are of great importance in explaining metropolitan performance appears to hold in particular for the largest metropolitan areas as these are the main locations for knowledge-intensive activities such as the advanced producer services and as such, the centres in the global network of information and knowledge exchange (Sassen, 1991; Hall and Pain, 2006). In this, it would be interesting to see whether agglomeration externalities are also shared between even more distant cities. Other important research issues following from our findings are whether the gap in urbanisation externalities between more polycentric and more monocentric metropolitan areas is increasing or diminishing over time, whether typical agglomeration disadvantages are less severe in polycentric metropolitan areas indeed and whether the effects of spatial structure on productivity levels differ across sectors.

Appendix 9A: Selection of Metropolitan Regions.

In principle, all CSAs as well as MSAs not part of a CSA with a total population of over 250,000 inhabitants in 2006 located in the U.S. continental states were included in the analysis. Metropolitan areas are defined by the U.S. Office of Management and Budget (OMB), and the latest revised version (2007) of the 2000 definitional standards was used. An MSA contains a core urban area with a population of 50,000 or more. It consists of one or more counties and includes the counties containing the core urban area, as well as any adjacent counties of which more than 25% of employed residents work in the urban core. MSAs that are adjacent may be joined in order to form a Combined Statistical Area if the employment interchange is at least 25. Adjacent MSAs that have an employment interchange measure of at least 15 and less than 25 are combined if local opinion favors combination (OMB, 2000). There are also micropolitan areas that contain an urban core with a population of at least 10,000 but less than 50,000. These are not considered here, unless they form part of a CSA that is furthermore composed of at least one MSA.

Some regions had to be left out for other reasons:

1) CSAs are composed of metropolitan statistical areas and/or micropolitan statistical areas. Often, data was not available for micropolitan areas. In a limited number of cases, this meant that no reliable data for the CSA could be retrieved. There were a couple of CSAs, where more than 20% of their population was located in a micropolitan statistical area, which were left out for this reason. These were Charlotte-Gastonia-Salisbury, NC-SC; Fort Wayne – Huntington- Auburn, IN; and, Lexington-Fayette--Frankfort--Richmond, KY.
2) New Orleans was left out as the data appeared biased as a result of Hurricane Katrina.

As argued in the text, polycentric conurbations had to be left out. These include: Albany-Schenectady-Amsterdam, NY; Charleston-North Charleston, SC; Dallas-Fort Worth, TX; Davenport-Moline-Rock Island, IA-IL; Fayetteville-Springdale-Rogers, AR-MO; Hartford-West Hartford-East Hartford, CT; McAllen-Edinburg-Mission, TX; Miami-Fort Lauderdale-Miami Beach, FL; Minneapolis-St. Paul- St. Cloud, MN-WI; Palm Bay-Melbourne-Titusville, FL; Provo-Orem, UT; Sarasota-Bradenton-Punta Gorda, FL; Scranton—Wilkes-Barre, PA; Tampa-St. Petersburg-Clearwater, FL; Virginia Beach-Norfolk-Newport N., VA-NC.

Chapter 10:

Spatial Structure and Retail Amenities in Dutch Regions

Abstract[1]

This chapter examines how the presence of retail amenities in Dutch regions is dependent on their spatial structure. Retail amenities, in particular those specialised retail functions that require a large urban support base, are less found in more polycentric and more dispersed regions. This can be explained by the observation that in polycentric and dispersed regions the degree of market fragmentation is higher, as a result of more intense regional competition and spacing between retail centres. We found evidence for ways to overcome the lack of agglomeration benefits in more polycentric and more dispersed regions. Both concentration of retail and more complementarities between cities' retail amenities may make up for the disadvantages of region's being polycentric or dispersed. These findings provide a rationale to regionally coordinate specialised retailing in polycentric and dispersed regions.

[1] This chapter is currently under review and has been co-authored with Evert Meijers and Frank van Oort as "Regional spatial structure and retail amenities in the Netherlands". It has been slightly edited to fit the format of this book.

10.1 Introduction

Contemporary urban studies put much emphasis on the significance of urban networks in explaining the economic, social and cultural functioning and performance of cities and regions. In this, it is recognised that no city is an island, but part of a functionally interdependent system of cities. While there has been an emphasis on studying the external, global linkages of world cities (e.g., Alderson and Beckfield, 2004; Taylor, 2004; Wall and Van der Knaap, 2011), many social-economic processes such as commuting and shopping are still local and, hence, there is increasing need for studying interdependencies between centres at lower spatial scales. This is fuelled by a broadly underpinned rise of a new regional form, in which cities are part and parcel of a larger urban region which comprises more than a central city and its direct hinterland. Such regional spatial structure can be characterised by multiple, interacting concentrations of jobs and people, with a spatial division of functions between them. Many concepts for these new regional types circulate, an important common denominator being their more polycentric and more dispersed spatial structure (Scott, 2000; Kloosterman and Musterd, 2001; Taylor and Lang, 2004; Meijers, 2005; Hall and Pain, 2006; Hoyler *et al.*, 2008; Lambregts, 2009; Burger and Meijers, 2011).

Polycentricity is here understood as a balanced distribution with respect to the size of cities or centres in a region, where several cities are located within close proximity of each other. The more the largest centres in a region are equally sized in terms of population or employment, the more polycentric the region is (Meijers, 2008a).[2] Dispersion refers to the situation in which the population is sprawled across a region in a non-concentrated pattern. Both polycentricity and dispersion inevitably draw attention to the interdependencies between the different parts of a region. However, despite awareness of the importance of these interdependencies for regional competitiveness and cohesion (Meijers, 2005; Hoyler *et al.*, 2008), these intra-regional and inter-city relationships constitute a so-far little developed field of research. Although attention has been paid to the regional spatial structure of commuting (see e.g., Clark and Kuijpers-Linde, 1994; Van der Laan, 1998; Aguilera and Mignot, 2004; Nielsen and Hovgesen, 2005; Van Nuffel and Saey, 2005; Green, 2008; Burger *et al.*, 2011a), other types of economic interaction (most notably,

[2] Here we use a morphological approach to spatial structure. For a distinction between the morphological and functional approach (focusing on distribution of linkages), see Burger and Meijers (2011).

consumer- and producer-oriented trade) within urban systems have received limited attention.[3] Moreover, studies relating regional spatial structure to issues such as competitiveness, environmental sustainability or social well-being are thin on the ground. Such knowledge, however, has become all the more urgent given the rise of polycentric and dispersed regional forms, and, hence, calls for further empirical research into the effects of regional spatial structure on the performance of regions are widespread (see e.g. Kloosterman and Musterd, 2001; Parr, 2004; Turok and Bailey, 2004; Cheshire, 2006; Davoudi, 2007; Meijers, 2008b; Hoyler *et al.*, 2008; Lambregts, 2009).

The aim of this chapter is first of all to shed light on how the spatial organisation of regions affects their performance. More explicitly, we base our judgement of performance of a region on the presence of (specialised) retail amenities in a region. Retail amenities are known to be strongly dependent on the size of local population (Berry and Parr, 1988). The presence of a large quantity of specialised retail outlets is strongly positively associated with the size of a city, and as such, a manifestation of the presence of urbanisation economies through consumption (Glaeser *et al.*, 2001). Our point of departure is the recent finding that more polycentric and more dispersed regions lack agglomeration externalities being present in more monocentric regions. Meijers (2008b) found for Dutch regions that a more polycentric settlement pattern is related to the presence of fewer cultural, leisure and sports amenities. Meijers and Burger (2010) obtained for US metropolitan areas with a more polycentric settlement pattern that the positive influence of metropolitan size on labour productivity diminishes. Although urbanisation economies are not necessarily confined to a single urban core anymore, but increasingly shared among a group of functionally linked settlements (Capello, 2000; Phelps and Ozawa, 2003), travel, commodity and knowledge flows do not circulate as easily as in a single larger city (Parr, 2004). Hence, polycentric regions "*lack the critical mass of large cities with agglomeration economies*" (Lambooy, 1998, p. 459).

However, the aim of this chapter is not just to test whether these findings also hold for the presence of retail amenities in Dutch regions, but also to innovatively explore several ways to overcome the negative effects of polycentricity and dispersion on the presence of urbanisation economies, if present. Therefore, we analyse two strategies that may lead to a stronger presence of specialised retail in more polycentric and more dispersed regions.

[3] Notable exceptions are Van Oort *et al.* (2010), who study buyer-supplier relations and a number of chapters in Hall and Pain (2006) which discuss regional office networks.

These include: (a) concentrating top retail functions in one city and (b) overcoming the barriers of distance by improving infrastructure between cities. Exploring these factors fills an urgent need in planning practice, as it provides a so-far missing evidence-base for two main components of regional development strategies aimed at fostering polycentric and dispersed regions. The first component is the policy idea that improving connections between the cities may overcome the barriers to economic exchange. The second is the unresolved debate whether strategies should aim for concentration of specialised urban functions or for a spread of these functions over the constituent cities in a complementary way.

The remainder of this chapter is organised as follows. The next section (10.2) discusses the literature on agglomeration, regional spatial structure and retail amenities, which culminates in a set of propositions that will be investigated. Section 10.3 provides more background on our case study of retail geography in the Netherlands. Section 10.4 presents the data and research approach, including a quantification of regional spatial structure. Empirical results are presented in section 10.5. We conclude with a discussion of our findings in section 10.6.

10.2 Agglomeration, Regional Spatial Structure and Retail Amenities

Agglomeration Economies and Consumption

In economic geography and urban economics, it is now widely accepted that the urban environment adds to the productivity of firms (Rosenthal and Strange, 2004; Puga, 2010). Productivity of firms located in large cities is thought to be higher because of larger input markets, larger labour pools, and the presence of a better infrastructure and public facilities. Large cities allow for better matching between employers and employees and business partners and are also more likely to be home to universities, R&D facilities, and other knowledge-generating institutions (Van Oort, 2004). In addition, the often diverse industry mix in large cities stimulates the generation, replication, modification and recombination of ideas and applications across different industries and protects a city from a volatile demand (Frenken *et al.*, 2007). A recent meta-analysis of the empirical literature on agglomeration economies indicates that doubling of city size increases productivity by on average 5.8% percent (Melo *et al.*, 2009). However, the relationship between city size and productivity typically depends on the area, sector and time period under observation (see also Rosenthal and Strange, 2004). In this respect, optimal city size tends to vary according to the functions and sector of the cities in question (Richardson, 1972).

However, cities do not only facilitate production, but also provide a good environment for consumption. As indicated by Tabuchi and Yoshida (2000), nominal wages increase by city size, but the costs of living (e.g., housing costs) increase even more. Hence, citizens seem to be willing to give up real wage in order to take pleasure in consumption amenities. According to Glaeser *et al.* (2001), one can here think of the aesthetic properties of large cities and the provision of some public services in large cities (e.g., specialised schools) that are not available elsewhere, as well as the presence of more specialised goods and services in large cities (e.g., theatres and specialised stores). Hence, in large cities hospitals, restaurants, stadiums, theatres, zoos and higher-order retail functions such as clothing stores, furniture stores, and specialised food stores are found, while consumers in small towns lack these amenities. In addition, a city offers speed of interaction facilitated by urban density, reducing transport costs and travel times. Consumers save costs when shops are concentrated, including time savings and other sorts of cost savings such as having to pay for parking or public transportation only once.

A similar train of thought is found in urban economic and new economic geography models, where the firms' proximity to consumers in combination with the consumer benefits of the greater variety of goods and services offered in large cities induces spatial agglomeration (Fujita, 1988). Consumption possibilities as source of agglomeration are reflected in higher growth of high-amenity cities compared to low-amenity cities (Glaeser *et al.*, 2001; Clark *et al.*, 2002; Markusen and Schrock, 2009) as well as the recent increase in exchange commuting in many Western societies, i.e. people living in the more expensive central cities and working in the suburbs (Van der Laan, 1998; Burger *et al.*, 2011a).

Central Places, Regions and Retail Amenities

Other demand-side explanations of agglomeration, which focus on the match between specific demands and suppliers, can be found in the central place and urban systems literature of the second half of the 20th century, which build on the work of Christaller (1933) and Lösch (1944). Although this literature has been on the wane the last two decades (Coffey *et al.*, 1998), it has still great relevance for understanding the relationship between city size and consumption benefits. As indicated by Berry and Parr (1988), central place theory is occupied with the study of the distribution, size and functions of cities and towns and originally focused on city-hinterland relationships and consumer-oriented trade. Assuming that consumers use the nearest centre to acquire goods and services they need (minimisation of transportation costs) and goods and services of a given level can be found in the same centre, central place theory predicts a hierarchy of centres, where the size of a centre and the variety of goods and services it provides are thought to be perfectly correlated (Berry and Garrison, 1958; Davies, 1967). In this, it is conjectured that each good and service has a minimum demand threshold to support suppliers as well as a fixed geographical domain beyond which consumers are unwilling to travel for (Berry and Garrison, 1958). For specialised goods and services the demand threshold and spatial range is generally larger.

Central place theory predicts that all urban systems are rather monocentric, containing a principal centre and several surrounding subordinate centres of different hierarchical orders that are part of the principal centre's market area (Haggett, 1965). In this, subordinate centres are dependent on the principal centre for the provision of some specialised goods and services for which they do not meet the minimum demand threshold.[4] Only a small proportion of the centres will be self-contained in that they offer the full range of goods and services. At the same time, the provision of specialised goods and services in the principal centre is often possible because it controls the wider region as a trade area for these specialised goods and services. In other words, through functional linkages with higher-order centres, subordinate centres can help providing the minimum demand threshold for supporting some retail functions (Wensley and Stabler, 1998).

Extensions of the central place model, which relax some of its underlying assumptions and provide a more sophisticated treatment of consumer behaviour, provide additional explanations of retail agglomeration. Although one of the underlying themes of original central place theory is that competitors try to avoid each other, Parr and Denike (1970) and Eaton and Lipsey (1979) showed that the agglomeration of similar stores can be explained by the tendencies of consumers to compare products and prices on sale in a variety of stores. Likewise, the agglomeration of stores selling different goods and services can be explained by savings on travel, search, and transaction costs associated with multi-purpose shopping (Eaton and Lipsey, 1982; Ghosh, 1986). Obviously, the benefits of co-location of

[4] In this it is assumed that lower-order centres do not provide goods and services to the highest-order central place and trade between centres of similar size is considered redundant as these centres provide the same goods and services.

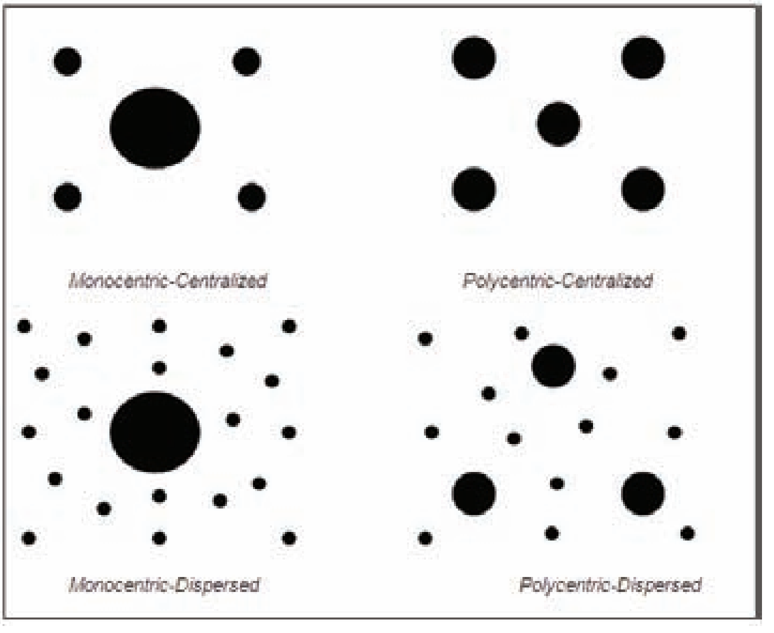
retailers for consumers – who avoid smaller centres – imply that agglomeration is to their advantage as well. Anticipating on consumer behaviour, a store that shares its location with other competing and complementary stores is more likely to attract customers than an otherwise identical store located on its own. Accordingly, agglomeration of stores creates advantages for both consumers and retailers (Mulligan, 1984).

In this, it can be expected that some store types profit more from clustering than other store types. First, comparison shopping is more common for infrequently purchased, heterogeneous and expensive goods. One can think here of personal goods such as clothing and jewellery and household goods such as furniture and cars, where there can be considerable quality and price variations between the different products. Customers of stores selling convenience goods (supermarkets, bakeries, butchers) do not often engage in search as quality and price variations are often too small compared to the associated search costs (West *et al.*, 1985). Second, although multipurpose shopping is both found for convenience and comparison goods, it can be argued that multipurpose shopping is most beneficial for specialised stores that sell infrequently purchased goods and require a larger customer base. This is reflected in that multipurpose trips are more common for non-grocery shopping (O'Kelly, 1981), consumers are willing to travel longer distances for infrequently bought goods (Jones and Simmons, 1990) and in particular smaller, specialised retailers profit from additional traffic that is generated by larger anchor retailers in a centre such as supermarkets and department stores that offer a wide variety of products (Ingene and Ghosh, 1990; Yeates *et al.*, 2001). Third, stores drawing on both multipurpose and comparison shopping will profit more from clustering than stores drawing only on multipurpose shopping. Some even argue that multipurpose shopping by itself generally leads to a dispersion of similar, competing retail establishments (McLafferty and Ghosh, 1986), while stores relying on single-purpose comparison shopping do not need to be located in proximity of stores selling different goods or services (West *et al.*, 1985).

Regional Spatial Structure and Market Fragmentation

Two important dimensions of a regional spatial structure stand central in this chapter – polycentricity and dispersion. A polycentric spatial structure refers to the situation in which the cities in a region are relatively equal in size. A dispersed spatial structure refers to the situation in which a large part of the population is not living in cities but spread out across the territory in a non-concentrated pattern (see Figure 10.1). Although polycentric and dispersed spatial structures have always been existent, the process of decentralisation and dispersion has accelerated the past decades and functional linkages are formed at increasingly higher levels of scale than those of the 'traditional' city. The reader is referred to Scott, 2001, Champion, (2001), Hall and Pain (2006), Lambregts (2009) and De Goei *et al.*, 2010) amongst others for discussions of the drivers of these changes.

Figure 10.1: Dimensions of Regional Spatial Structure



As was indicated in the previous subsections, present day retailing is based on agglomeration and the potential for multipurpose and comparison shopping. Accordingly, the different spatial structures in Figure 10.1 vary in the extent to which they support retail. Theoretically, it can be argued that a monocentric and centralised spatial structure is more efficient for retailing than is a polycentric and dispersed spatial structure. Empirically, it remains unclear how regional spatial structure has an effect on the retail amenities present in a region (Henderson et al, 2000). On the one hand, it can be expected that retail establishments are more frequently found in more polycentric and dispersed regions. Wensley and Stabler (1998) indicate that due to higher transportation costs in sparse populated areas, demand thresholds in these areas are generally lower in that less population is required to support a retail function. In turn, less spatial competition between retail establishments in sparse populated areas increases the number of retail establishments (Mushinski and Weiler, 2002; Thilmany *et al.*, 2005). Accordingly, it can be expected that the frequency of retail establishments in sparse populated areas is higher and it can be expected that an isolated place of 25.000 inhabitants is home to more retail establishments per inhabitant than a metropolitan-proximate place of the same size. At the regional level, this would mean that polycentric and dispersed regions are characterised by a higher frequency of retail establishments, holding everything else constant.

However, physical and socio-cultural barriers to the movement of consumers in more polycentric and rural regions also result in the relative absence of urbanisation economies in more polycentric and dispersed regions (Buckwalter, 1990; Henderson *et al.*, 2000; Turok and Bailey, 2004; Meijers and Burger, 2010). Although agglomeration-inducing spatial competition may hamper the multiplication of retail establishments, threshold demand levels in more polycentric and dispersed regions for some specialised goods and services may sometimes not be met, despite the fact that at the regional level the minimum demand threshold to support these functions would be adequate (Buckwalter, 1990). Indeed, although it is often argued that geographical processes are widening and urbanisation economies are not confined to a single place, but shared among a group of functionally linked settlements – taking the form of urban network externalities (Capello, 2000) – the geographical scope of shopping is still very local and travel flows in a polycentric urban network do not circulate as easily as in a monocentric city. Accordingly, polycentric regions lack the demand externalities associated with large cities. This 'lack of critical mass' in polycentric and dispersed regions is reinforced by existing political structures and lack of coordination in planning retail functions. A related point is made by Henderson *et al.* (2000), who argue that especially those goods and services that profit from urbanisation economies do not need the demand advantages originating from competitive protection of spatial isolation to survive. One can think here especially of specialised goods and services that draw to a large extent on multipurpose and comparison shoppers, and are therefore more often found in densely populated areas.

Propositions to be Investigated

On the basis of the discussion above, five propositions on the relationship between regional spatial structure and the presence of retail amenities can be derived.

Proposition 1: The more polycentric or dispersed a region, the less retail amenities are present.

Although stores in polycentric and dispersed regions face less spatial competition, at the same time stores profit less from urbanisation economies as travelling time limits interaction possibilities in comparison to the denser monocentric and centralised regions, undermining the support for specialised retailing which often requires a large demand threshold. Overall, we expect a negative effect of polycentricity and dispersion on the presence of retail amenities.

Proposition 2: The more polycentric or dispersed a region, the less specialised retail amenities are present.

While the first proposition considers the quantity of retail present in regions, this second proposition is about the qualitative dimension of the retail, more precisely, the extent to which specialised retail is present. It can be expected that individual branches of stores are to varying degrees affected by the regional spatial structure, as the demand thresholds for some goods and services are larger than for others. A polycentric and dispersed regional spatial structure would have especially a negative influence on those specialised goods and services that require greater demand in order to achieve minimum efficient scale as well as those goods and services drawing on comparison shoppers. Accordingly, a region consisting of four nearby towns of 25.000 inhabitants each will probably accommodate less specialised retail establishments per inhabitant compared to a region consisting of one city of 100.000 inhabitants.

Proposition 3: A polycentric or dispersed region in which the main cities are located more closely hosts more, and more specialised, retail amenities.

Distance is the barrier to overcome if both polycentric and dispersed regions want to exploit their critical mass, and it is therefore of interest to explore whether the spacing of cities with retail matters in determining a region's retail amenities. As indicated by Meijers and Sandberg (2008), polycentric and dispersed regions in which the different cities are located in close proximity of each function more like a monocentric region than polycentric and dispersed regions in which the spacing between the different cities is large. Exploring this proposition will shed light on the question whether improving infrastructure linkages between the cities and towns of a polycentric or dispersed region is of help in organising agglomeration advantages at the level of the joint size of the constituent places.

Proposition 4: A polycentric or dispersed region in which (specialised) retail is relatively concentrated in once centre, hosts more, and more specialised, retail amenities.

In this chapter, we base our judgment of a region's extent of polycentricity and dispersion on the spread of population. Even though there is a strong relation between city size and retail present, this may not necessarily mean that retail amenities follow an equally polycentric or dispersed pattern. Here, we explore whether a more concentrated distribution of specialised retail in polycentric and dispersed regions implies the presence of more retail amenities.

Proposition 5: A polycentric or dispersed region with a large net outflow of shopping trips, hosts less and less specialised retail amenities.

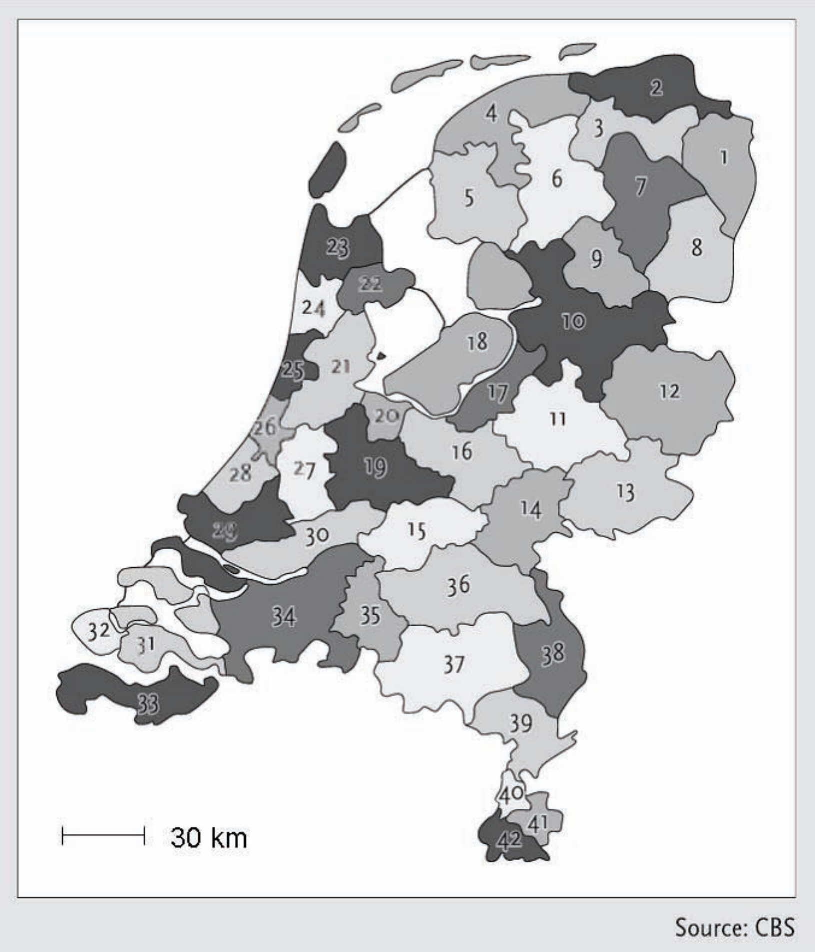
Analyses relating to the previous propositions evaluate the effect of regional spatial structure on the number of stores in a region. In this, we have treated regions as spatially fixed. However, regions are not spatial entities that operate on their own and certainly in the present day economy, most regions interact at least to some extent. In this, it can be expected that polycentric and dispersed regions which are relatively isolated host more and more specialised retail amenities as these regions face less spatial competition from neighbouring regions, which would result in lower demand thresholds for retailing functions.

Before presenting our research approach to test these propositions, we briefly introduce our case study in more detail. Therefore, the next section addresses the spatial and institutional context for studying retail in the Netherlands.

10.3 Dutch Retail Structure

The benefits of co-location of retail do not necessarily imply that shops are located centrally, as in many countries they have decentralised to out of town locations, albeit still generally being co-located with other shops, for instance in malls. Reasons for this centrifugal process are the costs involved in a central location, such as high rents, lack of space and, for consumers, higher parking costs. These new shopping locations are increasingly less connected to pockets of employment (Lang, 2003) which limits the possibilities for trip chaining. This centrifugal process of retail, however, has not appeared to a large extent in our case study regions in the Netherlands. This brings us to the role of institutions in shaping the micro-level location behaviour of retailers, and consequently consumers. Several authors have provided good syntheses of Dutch retail planning (Borchert, 1998; Weltevreden *et al.*, 2005) that show how restrictive planning policies have had a strong mark on Dutch retail geography in that they have long not allowed for decentralisation of shopping towards the urban fringe in order to protect the inner cities (Evers, 2002). It makes Dutch retail geography stand out from most other countries, such as for instance the United States, Spain and France, where shopping has most often decentralised to greenfield locations way beyond the city centre (Garreau, 1991). In contrast, the inner cities of Dutch cities still top the retail hierarchy (Borchert, 1998; Evers, 2002), even though competition from peripheral shopping locations – resulting from slightly lessened planning control for some space-extensive retail segments in response to retail dynamics (Evers, 2002) - and, increasingly, e-retailing or e-commerce has been rising (Weltevreden *et al.*, 2005). However, except for the clustering of stores specialised in garden supplies, cars, furniture and building materials, out-of-town hypermarkets or shopping malls as found in many other European countries are relatively uncommon in the Netherlands. This pays off in terms of the large share of sustainable transport modes as cycling or walking for shopping trips (Dieleman *et al.*, 2002) and greater attractiveness of city centres and increased possibilities for multipurpose shopping. The decentralisation of some segments of retail has often been more than compensated for by the growth or emergence of other sectors in the inner city. Weltevreden *et al.* (2005: 831) describe the outcome of this sorting process for the traditional inner city shopping area as a "*transformation from daily and heavy, space consuming goods to non-daily, recreational goods*". Part of the explanation for inner cities topping the retail hierarchy is also that the limited number of retail developers have strong and vested interests in inner city retail real estate and that space in the Netherlands, one of the most densely populated countries in the world, is limited (Borchert, 1998; Evers, 2002). This means that the spatial structure of a region might influence retail geography mainly through the degree of agglomeration.

Figure 10.2: WGR Regions in the Netherlands



1 Veendam	10 Zwolle	19 Utrecht	28 's-Gravenhage	37 Eindhoven
2 Delfzijl	11 Apeldoorn	20 Hilversum	29 Rotterdam	38 Venlo
3 Groningen	12 Enschede	21 Amsterdam	30 Dordrecht	39 Roermond
4 Leeuwarden	13 Doetinchem	22 Hoorn	31 Goes	40 Sittard
5 Sneek	14 Nijmegen	23 Den Helder	32 Middelburg	41 Heerlen
6 Drachten	15 Tiel	24 Alkmaar	33 Terneuzen	42 Maastricht
7 Assen	16 Amersfoort	25 Haarlem	34 Breda	
8 Emmen	17 Harderwijk	26 Leiden	35 Tilburg	
9 Hoogeveen	18 Almere	27 Gouda	36's-Hertogenbosch	

10.4 Research approach

Retail Amenities and Store Types in Dutch WGR-Regions

To examine the relationship between spatial structure and urban and regional retail amenities, we focus on retailing in 42 Dutch WGR regions (see Figure 10.2), which together cover the entire Netherlands. The delimitation of WGR-regions is based on administrators' and councillors' perceptions of the scale on which issues need to be regionally coordinated. In practice, such issues often include economic development, tourism, recreation, housing, employment, traffic and transport, spatial development, nature and environmental affairs, welfare and social affairs. Accordingly, these regions constitute an indirect proxy of functionally coherent regions and coincide fairly well with what are believed to be travel-to-work areas. In order to examine retail structure, data on establishments and employment in retail were obtained from the LISA (*Landelijk Informatie Systeem Arbeidsplaatsen – National Information System of Employment*) database, an employment register that covers all establishments in the Netherlands for the period 2000-2008. For each retail establishment, we were able to retrieve detailed information about the number of employees, economic activity and geographic position. On the basis of the NACE sector classification and information of the Central Industry Board for the Retail Trade (HBD) in the Netherlands, we distinguish between 51 different types of retailing functions.

To assess how specialised these retailing functions are, we focus on two dimensions: urbanism and consumer orientation. First, retailing functions can be classified on the basis of their 'urbanism' or the extent to which they profit from being located in a densely populated environment. In this, the finding that some store types are overrepresented in large cities (measured by means of a location quotient) indicates that they profit from being located in a densely populated environment. Second, we use the consumer orientation of stores as outlined by West and colleagues (West *et al.*, 1985; West, 1992; Golosinksi and West, 1995). These scholars distinguish between the following store categories on the basis of the extent to which these types benefit from multipurpose and comparison shopping[5]:

- *M stores* attract mainly multipurpose shoppers. Although these stores profit from proximity to complementary stores (e.g. bakery and butcher), they dislike the nearby

[5] In their original classification, West *et al.* (1985) also mention the existence of *S* stores, which provide single isolated purchases. These mainly concerns business related to entertainment such as restaurants, bars, movie theatres and arcades. These types of stores are not classified as retail establishments in the Netherlands and therefore beyond the scope of this chapter.

presence of stores selling similar goods. As indicated by West *et al.* (1985), this type usually concerns stores selling frequently bought convenience goods with limited quality and price variations between stores. Yet some M stores, such as book and music stores, require a larger customer base in that these types of goods are more infrequently sold.

- *C stores* mainly attract single-purpose comparison shoppers. This mainly concerns
- stores selling expensive and/or infrequently purchased goods. Examples: do-it-yourself and garden supplies. As pointed out by West *et al.* (1985), consumers will perceive some net gains to search.
- *MC stores* are stores catering to multipurpose and comparison shoppers. This includes clothing, toys and games, and jewelry stores. However, as indicated in later work by Yeates (1990), West (1992) and Golosinski and West (1995), these store types mainly benefit from comparison shoppers.

Table 10.1: Store Type by Degree of Urbanism and West Classification

Store Type	Store Urbanism (see Appendix A)	Store Orientation	NACE codes
Clothing	Loving	MC	47293
Fashion articles	Loving	MC	4775
Jewelry and watches	Loving	MC	4726
Leather goods and luggage	Loving	MC	47722
Shoes	Loving	MC	4742
Telecom	Loving	MC	4762
Toys and games	Loving	MC	4761
Art and antique	Neutral	MC	47592
Body fashion	Neutral	MC	4771
Camera	Neutral	MC	47717
Computers	Neutral	MC	47721
Department store	Neutral	MC	47711-47715
Household appliances	Neutral	MC	7722
Household articles	Neutral	MC	4773; 47742
Sporting goods	Neutral	MC	47242
Textile supermarkets	Neutral	MC	47716
Books	Loving	M	47782
Candy and nut	Loving	M	4723
Fish	Loving	M	47292
Foreign food	Loving	M	47594
Health food	Loving	M	47781
Music and video recordings	Loving	M	4743; 4754
Perfumery	Loving	M	4725
Tobacco	Loving	M	4765
Bread	Neutral	M	47783; 47791
Cheese	Neutral	M	4763
Dispensing chemist	Neutral	M	4719
Drug store	Neutral	M	47593; 47595-47597
Fruit and vegetables	Neutral	M	27291
Liquor	Neutral	M	4753; 47591

Meat and poultry	Neutral	M	47241
Newspapers and stationery	Neutral	M	4532
Optician	Neutral	M	4741
Pet	Neutral	M	47741
Supermarket	Neutral	M	47642-47644
Video rental	Neutral	M	47521
Florist	Avoiding	M	4722
Gasoline stations	Avoiding	M	47522
Lighting products	Loving	C	47718
Music equipment	Loving	C	4721
Car accessories	Neutral	C	47763
Furniture and carpets	Neutral	C	4711
Hardware	Neutral	C	4751
Paint and wallpaper	Neutral	C	47524
Textiles	Neutral	C	47761
Bikes	Avoiding	C	47641
Building materials	Avoiding	C	47527
Do-it-yourself	Avoiding	C	4730
Garden supplies	Avoiding	C	47528
Sanitary	Avoiding	C	47523

Table 10.1 indicates the extent to which stores profit from a densely populated environment ("urban loving", "urban neutral", "urban avoiding") based on location quotients, as well as the extent to which they profit from multipurpose and comparison shopping based on the classifications by West and colleagues (West *et al.*, 1985; West, 1992; Golosinski and West, 1995). So, "urban loving" stores are store types that are strongly overrepresented in large cities. On the contrary, "urban avoiding" stores are store types that are overrepresented in villages and hamlets. From Table 10.1 it can be obtained that in particular the MC stores (e.g., clothing, luggage and leather goods, telecommunication, and jewellery) and more specialised M stores (e.g., foreign food, tobacco, book and music stores, and perfumery) are relatively more frequently present in large cities. Not surprisingly, C stores (e.g., do-it-yourself and garden supplies), which often require large floor spaces are underrepresented in large cities. Although there are some specialised M store types that are not overrepresented in large cities (especially those selling frequently bought convenience goods, there are hardly any combination M stores (supermarkets, department stores, drug stores) strongly overrepresented in large cities. Given the theories discussed, these findings are not surprising. Provided that the store types more frequently found in large cities are more dependent on urbanisation economies,

it can be expected that these store types are less frequently found in polycentric and dispersed regions.

Quantifying Regional Spatial Structure

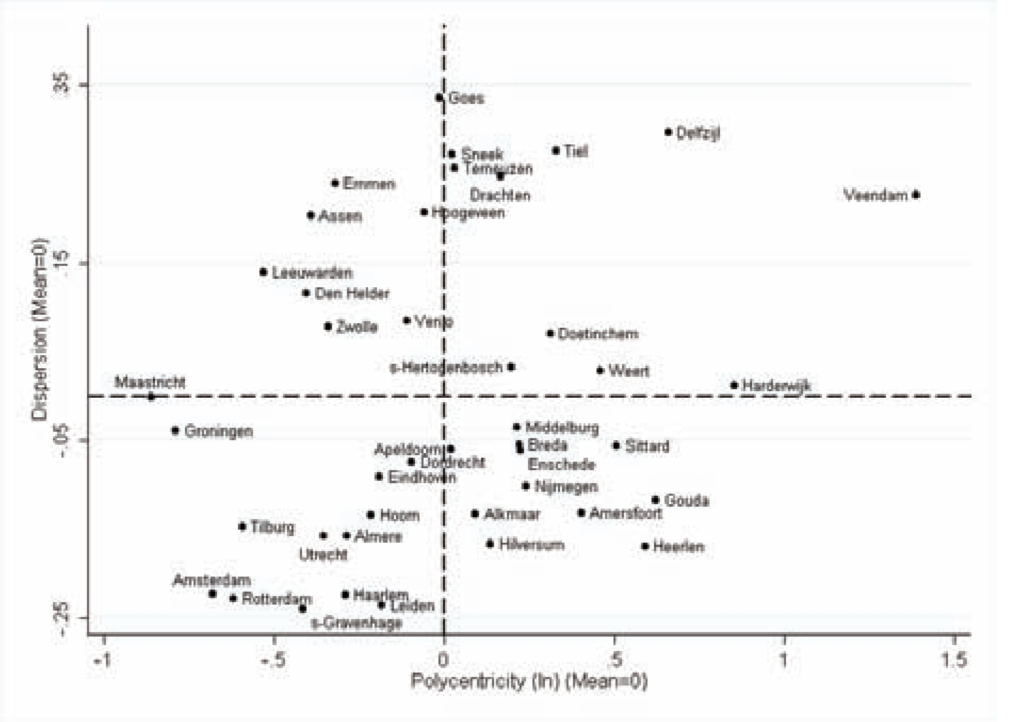
Building on the work of Anas *et al.* (1998), we distinguish between two *morphological* aspects of the spatial organisation of regions (recall Figure 10.1). First, the monocentricity-polycentricity dimension reflects the degree to which the urban population is concentrated in one city or spread over multiple cities in the city-region. Second, the centralisation-dispersion dimension reflects the degree to which the regional population is centralised in cities or dispersed over smaller non-urban places in the area in a non-centralised pattern.

The degree of polycentricity is related to the balance in the size distribution of these cities in regions. The more equally sized the largest cities in a region are, the more polycentric a region is (Kloosterman and Lambregts, 2001; Parr, 2004; Meijers, 2005). The rank-size distribution of the regional urban system provides information on this hierarchy and is therefore a useful indication of the extent of mono- or polycentricity (Parr, 2004). Following Meijers (2008) and Burger and Meijers (2011), we calculated the slope of the regression line of the rank-size distribution of incorporated places in each Dutch WGR region for different number of places per WGR region (2, 3 and 4 largest incorporated places).[6] Subsequently, the average of these three scores was used to assess the degree of monocentricity-polycentricity in a region. Given that these slopes were normally distributed, it can be argued that most regions cannot be considered completely monocentric or polycentric, but are somewhere in between these two extremes; only the most polycentric WGR regions can be considered polycentric regions proper (the type of region for instance Kloosterman and Musterd (2001) and Parr (2004) refer to). The degree of dispersion is related to the share of the regional population not living in urban centres. In this, the degree of centralisation-dispersion in a region is estimated as the share of the population living in non-urban places, which are defined as places with less than 500 addresses. Figure 10.3 indicates the presence of polycentric and dispersed patterns for the

[6] Here, the parameter values have been estimated using the rank-size regression approach by Gabaix and Ibragimov (2011), which corrects for small sample bias.

different Dutch WGR regions. The demarcation lines represent the average degree of polycentricity and dispersion respectively. Regions such as Amsterdam and Rotterdam score low on both the degree of polycentricity and dispersion and can therefore be characterised as monocentric-centralised regions. On the contrary, polycentric and dispersed regions such as Veendam and Delfzijl score high on both dimensions. All possible combinations (polycentric-dispersed; polycentric-concentrated; monocentric-dispersed; monocentric-concentrated) are present.

Figure 10.3: Regional Spatial Structure in the Netherlands



Estimation Strategy

Since our dependent variable – the number of stores – is a count variable, we examine the relationship between regional spatial structure and retail amenities using negative binomial regression models. A more detailed discussion of these issues is provided by Greene (1994), Long (1997) and Burger *et al.* (2009a).[7]

Besides our indicators for regional spatial structure and in line with previous research on retail structure (e.g., Harris and Shonkwiler, 1993; Shonkwiler and Harris, 1996; Henderson *et al.*, 2000; Mushinski and Weiler, 2002; Thilmany *et al.*, 2005), control variables such as regional population size, average household income, age and household demographics, and the number of hotels as indicator of tourism are included in the model. These control variables are important to include in the model because they are all related to the demand for retail and can affect the relationship between spatial structure and retail amenities. Although the degree of dispersion and number of stores can be negatively correlated, in reality, the degree of dispersion and number of stores may only be correlated with each other because they are both correlated with a third, e.g. average household income. More rural areas tend to be poorer and therefore can be characterised by less retail amenities, and accordingly, the observed correlation between dispersion and retail amenities may be attributed to average household income instead of the degree of dispersion. Hence, these control variables reduce the likelihood that the observed relationships between our regional spatial structure variables and our dependent variable are spurious. As the regional presence of retail amenities is best represented by the number of stores per inhabitant, we constrain the parameter of population size to be equal to 1.[8] An overview of the variables included in our regression models is provided in Table 10.2.

To assess proposition 3, 4 and 5, we calculated the spacing between the cities in a region, specialised retail concentration and the net outflow of shopping trips for each Dutch WGR region. Spacing is defined as the average distance (as the crow flies) between the four largest cities in a region. The lower the average distance between the cities, the more the cities are geographically clustered. Polycentric and dispersed regions with a high degree of clustering in one part of the region would behave more like a monocentric region compared to the situation in which the cities are spread over the region (Meijers and Sandberg, 2008). Retail concentration is measured as the share of the stores in a region concentrated in the largest retail centre. The degree of retail concentration is estimated for the different store types and also obtained from the LISA database. Finally, the net outflow of shopping trips of a region is estimated as the difference between the number of shopping trips originating from the region that are targeted at another region *minus* the shopping

[7] Here, negative binomial models are preferred over Poisson model due to the presence of considerable overdispersion (see Gourieroux *et al.*, 1984). These models can be considered modification of the conventional Poisson regression model (Greene, 1994), which is the conventional count data model.
[8] In regressions in which this parameter is not constrained, the parameter value for Population (ln) is most often very close to 1.

trips from outside the region targeted at that region divided by the total number of shopping trips targeted and originating from that region (including intra-regional shopping trips). Data on shopping trips is obtained from *Mobiliteitsonderzoek Nederland* (National Travel Survey) for the period 2004-2008. The scores of these variables by WGR region are presented in Table 10.3.

Table 10.2: Descriptive Statistics of Control Variables (N=378, all measured by region-year, 2000-2008)

Variable Name	Definition	Mean	Standard Deviation	Minimum	Maximum
Population size	Number of inhabitants (1000s)	387.4	291.4	107.2	1389
Average store size	Number of jobs per store	6.36	.669	4.63	7.93
Average store size ("urban loving" stores)	Number of jobs per store of "urban loving" stores	4.17	.498	3.03	5.49
Average store size ("urban neutral" stores)	Number of jobs per store of "urban neutral" stores	9.31	1.07	6.82	12.12
Average store size ("urban avoiding" stores)	Number of jobs per store of "urban avoiding" stores	5.69	.820	3.94	7.88
Average store size (MC stores)	Number of jobs per store of MC stores	3.98	.502	2.82	5.20
Average store size (M stores)	Number of jobs per store of M stores	9.48	1.20	6.66	13.1
Average store size (C stores)	Number of jobs per store of C stores	5.68	.966	3.92	10.6
Average income	Average annual income per inhabitant (1000s of euros)	17.8	1.24	14.7	22.5
Share single households	Share of one-person households	.321	.054	.230	.489
Share population <20	Share of the population that is under 20 years old	.236	.030	.078	.304
Share population >65	Share of the population that is over 65 years old	.142	.025	.048	.197
Hotels	Number of hotels	68.0	61.7	13	403

Table 10.3: Spacing, Retail Concentration and Net Outflow of shopping trips by WGR region

WGR	Spacing (km)	Retail concentration (%)	Net outflow (%)	WGR	Spacing (km)	Retail concentration (%)	Net outflow (%)
Veendam	19.0	21.6	0.33	**Hoorn**	11.1	38.0	3.13
Delfzijl	15.5	22.7	10.84	**Den Helder**	17.3	33.0	3.97
Groningen	14.2	65.2	-6.07	**Alkmaar**	10.0	42.1	-2.01
Leeuwarden	24.4	40.2	-4.56	**Haarlem**	9.7	43.3	-2.44
Sneek	17.0	28.3	4.84	**Leiden**	7.6	34.3	-4.89
Drachten	19.8	22.8	3.27	**Gouda**	**10.6**	25.1	5.21
Assen	20.2	39.3	0.54	**‘s-Gravenhage**	9.4	55.5	1.89
Emmen	15.0	39.8	1.33	**Rotterdam**	7.9	49.2	-1.35
Hoogeveen	12.7	35.7	-1.03	**Dordrecht**	11.8	28.1	2.61
Zwolle	30.0	29.9	3.52	**Goes**	14.7	26.8	5.26
Apeldoorn	18.2	30.4	-0.90	**Middelburg**	4.9	41.5	-2.09
Enschede	13.7	25.0	-0.52	**Terneuzen**	21.2	20.8	0.99
Doetinchem	23.5	17.5	0.99	**Breda**	19.9	27.4	-0.02
Nijmegen	12.3	23.5	-1.72	**Tilburg**	12.5	44.3	0.01
Tiel	19.1	17.9	4.74	**‘s-Hertogenbosch**	15.8	22.9	0.03
Amersfoort	18.2	21.7	0.90	**Eindhoven**	13.0	30.3	-1.20
Harderwijk	11.2	26.3	1.71	**Venlo**	14.8	34.9	3.11
Almere	30.8	39.9	1.67	**Weert**	17.0	28.8	1.13
Utrecht	7.7	36.6	-0.90	**Sittard**	5.5	32.5	-2.90
Hilversum	9.9	37.4	-1.31	**Heerlen**	6.6	33.8	-2.28
Amsterdam	13.8	60.6	-1.00	**Maastricht**	9.1	66.3	2.51

Retail concentration figures for the different store types are available on request

10.5 Econometric Testing

Regional Spatial Structure and Retail Amenities

Table 10.4 shows the results of the negative binomial estimation of regional spatial structure variables on the number of stores in a region, including year fixed effects and controlling for other region-specific characteristics that may have an impact on our spatial structure parameters. All models are estimated using robust standard errors to correct for clustering of observations in regions. The statistically significant likelihood-ratio test of alpha (α) indicates that the negative binomial specification is preferred over its Poisson counterpart because of the presence of overdispersion.

Turning to the regression results, and limiting our discussion to the variables of our interest, we find no effect of the degree of polycentricity and dispersion on the number of stores in a region, holding everything else constant. This is in contrast with our first proposition that polycentricity and dispersion would negatively affect the presence of retail. However, we find a negative and significant effect for the interaction between dispersion and polycentricity on the number of stores in a region. This indicates the presence of less retail amenities in regions that are characterised by both a polycentric and dispersed spatial structure, such as Delfzijl and Veendam as well as the presence of more retail amenities in regions that are characterised by both a monocentric and centralised spatial structure, such as Amsterdam and Rotterdam (see Figure 10.3).

Our second proposition stated that more specialised retail would be less present in polycentric or dispersed regions. Indeed, there are considerable differences across store types. Models 3-14 in Tables 10.5 and 10.6 present the estimates for the store type-specific negative binomial regression models. Models 3-8 show regressions by store urbanism. We find a negative and significant effect of polycentricity on the number of "urban loving" store types in a region, but no effect on the number of "urban neutral" and "urban avoiding" stores, holding everything else constant. This means that more polycentric regions are characterised by a more limited presence of "urban loving" store types, which tend to be more specialised. Similarly, also a more dispersed spatial structure leads to significantly less "urban loving" –store types. However, dispersion has a positive effect on the presence of "urban avoiding" store types. Regions that are both polycentric and dispersed tend to have a more limited presence of all these store types.

Table 10.4: Negative Binomial Pseudo Maximum Likelihood (NBPML) Estimation on Number of Stores in Retail

	All Stores (1)	All Stores (2)
Population (ln)	1.00	1.00
Average store size (ln)	-0.63 (.053)**	-0.65 (.052)**
Average household Income (ln)	-0.11 (.077)	-0.07 (.075)
Share single households	-0.39 (.145)	-0.03 (.128)
Share population <20	-1.21 (.207)**	-1.07 (.202)**
Share population >65	1.69 (.233)**	1.33 (.240)**
Hotels (ln)	0.06 (.007)**	0.06 (.007)**
Polycentricity (ln)	**-0.02 (.014)**	**0.00 (.013)**
Dispersion	**-0.07 (.043)**	**-0.02 (.043)**
Polycentricity(ln)*Dispersion		**-0.37 (.063)****
Year dummies	YES	YES
α (ln) / Sig. LR-test α	-5.14**	-5.26**
AIC	4974	4938
BIC	5045	5013
Observations	378	378

**p<0.01, *p<0.05, robust standard errors in parentheses; All variables are mean-corrected – coefficient of Population (ln) constrained at 1.

Table 10.5: NBPML Estimation on Number of Stores by Store Urbanism

	Urban Loving		Urban Neutral		Urban Avoiding	
	(3)	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Population (ln)	1.00	1.00	1.00	1.00	1.00	1.00
Average store size (ln)[a]	-0.32 (.082)**	-0.34 (.078)**	-0.51 (.041)**	-0.54 (.041)**	-0.37 (.061)**	-0.43 (.056)**
Average household Income (ln)	0.29 (.129)**	0.33 (.128)**	-0.11 (.063)	-0.09 (.061)	-0.39 (.097)**	-0.32 (.091)**
Share single households	-0.16 (.218)	0.27 (.196)	-0.49 (.110)**	-0.23 (.106)*	-1.06 (.176)**	-0.52 (.187)**
Share population <20	-2.19 (.347)**	-2.04 (.343)**	-1.09 (.161)**	-0.98 (.159)**	-0.77 (.214)**	-0.50 (.210)*
Share population >65	3.20 (.413)**	2.80 (.407)**	1.52 (.176)**	1.24 (.192)**	0.91 (.265)**	0.35 (.281)
Hotels (ln)	0.10 (.012)**	0.10 (.011)**	0.05 (.006)**	0.05 (.005)**	0.01 (.012)	0.01 (.010)
Polycentricity (ln)	**-0.05 (.020)****	**-0.02 (.019)**	**-0.01 (.016)**	**0.01 (.012)**	**0.01 (.018)**	**0.05 (.021)***
Dispersion	**-0.46 (.066)****	**-0.29 (.062)****	**0.03 (.035)**	**0.07 (.034)**	**0.32 (.059)****	**0.38 (.055)****
Polycentricity(ln)*Dispersion		**-0.45 (.100)****		**-0.27 (.055)****		**-0.59 (.089)****
Year dummies	YES	YES	YES	YES	YES	YES
α (ln) / Sig. LR-test α	-4.14**	-4.19**	-5.67**	-5.77**	-5.04**	-5.29**
AIC	4405	4388	4359	4332	3546	3491
BIC	4476	4463	4430	4407	3617	3566
Observations	378	378	378	378	378	378

**p<0.01, *p<0.05, robust standard errors in parentheses; All variables are mean-corrected – coefficient of Population (ln) constrained at 1.
a Average store size variable is store-type specific (e.g., for Model 3 and 4 the average store size of "urban loving" stores is used)

Table 10.6: NBPML Estimation on Number of Stores by Store Type

	MC Stores		M Stores		C Stores	
	(9)	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Population (ln)	1.00	1.00	1.00	1.00	1.00	1.00
Average store size (ln)	-0.57 (.073)**	-0.58 (.068)**	-0.55 (.039)**	-0.57 (.040)**	-0.34 (.038)**	-0.35 (.038)**
Average household Income (ln)[a]	0.10 (.132)	0.16 (.128)	-0.01 (.064)	0.00 (.063)	-0.56 (.109)**	-0.50 (.109) **
Share single households	-0.54 (.228)*	-0.05 (.200)	-0.27 (.105)**	-0.10 (.092)	-0.90 (.196)**	-0.47 (.207)*
Share population <20	-1.75 (.320)**	-1.59 (.315)**	-1.16 (.175)**	-1.17 (.174)**	-0.60 (.184)*	-0.47 (.177)**
Share population >65	2.96 (.377)**	2.50 (.378)**	1.60 (.206)**	1.39 (.210)**	0.67 (.276)*	0.30 (.292)
Hotels (ln)	0.09 (.013)**	0.09 (.011)**	0.06 (.005)**	0.06 (.006)**	-0.00 (.013)	-0.01 (.012)
Polycentricity (ln)	**-0.08 (.020)****	**-0.04 (.020)***	**0.01 (.012)**	**0.02 (.010)**	**-0.02 (.019)**	**0.01 (.022)**
Dispersion	**-0.28 (.067)****	**-0.19 (.061)****	**-0.06 (.031)**	**-0.03 (.031)**	**0.17 (.054)****	**0.24 (.054)****
Polycentricity(ln)*Dispersion		**-0.53 (.111)****		**-0.20 (.047)****		**-0.46 (.094)****
Year dummies	YES	YES	YES	YES	YES	YES
α (ln) / Sig. LR-test α	-4.12**	-4.20**	-5.81**	-5.87**	-4.62**	-4.71**
AIC	4470	4445	4136	4122	3891	3866
BIC	4541	4520	4206	4197	3962	3940
Observations	378	378	378	378	378	378

**p<0.01, *p<0.05, robust standard errors in parentheses; All variables are mean-corrected – coefficient of Population (ln) constrained at 1.
a Average store size variable is store-type specific

Models 9-14 (Table 10.6) analyse the determinants of the number of stores by store orientation. If the degree of polycentricity increases by 1%, the number of stores that cater to multipurpose and comparison shoppers (MC) decreases by about 0.08%. On the contrary, polycentricity has no effect on the number of stores that rely on externalities generated by multipurpose (M) or comparison (C) shoppers only. This difference between MC stores and the other two store types is significant (MC-M: (χ^2=7.19, df=1, p<0.01; MC-C: χ^2=32.51, df=1, p<0.01). Likewise, dispersion has a stronger negative effect on the number of stores that attract multipurpose and comparison shoppers than on the number of stores that attract solely multipurpose shoppers (χ^2=18.07, df=1, p<0.01) and stores that predominantly cater to single-purpose comparison shoppers (χ^2=50.10, df=1, p<0.01). Interestingly, single-purpose comparison shops tend be more present the more dispersed a region is, while multipurpose and comparison shopping is less present the more dispersed a region is. The effect of the interaction between dispersion and polycentricity is negative for all store orientation categories, but is more strongly negative for the MC and C store types. Accordingly and in line with the second proposition, it can be concluded that more polycentric and dispersed regions are home to less specialised retail amenities.

Spacing, Retail Concentration and Retail Amenities

The third proposition stated that having more proximate centres in a polycentric or dispersed region would be beneficial compared to the situation in they were more spread out. Examining the interaction between spacing and the regional spatial structure variables in Table 10.7, we find no main effect of the degree of spacing between centres in a region on the number of stores in a region (Model 15). However, there is a negative effect of the interaction between spacing and polycentricity and the interaction between spacing and dispersion. These negative and significant interaction terms can be interpreted as the fact that retail amenities in polycentric and dispersed regions are more negatively affected by large distances between the centres than that is the case in monocentric regions. Alternatively, this confirms our expectations based on the third proposition that the larger the spacing between centres in a region, the more negative the effect of polycentricity and dispersion on the number of stores in a region is. However, the interaction effect between spacing and dispersion differs across store types (Model 16-21) and is significantly lower for “urban loving” and MC store types than for the other store types.[9] The interaction effect

[9] The related Wald tests on the equality of coefficients are available upon request.

between spacing and polycentricity varies less drastically across store types, although it is significantly more negative for MC and C store types than for M store types (MC-M: χ^2=7.73, df=1, p<0.01; C-M: χ^2=12.35, df=1, p<0.01). Accordingly, it can be inferred that spacing between the centres has especially a negative effect on the number of specialised stores in a region.

Our fourth proposition concerns the question whether concentration of retail in one centre of a polycentric or dispersed region would be beneficial. Table 10.8 shows the results on retail concentration, regional spatial structure and the number of stores in a region.[10] For a region with an average level of polycentricity and dispersion, we find no effect of retail concentration of stores on the number of stores in a region[11], as well as no effect of the interaction term between retail concentration and polycentricity. However, the interaction effect between retail concentration and dispersion is positive and significant. This means that, in line with our fourth proposition, more retail amenities are present in dispersed regions in which retail is concentrated. Parameter estimates differ across store types and especially the specialised store types that cater to multipurpose and comparison shoppers (Model 26) profit from retail concentration. This also makes sense from a theoretical point of view as these stores profit from the concentration of similar types of stores. To compare, for stores that only draw on multipurpose shoppers (Model 27), we find a negative effect of retail concentration (although not significantly so) and the interaction effect between retail concentration and polycentricity. This is in line with McLafferty's and Ghosh's (1986) prediction that multipurpose shopping by itself generally leads to a dispersion of similar, competing retail establishments. Nevertheless, more disaggregated analysis by retailing function is needed here to validate this claim. We also find a positive interaction effect between retail concentration and dispersion for the urban avoiding stores, meaning that in dispersed areas we find more of such stores in case these are concentrated. However, this does not necessarily mean that these store types profit from concentration in large cities as it is well known that the retailing functions such as garden centres and furniture stores cluster together on business areas at the fringe of the city.

[10] VIF statistics indicated no multicollinearity problem between the spatial structure and retail structure variables.
[11] Similar conclusions can be drawn based on a model without interaction terms.

Table 10.7: NBPML Estimation on Number of Stores in Retail – Spacing Effect

	All Stores (15)	**Urban Loving (16)**	**Urban Neutral (17)**	**Urban Avoiding (18)**	**M**
Population (ln)	1.00	1.00	1.00	1.00	1.00
Average store size (ln)[a]	-0.59 (.048)**	-0.35 (.079)**	- 0.47 (.041)**	-0.40 (.058)**	-0.59
Average household Income (ln)	0.03 (.077)	0.44 (.125)**	-0.02 (.065)	-0.29 (.100)**	0.28
Share single households	-0.18 (.123)	0.20 (.201)	-0.36 (.098)**	-0.89 (.187)**	-0.17
Share population <20	-1.55 (.214)**	-2.61 (.365)**	-1.29 (.166)**	-0.97 (.226)**	-2.25
Share population >65	1.98 (.247)**	3.57 (.381)**	1.59 (.200)**	1.15 (.291)**	3.54
Hotels (ln)	0.07 (.007)**	0.10 (.010)**	0.05 (.006)**	0.01 (.013)	0.10
Spacing (ln)	**-0.01 (.013)**	**-0.05 (.021)***	**-0.02 (.011)**	**0.04(.013)***	**-0.02**
Polycentricity (ln)	-0.01 (.013)	-0.04 (.018)*	0.00 (.011)	0.03 (.018)	-0.06
Dispersion	0.05 (.043)	-0.13 (.061)*	0.13 (.037)**	0.30 (.062)**	-0.08
Polycentricity(ln)*Spacing(ln)	**-0.12 (.019)****	**-0.11 (.032)****	**-0.10 (.017)****	**-0.12 (.032)****	**-0.12**
Dispersion*Spacing(ln)	**-0.56 (.076)****	**-1.25 (.133)****	**-0.33 (.067)****	**-0.14 (.115)**	**-1.23**
Year dummies	YES	YES	YES	YES	
α (ln)	-4.35**	-4.40**	-5.83**	-5.11**	-
AIC	4915	4333	4318	3532	
BIC	4997	4416	4402	3615	
Observations	378	378	378	378	

**p<0.01, *p<0.05, robust standard errors in parentheses; All variables are mean-corrected – coefficient of Population (
a Average store size variable is store-type specific

Table 10.8: NBPML Estimation on Number of Stores in Retail –Retail Concentration Effect

	All Stores (22)	**Urban Loving (23)**	**Urban Neutral (24)**	**Urban Avoiding (25)**	**MC Stores (26)**	**M Stores (27)**	**C Stores (28)**
Population (ln)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Average store size (ln)	-0.64 (.059)**	-0.29 (.089)**	-0.53 (.046)**	-0.45 (.064)**	-0.62 (.072)**	-0.57 (.046)**	-0.35 (.037)**
Average household Income (ln)[a]	-0.04 (.076)	0.32 (.123)**	-0.12 (.062)	-0.31 (.095)**	0.17 (.126)	-0.01 (.063)	-0.56 (.115)**
Share single households	-0.29 (.144)	-0.41 (.237)	-0.33 (.129)*	-0.42 (.201)*	-0.45(.223)*	-0.34 (.119)**	-0.36 (.260)
Share population <20	-1.13 (.223)**	-1.93 (.362)**	-1.06 (.174)**	-0.57 (.214)**	-1.37 (.323)**	-1.20 (.179)**	-0.60 (.186)**
Share population >65	1.46 (.272)**	2.77 (.452)**	1.48 (.202)**	0.70 (.322)*	2.10 (.411)**	1.72 (.227)**	0.67 (.315)*
Hotels (ln)	0.07 (.007)**	0.11 (.012)**	0.05 (.006)**	0.01 (.012)	0.11 (.012)**	0.06 (.007)**	-0.01 (.013)
Retail concentration[b]	**0.12 (.089)**	**0.45 (.120)****	**-0.08 (.071)**	**-0.09 (.105)**	**0.59 (.110)****	**-0.13 (.099)**	**-0.16 (.119)**
Polycentricity (ln)	0.00 (.021)	0.02 (.029)	-0.02 (.018)	0.01 (.027)	0.03 (.026)	-0.02 (.021)	-0.04 (.024)
Dispersion	-0.01 (.045)	-0.34 (.069)**	0.04 (.041)	0.38 (.067)**	-0.15 (.065)*	-0.10 (.037)**	0.02 (.119)
Polycentricity(ln)*Retail conc.	**0.05 (.084)**	**0.14 (.151)**	**0.04 (.081)**	**0.23 (.116)**	**0.29 (.132)***	**-0.22 (.098)***	**0.24 (.147)**
Dispersion* Retail conc.	**0.79 (.278)****	**0.02 (.507)**	**0.17 (.238)**	**1.76 (.394)****	**1.53 (.484)****	**-0.01 (.213)**	**0.66 (.392)**
Year dummies	YES	YES	YES	YES	YES	YES	YES
α (ln)	-5.18**	-4.22**	-5.69**	-5.22**	-4.27**	-5.84**	-4.67**
AIC	4970	4374	4362	3517	4431	4136	3883
BIC	5053	4425	4444	3600	4514	4218	3966
Observations	378	378	378	378	378	378	378

**p<0.01, *p<0.05, robust standard errors in parentheses; All variables are mean-corrected – coefficient of Population (ln) constrained at 1.
a Average store size variable is store-type specific; b Retail primacy variable is store-type specific (e.g., for MC stores (Model 26) the retail primacy of MC stores is used)

Table 10.9: NBPML Estimation on Number of Stores in Retail – Net Outward Consumers Effect

	All Stores (29)	**Urban Loving (30)**	**Urban Neutral (31)**	**Urban Avoiding (32)**	**MC Stores (33)**	**M Stores (34)**	**C Stores (35)**
Population (ln)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Average store size (ln)	-0.62 (.052)**	-0.49 (.074)**	-0.50 (.041)**	-0.38 (.061)**	-0.72 (.068)**	-0.51 (.041)**	-0.36 (.034)**
Average household Income (ln)	0.00 (.072)	0.37 (.118)**	-0.03 (.060)	-0.23 (.091)**	0.22 (.116)	0.03 (.064)	-0.36 (.103)**
Share single households	0.09 (.162)	1.05 (.235)**	-0.14 (.139)**	-0.92 (.196)**	0.61 (.228)**	0.11 (.130)*	-0.92 (.199)**
Share population <20	-0.89 (.184)**	-1.45 (.312)**	-0.89 (.150)**	-0.35 (.209)	-0.97 (.286)**	-1.23 (.177)**	-0.13 (.201)
Share population >65	0.94 (.230)**	1.55 (.394)**	1.00 (.190)**	0.11 (.297)	1.22 (.361)**	1.31 (.207)**	-0.08 (.342)
Hotels (ln)	0.05 (.007)**	0.07 (.012)**	0.04 (.006)**	0.01 (.011)	0.07 (.013)**	0.05 (.006)**	-0.00 (.012)
Share net outward	**-0.61 (.152)****	**-0.78 (299)****	**-0.40 (.116)****	**-1.45 (.157)****	**-1.23 (.291)****	**0.10 (.143)**	**-1.81 (.269)****
Polycentricity (ln)	0.00 (.016)	-0.01 (.020)	0.01 (.014)	0.02 (.019)	-0.03 (.020)	0.01 (.010)	-0.01 (.019)
Dispersion	0.13 (.047)**	0.00 (.067)	0.17 (.044)**	0.52 (.069)**	0.13 (.065)	0.04 (.037)	0.38 (.058)**
Polycentricity(ln)*Share outw.	**-1.69 (.299)****	**-3.84 (.486)****	**-1.33 (.275)****	**-1.34 (.383)****	**-3.96 (.487)****	**-1.25 (.250)****	**-0.69 (0.44)**
Dispersion)*Share outward	**-2.70 (.754)****	**-6.57 (1.28)****	**-1.50 (.061)***	**-0.81 (.643)**	**-6.34 (1.35)****	**-1.03 (.559)**	**-2.09 (1.27)**
Year dummies	YES	YES	YES	YES	YES	YES	YES
α (ln)	-5.36**	-4.45**	-5.81**	-5.23**	-4.39**	-5.91**	-4.81**
AIC	4905	4304	4320	3503	4347	4118	3832
BIC	4988	4387	4403	3586	4430	4201	3915
Observations	378	378	378	378	378	378	378

**p<0.01, *p<0.05, robust standard errors in parentheses; All variables are mean-corrected – coefficient of Population (ln) constrained at 1.
a Average store size variable is store-type specific

Regional Spatial Structure and Outward Orientation

The foregoing analyses implicitly assumed that retailing functions outside a certain region do not have any effect on the retailing functions within that region. Although on average 93% of all Dutch shopping trips take place within the own region, there are considerable differences across regions, and especially in polycentric and dispersed regions. For example, Delfzijl in the north of the Netherlands can be considered a second-order region within some first-order region at a higher geographical scale with Groningen (see also Figure 10.2) as principal centre. This is reflected in the large share of shopping trips (13.6%) that originate from the Delfzijl region and are targeted at Groningen. At the same time, few people living in Groningen (0.9%) do their shopping in the Delfzijl region. Comparable regions that are also characterised by a net outflow of shopping trips to neighbouring regions are Gouda (large net loss of consumers to Rotterdam and The Hague), Goes (net loss to Breda), and Sneek (large net loss to Drachten and Leeuwarden). There exists a moderately strong correlation between the degree of polycentricity and the net outflow of shopping trips (0.24) and the degree of dispersion and the net outflow of shopping trips (0.52) in the sense that more polycentric and more dispersed regions are characterised by higher net outflows of consumers. In actual fact, monocentric regions with large principal cities such as Amsterdam, Rotterdam and Groningen experience a net inflow of consumers. Yet, some polycentric and/or dispersed regions such as Middelburg and Terneuzen that are relatively spatially isolated, face less competition from neighbouring regions, and, hence, do not experience a large loss of consumers to neighbouring regions.

Table 10.9 shows the regression results of the net outflow of shopping trips on the number of stores in a region. Although this specification faces some serious endogeneity problems given that the direction of the relationship between consumer mobility and retail amenities is far from clear (in that the absence of retail amenities in a region can also lead to the generation of shopping trips to other regions), we find a negative and significant relation between the net outflow of shopping trips and the number of stores in a region (Model 29). This is in line with our fifth proposition, in which a net outflow of shopping trips was considered to lead to less, and in particular less specialised retail. For a region with an average level of polycentricity and dispersion, a 1 percent point increase in the net outflow of shopping trips translates into a decrease in the number of stores by 0.61%, holding everything else constant. The interaction effects between the net outflow of shopping trips and the regional spatial structure variables are also negative[12]. This means that the larger the net outflow of shopping trips to other regions, the more negative the effect of polycentricity and dispersion on the number of stores in a region is. Especially stores that profit from a densely populated environment and cater to multipurpose and comparison shoppers are affected by a relatively large net outflow of shopping trips (Model 30-35). This is in line with our expectations, as these are more specialised stores for which consumers are willing to travel longer distances and which require a large demand threshold.

10.6 Conclusions and Discussion

In this chapter, we have researched the relationship between regional spatial structure and the presence of retail amenities in a region. It was found that there is no relationship between polycentricity or dispersion and the overall number of stores, but regions that are both polycentric ánd dispersed are characterised by relatively less retail amenities. In addition, it was found that polycentric and dispersed regions host less specialised retailing functions that cater to multipurpose and comparison shoppers and/or demand an urban environment. This chapter subsequently explored ways to overcome these negative effects of polycentricity and dispersion. It was obtained that the effect of polycentricity and dispersion is dependent on (1) the spacing between cities in a region, (2) retail concentration, and (3) spatial competition from neighbouring regions. Polycentric or dispersed regions that fared better than other polycentric or dispersed regions were characterised by (a) its constituent centres being located more proximally, (b) a relative strong concentration of retail in one centre, and (c) less competition from centres outside the region. These findings have important implications for regional policy.

First, as polycentric and dispersed regions in which the distances between the different cities are relatively small perform generally better in the sense that they host more (specialised) retail amenities, it would make sense to limit these distances. Although one cannot change physical distance between cities in a region, investments in infrastructure and public transportation could be targeted to limit the distance in terms of travel time. This overcomes barriers to consumer trade and, hence, allows to 'organise' critical mass in a region to generate urban network externalities.

[12] Yet we believe that in principal stores follow people and not the other way around. Hence, the net outflow of shopping trips foremost signifies the opportunities consumers have to shop outside a region.

Second, polycentric and dispersed regions in which retail is relatively concentrated perform generally better in terms of having more specialised retail amenities that cater to multipurpose and comparison shoppers, as well as store types that normally flourish in larger cities. Here, regional coordination between the different cities in a region can play an important role in realising concentration of specialised retail. Such coordination should aim at avoiding duplications in local retail development strategies in a situation where cities are often pursuing the same policy to promote their distinctiveness to increase local prosperity (Turok, 2009). It is not necessary, if not undesirable, to concentrate all retailing functions: those stores that sell frequently bought convenience goods and only cater to multipurpose shoppers do not need to be concentrated. Yet, reducing intra-regional spatial competition by means of concentration of retail to maximise retail amenities at the regional level will also be beneficial to battle competition from retail centres in neighbouring regions.

However, improving regional coordination with respect to retail planning is easier said than done, as the benefits and costs of such a strategy accrue to different stakeholders and appear at different moments in time. This calls for trade-off mechanisms, as well as (planning) tools, such as regional spatial visioning processes, to raise understanding of the 'regional' common good among local decision-makers.

Chapter 11:

Summary and an Agenda for Research and Policy

11.1 The Triumph of the Urban Network?

There has recently been a growing interest in urban networks in research motivated by efforts at spatial planning and policy. The appearance of the urban network concept in policy memoranda coincides with a number of recent studies on changing urban systems. In this literature, it is argued that demographic changes (e.g., a growing proportion of dual-earner and single-person households) and the rise of the network economy (e.g., advances in transportation and communication technology and growth of the service sector) have had a significant impact on the spatial structure of cities and regions (see, for example, Camagni, 1993; Batten, 1995; Champion, 2001). According to this model, at the local, intra-urban scale, monocentric cities are disappearing and developing into polycentric metropolitan areas, while at the same time, social and economic processes are taking place at an ever larger geographical scale, beyond that of the city, in which historically separate metropolitan areas are becoming increasingly functionally connected to form polycentric urban regions (PURs) at the inter-urban scale. It is therefore often argued that the traditional Christallerian central-place conceptualisation of urban systems characterised by a strict urban hierarchy is outdated and can best be replaced by a network view of urban systems characterised by the lack of an urban hierarchy and a significant degree of spatial integration between different centres. In this model, the relationships between cities and towns in a fully integrated urban network are largely complementary in nature, in that cities and town have different economic specialisations. Table 11.1 lists the most important differences between a hierarchical model and a network model of spatial organisation (for similar taxonomies, see Batten, 1995; Van der Knaap, 2002; Meijers, 2007) and the chapters in which the constituent characteristics are (directly or indirectly) discussed.

In contemporary spatial planning and policy, a shift to the network model is often seen as a panacea for regional economic-development problems. Polycentricity and urban networks have become catchphrases, where polycentric development policies have been introduced to support territorial cohesion as well as higher levels of urban and regional competitiveness (Meijers and Romein, 2003). However, despite this enthusiasm for the ideas of urban networks, polycentricity and spatial integration, previous empirical assessments of the network model leave much to be desired. As Davoudi (2003, p. 72) argues, a polycentric and networked spatial organisation "*now appears to be cropping up* *everywhere as an ideal type of regional spatial structure, despite a lack of common definition and empirical evidence about its desirability, effectiveness, or the potential for its alleged success being replaced elsewhere by policy intervention*." In addition to the problem of divergent approaches to conceptualising and measuring polycentricity and spatial integration, it remains unclear to what extent (1) urban systems are becoming more polycentric and spatially integrated, (2) relationships between cities in polycentric, spatially integrated urban systems are complementary rather than competitive and (3) polycentric, spatially integrated urban systems are more economically efficient than their monocentric and/or nonintegrated counterparts.

Table 11.1: Characteristics of Urban Systems in Hierarchical Versus Network Models

Characteristic	Network System	Hierarchical System	Chapters
Morphological structure	Multinodal; several centres in close proximity to each other; centres of relatively similar importance.	Uninodal; one principal centre; relatively significant separation between city and countryside.	2, 3, 7, 8
Orientation of functional linkages and spatial integration	Multidirectional; two-way core-periphery/periphery-core linkages and criss-cross linkages between centres of similar size.	Unidirectional; linkages directed at the principal centre; no relationships between centres of similar size.	2, 3, 4, 7, 8
Type of spatial constellation	Network city or polycentric urban region (PUR).	Monocentric metropolitan area	3, 4, 7, 8
Relationship between spatial units	Tendency toward complementarities and regional cooperation.	Tendency toward competition, local orientation and dependence.	5, 8, 10
Economic specialisation	Function of centres independent of centre size but dependent on urban-network position; spatial division of labour between centres.	Economic function of centres dependent on centre size, with higher-order functions concentrated in larger centres.	5, 8, 10
Economic externalities	Agglomeration economies shared among groups of cities of similar size; no agglomeration disadvantages.	Agglomeration economies restricted to the urban core.	9, 10

11.2 Summary of Major Findings and Contributions

This dissertation brings together a number of articles written over the past four years with the common theme of *spatial interdependence* regarding the aforementioned problems in the contemporary literature on urban systems. As the case studies differ considerably between chapters (ranging from Dutch WGR regions and English and Welsh metropolitan regions to American metropolitan areas), I focus in this section on the major overall findings and contributions of this dissertation to the existing literature on the spatial organisation of urban systems. For more specific conclusions with regard to each case study, the reader is referred to the respective chapters.

Conceptualisation and Measurement of the Spatial Organisation of Urban Systems

In this dissertation, we have – sometimes implicitly – argued that a useful conceptualisation of polycentricity, spatial integration and urban networks must be related to (1) the mainstream planning discourse on the spatial organisation of urban systems, so that it can provide guidance for planners and policy-makers with regard to appropriate levels for spatial planning and governance, and (2) the previous analytical work on spatial structures found in research on central-place theory (Christaller, 1933) and urban-systems research (Bourne and Simmons, 1978).

In such conceptualisations, we have argued that a lack of hierarchy with respect to importance among the larger centres in an urban system can be considered the defining characteristic of polycentricity. Such a conceptualisation of polycentricity corresponds closely with contemporary policy discourse and with earlier research in central-place and urban-systems theory, but differs somewhat from the conceptualisations used in other studies (mostly in urban economics) that have analysed polycentricity in urban systems with respect to the mere existence of multiple centres in such systems (see, for example, Giuliano and Small, 1991; McMillan, 2001).

Table 11.2: Morphological versus Functional Perspective in Urban Systems Theory

		Spatial Analysis	
		Morphological Perspective	**Functional Perspective**
Organisational Logic	Hierarchical System	Cities of different sizes following the rank-size rule; one principal centre; population and economic activities not occurring in the principal city are dispersed.	High degree of network centralisation; unidirectional flows directed at the principal centre; limited number of linkages.
	Network System	Cities of comparable size in close proximity to each other; multiple centres; multiple point of concentration of population and economic activities.	Low degree of network centralisation; multidirectional flows; large number of linkages.

However, polycentricity can have many faces. As we have pointed out in several chapters, one of the most significant differences of opinion in the debate on polycentricity centres on the question of whether the term refers only to morphological aspects of the urban system or whether it should also incorporate relational aspects between the centres making up the urban system in question. Table 11.2 provides an overview of the morphological and functional definitions of the hierarchical and network models of spatial organisation.

Because many polycentric-development policies are based on functional linkages between centres with respect to the physical movement of goods, people and information, the notion of functional polycentricity seems most useful. In addition, it has been shown that functional and morphological polycentricity can be linked theoretically, as they are both rooted in central-place theory and the urban-systems literature and can both be measured and compared using rank-size regressions (Chapter 2) or primacy indices (Chapter 3). Although a morphologically polycentric region does not necessarily have to be functionally polycentric, empirically, there is often a strong positive correlation between the degrees of morphological and functional polycentricity. Once a distinction has been drawn between morphological and functional polycentricity, the concept of functional polycentricity can be further refined by focusing on the *orientation* of the functional links within an urban system and distinguishing between two-way periphery-core and core-periphery links and criss-cross (inter-periphery) linkages at different geographical scales (see Chapter 3, 7, and 8). It is also possible to come up with auxiliary morphological forms in terms of the degree of dispersion or the extent to which population or employment opportunities are spread across a region in a nonconcentrated manner (see Chapters 9 and 10).

Table 11.3: Network Orientation versus Network Strength in Urban Network Models

		Network Characteristic	
		Orientation of Linkages	**Strength of Linkages**
Organisational Logic	Hierarchical System	Unidirectional linkage pattern between core and periphery; few places interconnected.	Strong bi-territorial linkages; overall low degree of network density.
	Network System	Multidirectional pattern with two-way and criss-cross linkages; many places interconnected.	Weak bi-territorial linkages; overall high degree of network density.

Another important aspect of urban networks is their degree of *spatial integration*. While the degree of functional polycentricity of an urban system is determined by the orientation of linkages, the degree of spatial integration is determined by the degree to which its centres are functionally linked. Table 11.3 lists the main characteristics of hierarchical and network systems based on the orientation of their functional linkages and their network density. Recent studies (e.g., Hall and Pain, 2006; Green, 2007) have used combined measures of functional polycentricity and spatial integration. However, we have argued that it is better not to combine measures of functional polycentricity and spatial integration because there are some hierarchically organised urban systems with high network density and functionally polycentric urban systems with low network density. Empirically, only a weak correlation has been found between the degree of functional polycentricity and network density, although morphologically polycentric regions do tend to be relatively more spatially integrated.

In addition, our research has focused on methods for evaluating urban networks. Building on the definitions of the PUR given in Champion (2001), Kloosterman and Musterd (2001) and Parr (2004), functional polycentricity and spatial integration were integrated into one formal testing model. The main advantage of such a methodology is that it (1) sets clear conditions for determining whether a given geographic area constitutes a PUR and (2) makes it possible to distinguish between different types of spatial constellations based on their degree of spatial integration and degree of functional polycentricity at different geographical scales (intra-urban or inter-urban), as shown in Table 11.4.

Table 11.4: Spatial Constellations at Different Geographical Scales

		Geographical scale	
		Intra-urban scale	**Inter-urban scale**
Organisational Logic	Hierarchical System	Monocentric urban region; unidirectional orientation of functional linkages at the intra-urban scale; intra-urban interdependencies significantly stronger than inter-urban interdependencies.	Monocentric greater metropolitan area; unidirectional orientation of functional linkages at the inter-urban scale; intra-urban interdependencies not stronger than inter-urban interdependencies.
	Network System	Network city; unidirectional orientation of functional linkages at the intra-urban scale; intra-urban interdependencies significantly stronger than inter-urban interdependencies.	PUR / Fully integrated urban network; multidirectional orientation of functional linkages at the inter-urban scale; intra-urban interdependencies not stronger than inter-urban interdependencies.

Using a gravity-model framework and count-data regression (see Chapter 6), it was argued that, within a PUR proper, the spatial-functional context has no effect on the intensity of functional linkages between places other than the masses of the origins and destinations and the physical distance between them. This analytical framework can be considered very stringent, while less rigorous testing leaves much room for speculation on the potential usefulness of paradigms such as the PUR model for planning an policy-making. Using this rigorous framework, we found only low degrees of functional polycentricity and spatial integration at the inter-urban scale in the greater southeast region of the United Kingdom (Chapter 7) and the Randstad region of the Netherlands (Chapter 8). The weakness of this pattern in the Randstad (the prototypical PUR) especially calls into question the applicability of the urban-network concept in general, although it should be noted that most urban systems have characteristics of both hierarchical and network systems.

In the chapters on the conceptualisation and measurement of the spatial organisation of urban systems, we also examined their temporal, spatial, and functional heterogeneity. We found that, firstly, urban systems are becoming more polycentric and spatially integrated, but that changes are generally slow (see Chapters 3 and 7). Secondly, there are large differences in the degrees of polycentricity and spatial integration across urban systems at both the intra-urban and inter-urban scales. Some urban systems are predominantly monocentric, while other urban systems are predominantly polycentric, and most urban systems are somewhere in between (see Chapters 2 and 3). Thirdly, the degrees of polycentricity and spatial integration of a particular region are highly dependent on the specific types of data being observed (in particular, see Chapter 4). A territory can appear functionally polycentric and integrated in terms of daily-activity patterns but functionally monocentric and nonintegrated in terms of corporate-control functions. In addition, the spatial organisation of urban systems can vary across spatial scales; it can be polycentric at the intra-urban and monocentric at the inter-urban scale or vice versa (see Chapters 7 and 8). Likewise, the geographical scope of spatial interaction varies from very local to predominantly international (see Chapter 4). Most pessimistically, as other researchers in geography and planning have argued (e.g., Albrechts et al., 2003; Healey, 2004; Lambregts et al., 2005; 2006), we conclude that any evaluation of the spatial organisation of an urban system is, at least to a certain extent, in 'the eye of the beholder' (Lambregts, 2005), as it is dependent on the lens through which it is viewed. In other words, perceptions of polycentricity and spatial integration, to a large extent, depend on the data sets on which they are based.

Competition and Complementarities in Urban Networks

In Chapters 5, 8 and 10, we focused on competition and complementarities in urban systems, where competition and complementarities can be perceived as two ends of the same spectrum. In this model, it is important to note that it is not regions themselves that are competing or cooperating, but groups representing regionally based economic interests, such as local or regional governments. In analysing the tension between competition and complementarities among centres in urban systems, three conditions for the emergence of regional competition were outlined: (1) sectoral market overlap, (2) functional market overlap, and (3) geographical market overlap. This conceptualisation of cities competing over overlapping market areas has a long-standing history in urban-systems research (see, for example, Berry et al., 1988; Parr, 1995) starting with the work of Galpin (1915) on urban-rural relations and Reilly (1931) on retail location. Using this conceptual framework, we developed an indicator to measure the intensity of competition between pairs of spatial units, which can be considered the most detailed level at which spatial competition can be measured (see Chapter 5). The relationship between spatial organisation and cooptition summarised in Table 11.5.

Table 11.5 Competition and Complementarities in Hierarchical and Network Systems

		Economic Specialisation	
Organisational Logic		**Dissimilar Specialisations**	**Similar Specialisations**
	Hierarchical System	All higher-order economic activities with a high demand threshold conducted in the principal centre; smaller centres participating only in lower-order activities; competition between centres.	Archipelago economy, in which small centres are miniature replicas of the principal centre.
	Network System	Division of labour and existence of complementarities between centres; different centres not necessarily specialising in lower- versus higher-order activities; cooperative relationships between centres.	Centres specialising in the same economic activities, resulting in a lack of complementarities; competitive relationships between centres.

Focusing on the market for greenfield investments in Europe, it was shown that, among other findings, European regions with similar locational endowments in close proximity pose a relatively more fierce competitive threat to one another. Although the case study discussed in Chapter 5 focused on competition and complementarities at the continental scale, the findings also draw attention to the potential lack of a pattern of complementarities within a PUR. Indeed, in similar studies on economic specialisations

(Van Oort et al., 2010) and inter-company trade patterns in the Randstad (Burger et al., 2011b), it was shown that competition is more the rule than the urban complementarities so much anticipated by regional- and national-level Dutch policy-makers. In fact, the urban centres in the Randstad are becoming more similar in terms of economic specialisations and show a strikingly high geographical market overlap. This pattern of competition rather than complementarities in the Randstad was also found in the case study discussed in Chapter 8, although the conceptualisation of complementarities in that analysis differs slightly from the one presented in Chapter 5. In Chapter 8, complementarities are defined as the spatial integration of cities and towns with different economic specialisations.

A competitive relationship between cities, leading to redundant supply of real estates, inefficient land-use patterns and unnecessarily costs of business acquisition, is usually seen as negative (Farell, 1996). This problem is also discussed briefly in Chapter 10, where it is suggested that intra- and inter-regional competition can explain the absence of specialised retailing in more polycentric regions. However, other studies have pointed out that a competitive urban climate in regions like the Randstad can coincide with strong economic growth indicators such as employment and productivity growth (OECD 2007), suggesting that competition may well function as a catalyst for urban and regional growth (Porter, 1990).

The Effect of Polycentricity on Regional Performance

In Chapters 9 and 10, the focus shifts from measuring the spatial organisation of urban systems to examining the consequences of the spatial organisation of urban systems. In that analysis, we focused predominantly on the effect of morphological polycentricity on regional economic performance at the intra-urban scale. Polycentricity has been perceived as a panacea for problems with local and regional economic development. For example, it is believed that, in the present day, external economies are no longer restricted to a single, well-defined urban core but are instead shared among a group of functionally linked places. On the other Conversely, polycentric systems are often assumed to be free of agglomeration disadvantages, such as fierce competition for land and labour, congestion, and pollution exposure. These relationships are summarised in Table 11.6.

However, based on our empirical case studies, we can conclude that polycentricity does not always enhance regional performance. In Chapter 9, we analysed the relationship between spatial structure and labour productivity in metropolitan areas in the United States and found a significant positive effect of polycentricity on regional labour productivity. However, we also showed that polycentric spatial structures have fewer agglomeration economies than their monocentric counterparts. One explanation for these findings is that travel, commodity flows and knowledge flows do not occur as easily in a polycentric structure as in a single larger city, which also has the advantages of a more metropolitan environment (Parr, 2004). Another possible reason that polycentricity is relatively more beneficial in smaller metropolitan areas is that cities in smaller polycentric metropolitan areas may be more functionally related than those in larger polycentric metropolitan areas.

Table 11.6 External Economies in Hierarchal and Network Systems

		Type of External Economies	
Organisational Logic		**Agglomeration Economies**	**Urban Network Economies**
	Hierarchical System	Significant agglomeration economies; Significant agglomeration diseconomies.	Agglomeration economies confined to the principal centre.
	Network System	Insignificant agglomeration economies; insignificant agglomeration diseconomies.	Agglomeration economies shared among a group of urban settlements

In Chapter 10, we focus on the effect of morphological polycentricity on the distribution of retailing in Dutch WGR regions. In that chapter, it was shown that morphologically polycentric regions have fewer specialised retailing functions, which have a high demand threshold. However, we also showed that the effect of polycentricity and population diffusion depends on (1) the spacing between cities in the region, (2) retail concentration, and (3) competition from neighbouring regions. Polycentric or diffuse regions that fared better than other polycentric or diffuse regions were characterised by (1) the centres being located closer together, (2) a relatively strong concentration of retailing in one centre, and (3) less competition from centres outside the region.

11.3 Limitations and an Agenda for Future Research Agenda

Having summarised the major findings and contributions of this dissertation, we now turn to the open questions raised by this work, as well as its limitations. While the limitations of these studies motivate some of our suggestions for future research, we also sketch a broader outlook, describing a comprehensive research agenda based on the concepts and methodologies developed in this dissertation. We believe that future analytical work on urban systems should focus more on the causes and consequences of the spatial organisation of urban systems. In particular, there is a need for further research into (1) mixed spatial structures, (2) the dynamics of urban systems, (3) measurements of functional coherence within regions, and (4) the relationship between the spatial organisation of urban systems and urban and regional performance.

Heterogeneity in the Behaviour of Individuals and Companies

The studies discussed in this dissertation indicate that the shift from a hierarchy-based spatial organisation to a network-based spatial organisation can be seen as movement along a continuum. The extent to which the network model is now replacing the hierarchy model is unclear; some metropolitan regions are predominantly monocentric, while others are predominantly polycentric, and most are somewhere in between. A similar assertion can be made with regard to the degree of spatial integration. However, any evaluation of the spatial organisation of urban systems depends on which function is examined; for example, the analysis of commuting patterns in Chapter 4 showed that the labour market for the highly educated labour force has a larger geographic scope than the labour market for the less-educated workforce. Given these findings, the heterogeneous spatial behaviour of individuals and companies requires further attention.

The PUR is a more salient daily reality for some sectors of society than for others; therefore, it is important to further investigate mixed hierarchical and network structures, based on analyses at the individual and company levels. Such micro-level analyses are already used in examining travel behaviour and migration and the location choices of households and firms, but they could be related more explicitly to the spatial organisation of urban systems. For example, research could be conducted regarding the extent to which the characteristics (e.g., income or level of education) of individuals initiating inter-urban, reverse or criss-cross commuting in an urban system differ from the characteristics of individuals initiating intra-urban or traditional commuting.

Explaining the Development of the Spatial Organisation of Urban Systems

In several chapters of this dissertation (most notably, in Chapters 3 and 7), we discussed a variety of reasons for the changing spatial organisation of urban systems. We argued that the possible reasons for these changes in urban systems can be broadly grouped under three different categories: (1) the increased spatial mobility and flexibility of companies, (2) the increased spatial mobility and flexibility of households and (3) local and regional policies. However, we have not empirically assessed *why* some urban systems become more polycentric and networked while the spatial organisation of other urban systems changes very little over time. Further empirical research is needed to determine the causes of changes in the spatial organisation of urban systems at a detailed level by conducting quantitative analyses of the relationship between spatial differentiation in the dynamics of urban systems and the heterogeneity of their initial shapes, economic and socio-cultural developments and local and regional land-use policies across spatial units. It would be particularly interesting to test competing hypotheses about the dynamics of urban systems, such as whether 'people follow jobs' or whether 'jobs follow people'. Again, the multidimensionality of urban systems must be taken into account in such analyses. Other important questions concern the dynamics and effects of regional competition and cooperation, especially with regard to spatial planning and policy. Under conditions of polycentric development and spatial integration, are cities and towns in urban systems becoming more competitive or more complementary?

However, the most important goal is to understand the extent to which urban systems are actually plannable. Some scholars perceive changes in the spatial organisation of urban systems as a consequence of economic and socio-cultural developments and of local and regional policies, while others argue that the development of the spatial organisation of urban systems is a more straightforward and deterministic process in which the initial shapes of cities and their subsystems determine their development. A more thorough understanding of the dynamics of urban systems will provide important guidance for spatial planning and policy-making with regard to the 'makeability' of society. This should include not only an analysis of whether spatial planning and policy can affect the spatial organisation of urban systems, but also of which *types* of policy have the greatest impact on urban systems. For example, in Chapter 7, we made a distinction between local and regional policies that have the explicit goal of economic deconcentration and urban network formation and policies for which such deconcentration and network formation are merely by-products. At a more general level, this discussion has drawn attention to the contrast between the conceptualisation of spatial planning as social engineering versus the conceptualisation of spatial planning as facilitating and accommodating economic activity.

Complementarities and Functional Coherence in Urban Systems

Another theme of this dissertation is functional integration and complementarities in urban systems. As we have noted, few studies have empirically assessed competition and complementarities in urban systems, despite the rich eclectic, theoretical literature available on the issue.

The empirical analyses in this dissertation should be perceived as simply the first step toward a better understanding of whether the viewpoint of competition or complementarities is most applicable to contemporary urban systems, in that the proposed conceptualisations and measurement techniques presented in Chapters 5 and 8 must still be validated and refined. For example, further evaluation should be conducted to determine the extent to which our measure of the competitive threat between European regions (Chapter 5) is sensitive to the delimitation of different market segments and whether similar results would obtained if different types of functional linkages were examined (e.g., trade; see Thissen et al., 2011). Complementarities between cities should also be measured across a fuller and more detailed spectrum of urban functions. Likewise, the analysis of complementarities between municipalities in the Randstad in Chapter 8 uses a very rough two-digit sector classification and does not take into account possible sectoral interdependencies.

A fruitful way to analyse complementarities in urban systems would be to look at functional coherence, in terms of skill relatedness and input-output relatedness between sectors. Recent research by Neffke and Henning (2011) has shown that some sectors can be described as skill-related in that they require similar types of skills and knowledge and that, accordingly, labour may tend to flow easily between them. Because employees who change jobs between skill-related sectors take with them the knowledge they acquired in the old sector to the new sector, regions with economic activities that are skill-related have labour markets that are well-suited for exchanging ideas. In addition, the consequences of economic hardships in any given sector are less catastrophic. If a local industry declines, it may have to lay off some of its workforce; however, if the affected workers can find employment in related industries elsewhere in the region, their human capital is not rendered irrelevant, because the skill-relatedness of the industries means that their skills are also valued at their new job. The functional-coherence framework is an ideal platform for researching complementarities within urban systems because it provides tools for assessing the extent to which sectors in one city or town in a region are skill-related to sectors in other cities or towns. By taking into account the interdependence of sectors in terms of workforce occupations, such an analysis would provide additional insights regarding whether a given metropolitan area or PUR is functionally coherent and whether a network of cities is indeed more than the sum of its parts.

More generally, it is important to understand how complementarities within urban systems is related to the economic performance of cities and regions. Although complementarities are often cited as an important characteristic of polycentric and spatially integrated regions and are thought to be important to urban and regional development, they seem to frequently be absent in PURs. At the same time, some scholars have suggested that competition might well function as a catalyst for urban and regional growth. This line of argument raises new questions about the tension between competition and complementarities in urban systems. Are cities and regions that face fewer competitive threats from other areas more likely to grow and strengthen their positions within their urban systems? Can the presence of strong competition or (complementarities) between centres in an urban system explain the decline of some regions and the growth of others?

The Effects of Regional Spatial Organisation on Regional Performance

Finally, future research should explore the relationship between the spatial organisation of urban systems and their performance in more depth. Firstly, the extent to which the findings of studies on the United States and the Netherlands can be generalised to account for the situations in other countries should be determined. In such research, performance indicators other than productivity and patterns in retailing should also be studied. Of particular interest is whether typical agglomeration diseconomies such as congestion, crime, social segregation, negative environmental impacts and high land prices are less pervasive in more polycentric regions.

Secondly, we have focused mainly on the relationship between morphological spatial structure and regional performance. However, especially with reference to spatial concepts like the PUR, data on the relationship between functional polycentricity and spatial integration and regional performance deserve further study. In addition, external linkages between more distant metropolitan regions should also receive more attention. The idea that such external linkages are highly important in explaining performance appears to be especially relevant for the largest metropolitan areas, as they are the main centres for knowledge-intensive economic activities such as advanced business services and are therefore centres in the global network of information and knowledge exchange (Sassen, 1991; Hall and Pain, 2006).

More generally, further research should focus on the conditions under which polycentricity is instrumental to regional performance by relating differences in economic performance between polycentric urban systems with other characteristics of those systems. For example, spacing between the centres, the prevalence of competition versus complementarities and the level of regional coordination and cooperation between centres within the urban system could be relevant factors. Similarly, the concentration of high-level functions, the degree of spatial integration and the presence or lack of a common cultural identity may influence the relationship between morphological polycentricity and regional performance. Such an investigation should examine whether polycentric regions with a greater degree of complementarities between their centres perform better than polycentric regions with a greater degree of overlap between their centres and whether regional coordination and cooperation in polycentric urban areas promote regional economic growth. These issues are also important with regard to formulating urban and regional development policies.

11.4 Implications for Planning and Policy

As has been stressed throughout this dissertation, urban systems are characterised by a considerable degree of ‘relational complexity’ (Healey, 2006). Urban networks are multiplex, and therefore, phenomena like polycentricity, spatial integration, competition and complementarities in a region can be analysed by looking at different types of functional linkages between cities and regions, for example, commuter trips, telephone calls, shopping, intra-firm and office networks, and inter-firm networks. The spatial organisations of these functional links are not necessarily similar, and therefore, a region may appear polycentric and spatially integrated with respect to one type of functional link but monocentric and loosely connected with respect to another type of functional link. At the same time, the geographic scope of functional linkages varies considerably, while the assessment of polycentricity is quintessentially scale-dependent. Above all, the effect of polycentricity on urban and regional performance differs across spatial contexts.

This 'relational complexity' in urban systems may cause planners and policy-makers to wonder whether regional planning and policy-making will be useful at larger geographical scales such as the PUR. The findings presented in this dissertation can provide guidance for planning and policy-making as to which functions can be best organised at that scale. The identification of key strategic issues should be based on (1) the potential for urban network formation at larger geographical scales and (2) the potential benefits of regional coordination and cooperation. Firstly, urban-network-related policies should focus on regional coordination and cooperation mainly with regard to supra-local functions. This is not to say that regional coordination and cooperation are impossible with regard to more locally oriented functions; however, a lack of functional coherence restricts what can be achieved with regards to PUR-level governance. Secondly, planning and policy-making should take into account the effects of polycentricity and spatial integration on regional performance; regional cooperation and coordination are of particular interest for situations in which a region that is polycentric and spatially integrated at the inter-urban scale outperforms a region made up of individual metropolitan areas with respect to supra-local indicators. The tension between competition and complementarities in urban networks deserves special attention here.

This dissertation can not only help planners and policy-makers to identify key strategic issues but can also provide a better understanding of what the concept of the PUR really means in terms of planning. Such an understanding should increase planners' and policy-makers' commitment to participation in such planning processes and encourage them to be open to network organisation. It is easier to organise supra-local functions at larger geographical scales when stakeholders are convinced that these scales are appropriate for planning and policy-making and that such planning will have positive local effects.

Abstract

Over the past decades, demographic changes, advances in transportation and communication technology, and the growth of the service sector have had a significant impact on the spatial structure of regions. Monocentric cities are disappearing and developing into polycentric metropolitan areas, while at the same time, social and economic processes are taking place at an ever larger geographical scale, beyond that of the city, in which historically separate metropolitan areas are becoming increasingly functionally connected to form polycentric urban regions. Such urban networks are characterised by the lack of an urban hierarchy, a significant degree of spatial integration between different cities and, complementary relationships between centres, in that cities and towns have different economic specialisations.

The growing literature on changing urban systems coincides with the increasing popularity of the urban network concept in contemporary spatial planning and policy, in which urban networks are often seen as a panacea for regional economic development problems. Polycentricity and spatial integration have become catchphrases, where poly - centric development policies have been introduced to support territorial cohesion and cooperation as well as higher levels of urban and regional competitiveness. Despite the enthusiasm for the ideas of a polycentric and networked spatial organisation, the assessment of the urban network concept leaves much to be desired. To what extent are regions becoming more polycentric and spatially integrated? Are relationships between cities in polycentric, spatially integrated regions complementary rather than competitive? And are polycentric, spatially integrated regions more economically efficient than their monocentric, non-integrated counterparts? In this study, these questions will be addressed.

Abstract (in Dutch)

In de afgelopen decennia hebben demografische veranderingen, vooruitgang in de transport-en communicatietechnologie, en de groei van de dienstensector een belangrijke invloed gehad op de ruimtelijke structuur van regio's. Monocentrische steden verdwijnen en ontwikkelen zich tot polycentrische stadsregio's. Tegelijkertijd vinden sociale en economische processen plaats op een steeds hoger ruimtelijk schaalniveau, waarbij van oudsher gescheiden stadsregio's steeds meer functioneel mer elkaar verbonden raken en polycentrische grootstedelijke regio's vormen. Dergelijke stedelijke netwerken worden gekenmerkt door het ontbreken van een stedelijke hiërarchie, een belangrijke mate van ruimtelijke integratie tussen verschillende steden en complementaire relaties tussen de centra, in de zin dat steden verschillende economische specialisaties hebben.

De groeiende literatuur over veranderingen in stedelijke systemen valt samen met de toenemende populariteit van het stedelijk netwerk begrip in de hedendaagse planologie en ruimtelijk beleid, waarin stedelijke netwerken vaak gezien worden als een wondermiddel voor regionale economische problemen. Polycentriciteit en ruimtelijke integratie zijn verworden tot slogans, waarbij polycentrisch ontwikkelingsbeleid is ingevoerd om de territoriale cohesie en samenwerking, alsmede het stedelijke en regionale concurrentievermogen te ondersteunen. Ondanks het enthousiasme voor de ideeën van een polycentrische en genetwerkte ruimtelijke organisatie, laat de toetsing van het stedelijk netwerk begrip nog veel te wensen over. In hoeverre zijn de regio's steeds meer polycentrische en ruimtelijk geïntegreerd? Zijn relaties tussen steden in polycentrische, ruimtelijk geïntegreerde regio's veeleer complementair dan concurrerend? En zijn polycentrische, ruimtelijk geïntegreerde regio's economisch efficiënter dan hun monocentrische, niet-geïntegreerde tegenhangers? In dit onderzoek zullen deze vragen aan bod komen.

Bibliography

Adolphson, M. (2009) Estimating a polycentric urban structure. Case study: urban changes in the Stockholm region. *Journal of Urban Planning and Development*, 135: 19-30.

Agresti, A. (2002) *Categorical Data Analysis*. Hoboken, NJ: John Wiley & Sons.

Aguilera, A. and Mignot, D. (2004) Urban sprawl, polycentrism and commuting. A comparison of seven French urban areas. *Urban Public Economics Review*, 1: 93-113.

Aharoni, Y. (1966) *The Foreign Investment Decision Process*. Cambridge, MA: Harvard University Press.

Aiken, M., Newton, K., Friedland, R. and Martinotti, G. (1987) Urban systems theory and urban policy: a four-nation comparison. *British Journal of Political Science*, 17: 341-358.

Albrechts L. (2001) How to proceed from image and discourse to action: as applied to the Flemish Diamond. *Urban Studies*, 38: 733-745.

Albrechts, L. (2004) Spatial (strategic) planning reexamined. *Environment and Planning B: Planning and Design*, 31: 743-758.

Albrechts, L., Healey, P. and Kunzmann, K.R. (2003) Strategic spatial planning and regional governance in Europe. *Journal of the American Planning Association*, 69: 113-129.

Albrechts, L. and Lievois, G. (2004) The Flemish diamond: urban network in the making? *European Planning Studies*, 12: 351-370.

Alderson, A. and Beckfield, J. (2004) Power and position in the world city system. *American Journal of Sociology*, 109: 811-851.

Allen J. and Cochrane A. (2007) Beyond the territorial fix: regional assemblages, politics and power. *Regional Studies*, 41: 1161-1175.

Allpass, J. (1968) Changes in the structure of urban centers. *Journal of the American Planning Association*, 34: 170-173.

Alonso, W. (1964) *Location and Land Use*. Cambridge, MA: Harvard University Press.

Alonso, W. (1973) Urban zero population growth. *Daedalus*, 102: 191-206.

Anas, A., Arnott, A. and Small, K.A. (1998) Urban spatial structure. *Journal of Economic Literature*, 26: 1426-1464.

Andersen, J.E. and Van Wincoop, E. (2003) Gravity with Gravitas: a solution to the border puzzle. *American Economic Review*, 93: 170-192.

Andersen, J.E. and Van Wincoop, E. (2004) Trade costs. *Journal of Economic Literature*, 17: 691-751.

Aoyama Y. and Castells M. (2002) The informational society, an empirical assessment: employment and occupational structures of G-7 countries in the 1990s. *International Labour Review*, 141: 123-159.

Baigent, E. (2004) Patrick Geddes, Lewis Mumford and Jean Gottmann: divisions over 'megalopolis'. *Progress in Human Geography*, 28: 687-700.

Bailey N. and Turok I. (2001) Central Scotland as a polycentric urban region: useful planning concept or chimera? *Urban Studies*, 38: 697-715.

Barnes, T.J. (2001) Retheorizing economic geography: from the quantitative revolution to the "cultural turn". *Annals of the Association of American Geographers*, 91: 546-565.

Barton, B. (1978) The creation of centrality. *Annals of the Association of American Geographers*, 68: 34-44.

Basile, R., Castellani, D., Zanfei, A. (2008) Location choices of multinational firms in Europe: the role of EU cohesion policy. *Journal of International Economics*, 74: 328-340.

Basile, R., Castellani, D., Zanfei, A. (2009) National boundaries and the location of multinational firms in Europe. *Papers in Regional Science*, 88: 733-748.

Bathelt, H., Malmberg, A. and Maskell, P. (2004) Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, 28: 31-56.

Batten D.F. (1995) Network cities: creative urban agglomerations for the 21st century. *Urban Studies*, 32: 313-327.

Beaverstock, J.V., Hoyler, M., Pain, K. and Taylor, P.J. (2001) *Comparing London and Frankfurt as World Cities: a Relational Study of Contemporary Urban Change*. London: Anglo-German Foundation.

Beckmann, M.J. (1958) City hierarchies and the distribution of city sizes. *Economic Development and Cultural Change*, 6: 243-258.

Beckmann, M.J. and McPherson, J. (1970) City size distribution in a central place hierarchy: an alternative approach. *Journal of Regional Science*, 10: 25-33.

Begg, I. (1999) Cities and competitiveness. *Urban Studies*, 36: 795-809.

Bergkvist, E. and Westin, L. (2001) Estimation of gravity models by OLS estimation, NLS estimation, Poisson and neural network specifications, in: Gastaldi, M. and Reggiani,

A. (Eds) *New Analytial Advances in Transportation and Spatial Dynamics*, pp. 135-155. Burlington, VT: Ashgate.

Berry, B.J.L. (1964) Cities as systems within systems of cities. *Papers in Regional Science*, 13: 147-163.

Berry, B.J.L. (1967) *Geography of Market Centers and Retail Distribution*. Englewood Cliffs, NJ: Prentice Hall.

Berry, B.J.L. (1973) *Growth Centers in the American Urban System, Vol. 1*. Cambridge, MA: Ballinger.

Berry, B.J.L. (1995) Whither regional science? *International Regional Science Review*, 17: 297-305.

Berry, B.J.L. (2002) Paradigm lost. *Urban Geography*, 23: 441-445.

Berry, B.J.L. and Garrison, W.L. (1958a) The functional bases of the central place hierarchy. *Economic Geography*, 34: 145-154.

Berry, B.J.L. and Garrison, W.L. (1958b) A note on central place theory and the range of a good. *Economic Geography*, 34: 304-311.

Berry, B.J.L and Harris, C. (1970) Walter Christaller: an appreciation. *Geographical Review*, 60, 116-119

Berry, B.J.L. and Horton, F.E. (1970) *Geographic Perspectives on Urban Systems*. Englewood Cliffs, NJ: Prentice Hall.

Berry, B.J.L. and Kasarda, J.D. (1977) *Contemporary Urban Ecology*. London: MacMillan.

Berry, B.J.L. and Kim, H.M. (1993) Challenges to the monocentric model. *Geographical Analysis*, 25: 1-4.

Berry, B.J.L. and Parr, J.B. with Epstein, B.J., Ghosh, A. and Smith, R.H.T (1988) *Market Centers as Retail Locations*. Englewood Cliffs, NJ: Prentice Hall.

Berry, B.J.L. and Pred, A. (1965) *Central Place Studies: A Bibliography of Theory and Applications*. Philadelphia, PA: Regional Science Research Institute.

Bertaud A. (2004) The spatial organization of cities: deliberate outcome or unforeseen consequence? Working Paper 2004-01, Berkeley, CA: Institute of Urban and Regional Development, University of California.

Best R.H. (1981) *Land Use and Living Space*. London: Methuen.

Bikker, J.A. and De Vos, A.F. (1992) An international trade flow model with zero observations: an extension of the Tobit model. *Cahiers Economiques de Bruxelles*, 135: 379-404.

Black, W.R. (1992) Network autocorrelation in transport network and flow systems. *Geographical Analysis*, 24: 207-222.

Boarnet, M.G. (1994) An empirical model of intermetropolitan population and employment growth. *Papers in Regional Science*, 73: 135-152.

Bode, E. (2008) Delineating metropolitan areas using land prices. *Journal of Regional Science*, 48: 131-163.

Bogue, D.J. (1949) *The Structure of the Metropolitan Community*. Ann Arbor, MI: Horace H. Rackham School of Graduate Studies.

Bohara, A.K. and Krieg, R.G. (1996) A zero-inflated Poisson model of migration frequency. *International Regional Science Review*, 19: 211-22.

Borcher, J.G. (1972) America's changing metropolitan regions. *Annals of the Association of American Geographers*, 62: 352-373.

Borchert, J.G. (1998) Spatial dynamics of retail structure and the venerable retail hierarchy. *GeoJournal*, 45: 327-336.

Bosquet, C. and Boulhol, H. (2010) Scale dependence of the negative binomial pseudo maximum-likelihood estimator. Working Paper, Université Paris I.

Boudeville, J.R. (1966) *Problems of Regional Economic Planning*. Edinburgh: Edinburgh University Press.

Bourne, L.S. and Simmons, J.W. (Eds) (1978) *Systems of Cities: Readings on Structure, Growth, and Policy*. New York, NY: Oxford University Press.

Boyce (1963) Myth versus reality in urban planning. *Land Economics*, 39: 241-251.

Boyle, P. and Feng, Z. (2002) A method for integrating the 1981 and 1991 British census interaction data. *Computers, Environment and Urban Systems*, 26: 241-256.

Bracey, H.E. (1953) Towns as rural service centres. *Transactions and Papers*, *Institute of British Geographers*, 19: 95-105.

Brakman, S., Garretsen, H., Van Marrewijk, C. and Van Witteloostuijn, A. (2006) *Nations and Firms in the Global Economy*. Cambridge, UK: Cambridge University Press.

Brienen, M.J., Burger, M.J., Van Oort, F.G. (2010) The geography of Chinese and Indian greenfield investments in Europe. *Eurasian Geography and Economics*, 51: 254-273.

Bristow, G. (2005) Everyone's a 'winner': problematising the discourse of regional competitiveness. *Journal of Economic Geography*, 5: 285-304.

Bröcker, J. (1989a) Partial equilibrium theory of interregional trade and the gravity model. *Papers of the Regional Science Association*, 66: 7-18.

Bröcker, J. (1989b) How to eliminate certain effects of potential formula. *Environment and Planning A*, 21: 817-830.

Bröcker, J. and Rohweder, H.C. (1990) Barriers to international trade: methods of measurement and empirical evidence. *The Annals of Regional Science*, 24: 289-305.

Broersma, L., Oosterhaven, J. (2009) Regional labor productivity in the Netherlands: evidence of agglomeration and congestion effects. *Journal of Regional Science*, 49: 483-511.

Brown, L.A. and Holmes, J. (1971) The delimitation of functional regions, nodal regions, and hierarchies by functional distance approaches. *Journal of Regional Science*, 11: 57-72.

Brueckner, J.K. (2001) Urban sprawl: lessons from urban economics. *Brookings-Wharton Papers on Urban Affairs*, 1: 65-97.

Brülhart, M. and Mathys, N.A. (2009) Sectoral agglomeration economies in a panel of European regions. *Regional Science and Urban Economics*, 38: 348-362.

Brush, J.E. (1953) The hierarchy of central places in Southwestern Wisconsin. *The Geographical Review*, 43: 380-402.

Buck N.H., Gordon I.R., Hall, P., Harloe M. and Kleinman M. (2002) *Working Capital: Life and Labour in Contemporary London*. London: Routledge.

Buckley, P.J., Devinney, T.M., Louviere, J.J. (2007) Do managers behave the way theory suggests? A choice-theoretic examination of foreign direct investment location decision-making. *Journal of International Business Studies*, 38: 1069-1094.

Buckwalter, D.W. (1990) Diverse retail structure and Christaller's separation principle in medium-sized metropolitan areas. *Growth and Change*, 21: 15-31.

Budd, L. (1998) Territorial competition and globalization: Scylla and Charybdis of European cities. *Urban Studies*, 35: 663-685.

Burger, M.J., De Goei, B., Van der Laan, L. and Huisman F.M.J. (2011a) Heterogeneous development of metropolitan spatial structure: evidence from commuting patterns in English and Welsh city-regions. *Cities*, 28: 160-170.

Burger, M. and Meijers, E. (2011) Form follows function? Linking functional and morphological polycentricity. *Urban Studies* (forthcoming).

Burger, M.J., Van Oort, F.G., Frenken, K. and Van der Knaap, B. (2009b) Networks and Economic Agglomerations. *Tijdschrift voor Economische en Sociale Geografie*, 100: 139-144.

Burger, M., Van Oort F. and Linders G.J. (2009a) On the specification of the gravity model of trade: zeros, excess zeros and zero-inflated estimation. *Spatial Economic Analysis*, 4: 161-183.

Burger, M.J., Van Oort, F.G., Van der Knaap, G.A. (2010) A treatise on the scale-dependence of agglomeration externalities and the MAUP. *Scienze Regionali*, 9: 19-40.

Burger, M.J., Van Oort, F.G., Wall, R.S. and Thissen, M.J.P.M. (2011b) Analysing the competitive advantage of cities in the Dutch Randstad by urban market overlap, in: Klaesson, J., Johansson, B., Karlsson, C. and Stough, R. (Eds) *Metropolitan Regions: Preconditions and Strategies for Growth and Development in the Global Economy* (forthcoming).

Burgess, E.W. (1925) *The Growth of the City*. Chicago: University of Chicago Press.

Burt, R.S. and Talmud, I. (1993) Market niche. *Social Networks*, 15: 133-149.

Burton, I. (1963) A restatement of the dispersed city hypothesis. *Annals of the Association of American Geographers*, 53: 285-289.

Cabus, P. and Vanhaverbeke, W. (2006) The territoriality of the network economy and urban networks: evidence from Flanders. *Entrepreneurship and Regional Development*, 18: 28-53.

Cairncross F. (1997) *The Death of Distance: How the Communications Revolution Will Change Our Lives*. Boston, MA: Harvard Business School Press.

Camagni, R. (1993) From city hierarchy to city network; reflections about an emerging paradigm. In: Lakshmanan, T.R. and Nijkamp, P. (eds) *Structure and Change in the Space Economy: Festschrift in Honour of Martin Beckmann*, pp. 66-87. Berlin: Springer.

Camagni, R. (2002) On the concept of territorial competitiveness: sound or misleading? *Urban Studies*, 13: 2395-2412.

Camagni, R. (2007) City networks as tool for competitiveness and sustainability. In: P.J. Taylor, B. Derudder, P. Saey and F. Witlox (Eds) *Cities in Globalization: Practices, Policies and Theories*, pp. 102-123. London: Routledge.

Camagni, R. and Capello, R. (2004) The city network paradigm: theory and empirical evidence', in: Capello, R. and Nijkamp, P. (Eds) *Urban Dynamics and Growth*, pp. 495-529. Amsterdam: Elsevier.

Camagni, R. and Salone, C. (1993) Network urban structures in Northern Italy: elements for a theoretical framework. *Urban Studies*, 30: 1053-1064.

Cameron, A.C. and Trivedi, P.K. (1986) Econometric models based on count data: comparisons and applications of some estimators and tests. *Journal of Applied Econometrics*, 1: 29-53.

Cameron, S. (2005) *Econometrics*. New York, NY: McGraw-Hill.

Capello, R. (2000) The city network paradigm: measuring urban network externalities. *Urban Studies*, 37: 1925-1945.

Capello, R. and Camagni, R. (2000) Beyond optimal city size: an evaluation of alternative urban growth patterns. *Urban Studies*, 37: 1479-1496.

Carey, H.C. (1858) *Principles of Social Science*. Philadelphia: Lippincott.

Castellani, D. and Pieri, F. (2010) The effect of foreign investments on European regional productivity. Working paper. ISSN 1825-0211.

Castells, M. (1996) *The Rise of the Network Society*. Oxford, UK: Blackwell Publishers.

Cattan, N. (2007) Introduction, in: Cattan, N. (Ed.) *Cities and Networks in Europe*, pp. IX-XIV. Esher: John Libbey Eurotext.

Champion, A.G. (Ed) (1989) *Counterurbanization: The Changing Pace and Nature of Population Deconcentration*. London: Edward Arnold.

Champion, A.G. (2001) A changing demographic regime and evolving polycentric urban regions-consequences for the size, composition and distribution of city populations. *Urban Studies*, 38: 657-677.

Champion, A.G. (2002) Population change and migration in the British urban system. In: Geyer, H.S. (Ed) *International Handbook of Urban Systems*, pp. 87-120. Cheltenham UK: Edward Elgar.

Champion, T. and Coombes, M. (2007) Using the 2001 census to study human capital movements affecting Britain's larger cities: insights and issues. *Journal of the Royal Statistical Society A (Statistics in Society)*, 170: 447-467.

Chase-Dunn, C., 1985, The system of world cities, A.D. 800–1975. In: Timberlake, M. (ed.) *Urbanization in the World-Economy*, pp. 269-292. Orlando, FL: Academic Press.

Cheshire, P. (1999) Cities in competition: articulating the gains from integration. *Urban Studies*, 36: 843-864.

Cheshire, P. (1999) Trends in sizes and structures of urban areas, in: Cheshire, P. and Mills, E.S. (Eds) *Handbook of Regional and Urban Economics, Volume 3*, pp. 1339-1372. Amsterdam: Elsevier Science.

Cheshire, P.C. (2006) Resurgent cities, urban myths and policy hubris: what we need to know. *Urban studies*, 43: 1231-1246.

Cheshire, P.C. and Gordon, I.R. (1995) European integration: the logic of territorial competiton and Europe's urban system. In: Brotchie, J., Batty, M., Blakely, E., Hall, P. and Newton, P. (Eds.) *Cities in Competition: Productive and Sustainable Cities for the 21st Century*, pp. 108-126. Melbourne: Longman.

Cheshire, P.C. and Gordon, I.R. (1998) Territorial competition: some lessons for policy. *The Annals of Regional Science*, 32: 321-346.

Chien, S.S. and Gordon, I. (2008) Territorial competition in China and the West. *Regional Studies*, 42: 31-49.

Christaller, W. (1933) *Die Zentralen Orte in Süddeutschland*. Jena: Gustav Fischer.

Christaller, W. (1937) *Die Ländliche Siedlungsweise im Deutschen Reich und ihre Beziehungsen zu Gemeindeorganisation*. *Einzelschriften des Kommunalwissenschaftlichen Institutes der Universität Berlin, VII*. Stuttgart/Berlin: W. Kohlhammer Verlag.

Christaller, W. (1940) Die Kultur- und Marktberiche der zentralen orte im deutschen Osten und die Gliederung der Verwaltung. *Raumforschung und Raumordnung*, 4: 498-503.

Christaller, W. (1941) *Die zentralen Orte in den Ostgebieten und ihre Kultur- und Marktbereichte*. Leipzig: K.F. Koehler.

Christaller, W. (1947) Die Raumidee des Föderalismus und die Neugestaltung Deutschlands. *Neues Abendland*, 11: 179-181.

Christaller, W. (1950) Das Grundgerust der räumlichen Ordnung in Europa: Die Systeme der europäischen zentralen Orte. *Frankfurer Geographische Hefte*, 24, 1.

Ciccone, A. (2002) Agglomeration effects in Europe. *European Economic Review*, 46: 213-227.

Ciccone, A. and Hall, R.E. (1996) Productivity and the density of economic activity. *American Economic Review*, 86: 54-70.

Clark, T.N., Lloyd, R., Wong, K.K. and Jain, P. (2002) Amenities drive urban growth. *Journal of Urban Affairs*, 24: 493-515.

Clark, W.A.V. and Kuijpers-Linde, M. (1994) Commuting in restructuring urban regions. *Urban Studies*, 31: 465-483.

Coe, N.M. and Townsend, A.R. (1998) Debunking the Myth of Localized Agglomerations: The Development of a Regionalized Service Economy in South-East England. *Transactions of the Institute of British Geographers*, 23: 385-404.

Coffey, W.J., Bourne, L.S., Randall, J.E., Davies, W.K.D. and White, R. (1998) Urban systems research: past, present and future. A panel discussion. *Canadian Journal of Regional Science*, 21: 327-364.

Coffey, W.J., Bourne, L.S., Randall, J.E., Davies, W.K.D. and White, R. (1998): 'Urban systems research: past, present and future: a panel discussion', *Canadian Journal of Regional Science* 21, 327-364.

Combes, P.P. (2000) Economic structure and local growth: France 1984-1993. *Journal of Urban Economics*, 47: 329-355.

Combes, P.P., Mayer, T. and Thisse, J-F. (2008) *Economic Geography: The Integration of Regions and Nations*. Princeton, NJ: Princeton University Press.

Constandse, A.K. (1972) The IJsselmeerpolders: an old project with new functions. *Tijdschrift voor Economische en Sociale Geografie* 63: 200-210.

Cooke, P. (1983) *Theories of Planning and Spatial Development*. London: Hutchinson.

Coombes, M. (2000) Defining locality boundaries with synthetic data. *Environment and Planning A*, 32: 1499-1518.

Coombes, M., Champion, T. and Wymer, C. (2011) Is the world's first urban industrial region becoming more polycentric? Working paper, University of Newcastle.

Coombes, M.G., Charles, D.R., Raybould, S.R. and Wymer, C. (2006) *City Regions and Polycentricity: The East Midlands Urban Network*. Nottingham: East Midland Development Agency.

Coombes, M.G. and Wymer, C. (2001) A new approach to identifying localities: representing 'places' in Britain. In: Medanipour, A., Hull, A. and Healey, P. (eds) *The Governance of Place: Space and Planning Processes*, pp. 51-69. Aldershot: Ashgate.

Corpataux, J. and Crevoisier, O. (2007) Economic theories and spatial transformations clarifying the space-time premises and outcomes of economic theories. *Journal of Economic Geography*, 7: 285-309.

Cörvers, F., Hensen, M., Bongaerts, D. (2009) The delimitation and coherence of functional and administrative regions. *Regional Studies*, 43: 19-31.

Couclelis, H. (2000) From sustainable transportation to sustainable accessibility: can we avoid a new 'tragedy of the commons'? In: Janelle, D.G. and Hodge, D.C. (Eds) *Information, Place, and Cyberspace: Issues in Accessibility*. Berlin: Springer Verlag.

Cowell, M. (2010) Polycentric Regions: Comparing Complementarity and Institutional Governance in the San Francisco Bay Area, the Randstad and Emilia-Romagna. *Urban Studies*, 47: 945-965.

CSD (1999) *European Spatial Development Perspective: Towards Balanced and Sustainable Development of the Territory of the EU*. Luxembourg: Office for Official Publications of the European Communities.

Cullingworth J.B. and Nadin V. (1997) *Town and Country Planning in the UK, 12th edition*. London: Routledge.

Curran, J. and Blackburn, R. (1994) *Small firms and local economic networks. The death of the local economy?* London: Paul Chapman Publishing.

Dacey, M.F. (1966) Population of places in a central place hierarchy. *Journal of Regional Science*, 6: 27-33.

Darwent, J. (1969) Growth poles and growth centers in regional planning – a review. *Environment and Planning A*, 1: 5-32.

Davies, W.K.D. (1967) Centrality and the central place hierarchy. *Urban Studies*, 4: 61-79.

Davoudi S. (2003) Polycentricity in European spatial planning: from an analytical tool to a normative agenda? *European Planning Studies*, 11: 979-999.

Davoudi, S. (2007) Polycentricity: panacea or pipedream? In: Cattan, N. (Ed.) *Cities and Networks in Europe*, pp. 65-74. Esher, UK: John Libbey Eurotext.

Davoudi, S. (2008) Conceptions of the city-region: a critical review. *Urban Design and Planning*, 16: 51-60.

De Goei, B., Burger, M.J., Van Oort, F.G. and Kitston, M. (2008) Testing the super-region. *Town and Country Planning*, 77: 458-464.

De Goei, B., Burger, M.J., Van Oort, F.G. and Kitson, M. (2010) Functional polycentrism and urban network development in the Greater South East, United Kingdom: evidence from commuting patterns. *Regional Studies*, 44: 1149-1170.

De Groot, H.L.F., Linders, G.H.M., Rietveld, P. and Subramanian, U. (2004) The institutional determinants of bilateral trade patterns. *Kyklos*, 57: 103–23.

Defever, F. (2005) Functional fragmentation and the location of multinationals in the enlarged Europe. *Regional Science and Urban Economics*, 36: 658-677.

Derks, H. (2001) *Deutsche Westforschung. Ideologie und Praxis im 20.Jahrhundert*. Leipzig: Akademische Verlagsanstalt

Derudder, B., Devriendt, L. and Witlox, F. (2007) Flying where you don't want to go: an empirical analysis of hubs in the global airline network. *Tijdschrift voor Economische en Sociale Geografie*, 98: 307-321.

Derudder, B. and Witlox, F. (2005) An appraisal of the use of airline data in assessing the world city network: a research note on data. *Urban Studies*, 42: 2371-2388.

Derudder, B., Taylor, P.J., Ni, P., De Vos, A., Hoyler, M., Hanssens, H., Bassens, D., Huang, D., Witlox, F., Shen, W. and Yang, X. (2010) Pathways of change: shifting connectivities in the world city network, 2000-08. *Urban Studies*, 47: 1861-1877.

Dickinson, R.E. (1947) *City, Region and Regionalism*. London: K. Paul, Trench, Trubner & Co.

Dieleman, F.M. and Faludi, A. (1998) Polynucleated metropolitan regions in northwest Europe: theme of the special issue. *European Planning Studies*, 6: 365-378.

Dieleman, F.M. and Musterd, S. (1992) *The Randstad: A Research and Policy Laboratory*. Dordrecht, Kluwer.

Dieleman, F.M., Dijst, M. and Burghouwt, G. (2002) Urban form and travel behavior: micro-level household attributes and residential context. *Urban Studies*, 39: 507-527.

Dijst, M.J. and Vidakovic, V. (2000) Travel time ratio: the key factor of spatial reach. *Transportation*, 27: 179-199.

Disdier, A.C. and Head, K. (2008) The puzzling persistence of the distance effect on bilateral trade. *Review of Economics and Statistics*, 90: 37–41.

Doxiadis, C.A. (1968) *Ekistics: An Introduction to the Science of Human Settlements*. London, Hutchinson.

Duboz, M.L. and Le Gallo, J. (2011) Are EU-15 and CEEC agricultural exports in competition? Evidence for 1995-2005. *Economics Bulletin*, 31: 146-154.

Ducruet, C., Rozenblat, C. and Zaidi, F. (2010) Ports in multi-level maritime networks: evidence from the Atlantic. *Journal of Transport Geography*, 18: 508-518.

Duncan, O.D., Scott, W.R., Lieberson, S. and Duncan, B. (1960) *Metropolis and Region*. New York, NY: Wiley.

Duncan, O.D. and Lieberson, S. (1971) *Metropolis and Region Revisited*. Baltimore, MD: Johns Hopkins Press.

Dunning, J.H. (1993) *Multinational Enterprises in the Global Economy*. Wokingham: Addison-Wesley.

Dunning, J.H. (1998) Location and the multinational enterprise: a neglected factor? *Journal of International Business Studies*, 29: 45-66.

Dunning, J.H. and Narula, R. (2004) *Multinational and Industrial Competitiveness: A New Agenda*. Cheltenham, UK: Edward Elgar.

Duranton, G. and Puga, D. (2000) Diversity and specialisation in cities: why, where and when does it matter? *Urban Studies*, 27: 533-555.

Eaton, B.C. and Lipsey, R.G. (1979) Comparison shopping and the clustering of homogeneous firms. *Journal of Regional Science*, 19: 421-435.

Eaton, B.C. and Lipsey, R.G. (1982) An economic theory of central places. *Economic Journal*, 92: 56-72.

Eaton, J. and Kortum, S. (2002) Technology, geography and trade. *Econometrica*, 70: 1741-79.

Egger, P. (2005) Alternative techniques for the estimation of cross–section gravity models. *Review of International Economics*, 13: 881–91.

Eichengreen, B. and Irwin, D.A. (1998) The role of history in bilateral trade flows, in: Frankel, J.A. (Ed.) *The Regionalization of the World Economy*, pp. 33-57. Chicago: University of Chicago Press.

Erickson, R.A. (1983) The evolution of the suburban space economy. *Urban Geography*, 4: 95-121.

ESF (2006) *European Social Fund supports employment and skills development for London 2012*. European Union-European Social Fund, Press Release 1st March 2006, London.

ESPON 1.1.1 (2004) *Potentials for Polycentric Development in Europe*. Stockholm/Luxembourg: Nordregio/ESPON Monitoring Committee.

Evers, D. (2002) The rise (and fall?) of Dutch retail planning. *Tijdschrift voor Economische en Sociale Geografie*, 93: 107-113.

Faludi, A. (2004) Spatial planning traditions in Europe: their role in the ESDP process. *International Planning Studies*, 9: 155-172.

Faludi, A. and Waterhout, B. (2002) *The Making of the European Spatial Development Perspective*. London: Routledge.

Feenstra, R.C. (2004) *Advanced International Trade: Theory and Evidence.* Princeton: Princeton University Press.

Feenstra, R.C., Lipsey, R.E., Deng, H., Ma, A.C. and Mo, H. (2005) World trade flows 1962-2000, NBER Working Paper 11040, Cambridge, MA: National Bureau of Economic Research.

Finch D. and Marshall A. (2007) *Urban Promise: Cities and the Economic Future of the East of England*. Histon: East of England Development Agency.

Finger, J.M. and Kreinin, M.E. (1979) A measure of 'export similarity' and its possible uses. *The Economic Journal*, 78: 905-912.

Fingleton B. (2003) Externalities, economic geography and spatial econometrics: conceptual and modelling developments. *International Regional Science Review*, 26: 197-207.

Florida, R. (2005) *Cities and the Creative Class*. New York: Routledge.

Florida, R., Gulden, T. and Mellander, C. (2008) The rise of the mega-region. *Cambridge Journal of Regions, Economy and Society*, 1: 459-476.

Flowerdew, R. and Aitkin, M. (1982) A method of fitting the gravity model based on the Poisson distribution. *Journal of Regional Science*, 22: 191-202.

Fogarty, M. and Garofolo, G. (1988) Urban Spatial Structure and Productivity Growth in the Manufacturing Sector of Cities. *Journal of Urban Economics*, 23: 60-70.

Fotheringham, A.S. and O'Kelley, M.C. (1989) *Spatial Interaction Models: Formulations and Applications*. Dordrecht: Kluwer.

Frandberg, B. and Vilhelmson, L. (2003) Personal mobility: a corporeal dimension of transnationalisation. The case of long-distance travel in Sweden. *Environment and Planning A*, 35: 1751-1761.

Frankel, J.A. (1997) *Regional Trading Blocs in the World Economic System*. Washington DC: Institute for International Economics.

Frenken, K., Van Oort F.G. and Verburg, T. (2007) Related Variety, Unrelated Variety and Economic Growth. *Regional Studies*, 41: 685-697.

Friedmann, J. (1966a) *Regional Development Policy*. Cambridge, MA: MIT Press.

Friedmann, J. (1966b) Poor regions and poor nations: perspectives on the problems of the Appalachia. *Southern Economic Journal*, 32: 465-473.

Friedmann, J. (1986) The world city hypothesis. *Development and Change,* 17: 69–83.

Friedmann, J. and Miller, J. (1965) The urban field. *Journal of the American Planning Association*, 31: 312-320.

Frost, M.E. and Spence, N.A. (1995) The rediscovery of accessibility and economic potential: the critical issue of self-potential. *Environment and Planning A*, 27: 1833-1848.

Frug, G.E. (1980) The city as legal concept. *Harvard Law Review*, 93: 1057-1154.

Fujita, M. (1988) A monopolistic competition model of spatial agglomeration: differentiated products approach. *Regional Science and Urban Economics*, 18: 87-124.

Fujita, M. (2010) The evolution of spatial economics: from Thünen to the new economic geography. *The Japanese Economic Review*, 61: 1-32.

Fujita, M. and Krugman, P. (1995) When is the economy monocentric? Von Thünen and Chamberlin unified. *Regional Science and Urban Economics*, 25: 505-528.

Fujita, M., Krugman, P. and Mori, T. (1999) On the evolution of hierarchical urban systems. *European Economic Review*, 43: 209-251.

Fujita, M. and Mori, T. (1997) Structural stability and evolution of urban systems. *Regional Science and Urban Economics*, 27: 399-442.

Fujita, M. and Ogawa, H. (1982) Multiple equilibria and structural transition of non-monocentric urban configurations. *Regional Science and Urban Economics*, 12: 161-196.

Fujita, M., Thisse, J.F. (2002) *Economics of Agglomeration: Cities, Industrial Location and Regional Growth*. Cambridge, UK: Cambridge University Press.

Fujita, M., Thisse J.F. and Zenou, Y. (1997) On the endogenous formation of secondary employment centres in a city. *Journal of Urban Economics*, 41: 337-357.

Gabaix, X. and Ibragimov, R. (2011) Rank-1/2: a simple way to improve the OLS estimation of tail exponents. *Journal of Business Economics and Statistics*, 29: 24-39.

Galpin, J. (1915) *The Social Anatomy of an Agricultural Community*. Madison, WI: Research Bulletin 34, Agricultural Experiment Station of University of Wisconsin.

Garreau J. (1991) *Edge City: Life on the New Frontier*. New York, NY: Doubleday.

Geyer H.S. (2002) On urban system evolution. In: Geyer, H.S. (Ed) *International Handbook of Urban Systems*, pp. 39-66. Cheltenham, UK: Edward Elgar.

Ghazalian, P., Tamini, L., Larue, B., and Gervais, J.P. (2007) A gravity approach to evaluate the signficance of trade liberalization in vertically-related goods in the presence of non-tariff barriers. MPRA Paper 2744, Laval University.

Ghosh, A. (1986) The value of a mall and other insights from a revised central place model. *Journal of Retailing*, 62: 79-97.

Gibrat, R. (1931) *Les Inégalités Économiques*. Paris; Sirey.

Gillespie, A. and Williams, H. (1988) Telecommunications and the reconstruction of regional comparative advantage. *Environment and Planning A*, 20: 1311-1321.

Glaeser, E.L. (2007) Do regional economies need regional coordination? In: Goldfiled, K.S. (Ed.) *The Economic Geography of Megaregions*, pp.11-57. Princeton: Princeton University.

Glaeser, E.L. and Kahn, M.E. (2001) Decentralized employment and the transformation of the American city. Working paper 8117, National Bureau of Economic Research, Cambridge, MA.

Glaeser, E.L. and Kahn M.E. (2004) Sprawl and urban growth, in: Henderson, J.V. and Thisse, J-F. (Eds.) *Handbook of Regional Science and Urban Economics, Vol. 4 Cities and Geography*, pp 2481-2527. Amsterdam: Elsevier.

Glaeser, E.L., Kallal, H.D., Scheinkman, A. and Shleifer, A. (1992) Growth in cities. *Journal of Political Economy*, 100: 1126-1152.

Glaeser, E.L. and Kohlhase, J.E. (2004). Cities, regions and the decline of transport costs. *Papers in Regional Science*, 83: 197-228.

Glaeser, E.L., Kolko, J. and Saiz, A. (2001) Consumer city. *Journal of Economic Geography*, 1: 27-50.

Glanzmann, L., Grillon, N., Kruse C. and Thierstein, A. (2004) *Polycentricity and metropolitan governance: a Swiss case-study*. Paper presented at the 44th European Congress of the European Regional Science Association, Porto, Portugal.

Gober, P. (1997) Megalopolis: the future is now. In: Hanson, S. (ed.) *Ten Geographic Ideas That Have Changed the World*, pp. 182-202. New Brunswick, NJ: Rutgers University Press.

Godlund, S. (1951) Bus services, hinterlands and the location of urban settlements in Sweden, specially in Scania. *Lund Studies in Geography, Series B, Human Geography*, 3: 14-24.

Goffette-Nagot, F. and Schmitt, B. (1999) Agglomeration economies and spatial configurations in rural areas. *Environment and Planning A*, 31: 1239-1257.

Goheen, P.G. (2002) Competing visions of the city. *Urban Geography*, 23: 414-422.

Golledge, R.G. (1981) Misconceptions, misinterpretations, and misrepresentations of behavioral approaches in human geography. *Environment and Planning A*, 13: 1325-1344.

Golledge, R.G. (2008) Behavioral theory and the theoretical/quantitative revolution. *Geographical Analysis*

Golledge, R.G. and Rushton, G. (ed.) *Spatial Choice and Spatial Behavior*. Columbus, OH: Ohio State University Press.

Golosinski, D. and West, D.S. (1995) Double moral hazard and shopping center similarity in Canada. *Journal of Law, Economics, & Organization*, 11: 456-478.

Gordon, I.R. (1999) Internationalisation and urban competition, Urban Studies, 36, pp. 1001-1016.

Gordon, I.R. (2003) Three into one: joining up the Greater South East. *Town and Country Planning*, 72: 342-343.

Gordon, I.R. and Cheshire. P. (1998) Locational advantage and the lessons of territorial competition in Europe. Paper prepared for the International Workshop on 'Theories of Regional Development: Lesson for Policies of Economic Renewal and Growth', Udevalla, Sweden, 14–16 June.

Gordon, I.R. (2004) A disjointed dynamo: the Greater South East and inter-regional relationships. *New Economy*, 11: 40-44.

Gordon, I.R. and McCann, P. (2000) Industrial Clusters: Complexes, Agglomeration and/or Social Networks? *Urban Studies*, 37: 513-532.

Gordon, P. and Richardson, H.W. (1996) Beyond polycentricity: the dispersed metropolis, Los Angeles, 1970-1990. *Journal of the American Planning Association*, 62: 289-294.

Gottdiener, M. (1985) *The Social Production of Urban Space*. Austin: University of Texas Press.

Gottmann, J. (1957) Megalopolis or the urbanization of the northeastern seaboard. *Economic Geography* 33, 189-200.

Gottmann, J. (1961) *The Urbanized Northeastern Seaboard of the United States*. New York, NY: The Twentieth Century Fund.

Gourieroux, C., Montfort, A. and Trognon, A. (1984) Pseudo maximum likelihood methods: applications to Poisson models. *Econometrica*, 52: 701-720.

Gradmann, J. (1916) Schwäbische Städte. *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*, [1916]: 425–457.

Graham, S. and Marvin, S. (2001) *Splintering Urbanism, Networked Infrastructures, Technological Mobilities and the Urban Condtion.* London: Routledge.

Gras, N.S.B. (1922) The development of metropolitan economy in Europe and America. *American Historical Review*, 27: 695-708.

Green, A.E., Hogarth, T. and Shackleton, R.E. (1999) Long distance commuting as a substitute for migration in Britain: a review of trends, issues and implications. *International Journal of Population Geography*, 5: 49-67.

Green, N. (2007) Functional polycentricity: a formal definition in terms of social network analysis. *Urban Studies,* 44: 2077-2103.

Green, N. (2008) City-states and the spatial in-between. *Town and Country Planning*, 77: 223-231.

Greene, D.L. (1980) Urban subcenters: recent trends in urban spatial structure. *Growth and Change*, 11: 29-40.

Greene, W.H. (1994) Accounting for excess zeros and sample selection in Poisson and negative binomial models. Working Paper 94-10. Stern School of Business, New York University.

Griffith, D.A. (1976) Spatial structure and spatial interaction: a review. *Environment and Planning A*, 8: 731-740.

Guth, D., Holz-Rau, C., Maciolek, M. (2009) Employment suburbanisation and commuter traffic in German city regions. Working paper, TU Dortmund.

Hägerstrand, T. (1970) What about people in regional science? *Papers in Regional Science*, 24: 7-21.

Haggett, P. (1965) *Locational Analysis in Human Geography*. London: Edward Arnold.

Haggett, P. and Chorley, R.J. (1967) *Network Analysis in Geography*. London: Edward Arnold.

Hague, C. and Kirk, K. (2003) *Polycentricity Scoping Study*. London: Office of the Deputy Prime Minister.

Halbert, L. (2008) Examining the Mega-City-Region hypothesis: evidence from the Paris City-Region / Bassin parisien. *Regional Studies*, 42: 1147-1160.

Hall, P. (1966) *The World Cities*. London: Weidenfield and Nicolson.

Hall. P. (1974) *Urban and Regional Planning*. London: Penguin Books.

Hall, P. (1997) The post-industrial city. *Futures*, 29: 311-322.

Hall, P. (2001) Global city regions in the twenty first century, in: Scott, A.J. (Ed.) *Global City Regions: Trends, Theory, Policy*, pp. 59-77. Oxford, UK: Oxford University Press.

Hall, P. (2003) The city of theory. In: LeGates, R.T. and Stout, F. (eds.) *The City Reader*, pp. 342-353. London: Routledge.

Hall, P. and Green, N. (2005) *South East England: Commuting and Definition of Functional Urban Regions*. London: Institute of Community Studies / The Young Foundation & Polynet Partners.

Hall, P. and Pain, K. (Eds) (2006) *The Polycentric Metropolis: Learning from Mega-City Regions in Europe*. London: Earthscan.

Hall, P. and Pain, K. (2006) From Metropolis to Polyopolis, in: Hall, P. and Pain, K. (Eds) *The Polycentric Metropolis: Learning from Mega-City Regions in Europe*, pp. 3-16. London: Earthscan.

Hall, P., Pain, K. and Green, N. (2006) The informational geography of Europolis: mapping the flow of information. In: Hall, P. and Pain, K. (Eds) *The Polycentric Metropolis: Learning from Mega-City Regions in Europe*, pp. 70-90. London: Earthscan.

Hall, R. and White, P. (1995) *Europe's Population: Towards the Next Century*. London: University College London Press.

Hannan, M.T. and Freeman, J.H. (1977) The population ecology of organizations. *American Journal of Sociology*, 82: 929-964.

Hansen, N. (1971) *Intermediate-Size Cities as Growth Centers: Applications for Kentucky, the Piedmont Crescent, the Ozarks and Texas*. New York: Praeger.

Hansen, N. (1977) Systems approaches to human settlement. *Papers of the Regional Science Association*, 38: 17-31.

Hanssens, H., Derudder, B., Van Aelst, S. and Witlox, F. (2011) Assessing functional polycentricity of the mega-city region of Central Belgium based on advanced producer service transaction links. Working Paper, University of Ghent.

Harris, C.D. and Ullman, E.L (1945) The nature of cities. *The Annals of the American Academy for Political and Social Science*, 242: 7-17.

Harris, T.R. and Shonkwiler, J.S. (1993) Application of count data procedures to estimate thresholds for rural commercial sectors. *Proceedings of the Western Agricultural Economies Association (1993)*, 410-415.

Harvey, D. (1972) Revolutionary and counter revolutionary theory in geography and the problem of ghetto formation. *Antipode*, 4: 1-13.

Haveman, J. and Hummels, D. (2004) Alternative hypotheses and the volume of trade: the gravity equation and the extent of specialization. *Canadian Journal of Economics*, 37: 199-218.

Hawley, A. (1950) *Human Ecology*. New York, NY: Ronald Press Company.

Haworth, J.M. and Vincent, P.J. (1979) The stochastic disturbance specification and its implications for log-linear regression. *Environment and Planning A*, 11: 781-790.

Haynes, K.E. and Fotheringham, A.S. (1984) *Gravity and Spatial Interaction Models*. London: Sage.

Head, K., Mayer, T., Ries, J. (2009) How remote is the offshoring threat? *European Economic Review*, 53: 429-444.

Healey, P. (2004) The treatment of space and place in the new strategic spatial planning Europe. *International Journal of Urban and Regional Research*, 28, 45-67.

Healey, P. (2006) Relational complexity and the imaginative power of strategic spatial planning. *European Planning Studies*, 14: 525-546.

Heckman, J.J. (1979) Sample selection bias as a specification error. *Econometrica*, 47: 153-161.

Helpman, E., Melitz, M. and Rubinstein, Y. (2008) Estimating trade flows: trading partners and trading volumes. *Quarterly Journal of Economics*, 123: 441-487.

Henderson, J.W. (2010) Cities and development. *Journal of Regional Science*, 50:

Henderson, J.W., Kelly, T.M. and Taylor, B.A. (2000) The impact of agglomeration economies on estimated demand thresholds: an extension of Wensley and Stabler. *Journal of Regonal Science*, 40: 719-733.

Hewings, G.J.D., Sonis, M., Cuello, F.A. and Mansouri, F. (1996) The role of regional interaction in regional growth: competition and complementarity in the US regional system. *Australasian Journal of Regional Studies*, 2: 133-149.

Hohenberg, P. and Lees, L. (1985) *The Making of Urban Europe, 1000-1994*. Cambridge, MA: Harvard University Press.

Horan, T.A, Chinitz, B. and Hackler, P. (1996) *Stalking the Invisible Revolution. The Impact of Information Technology on Human Settlement Patterns.* Claremont, CA: Claremont Graduate School.

Hoyler, M., Kloosterman, R.C. and Sokol, M. (2008) Polycentric puzzles - emerging mega-city regions seen through the lens of advanced producer services. *Regional Studies*, 42: 1055-1064.

Howard, E. (1902) *Garden Cities of Tomorrow*. London: Swan Sonnenschein & Co.

Hymer, S. (1970) The efficiency contradictions of multinational corporations. *American Economic Review*, 60: 441-448.

Iaonnides, Y.M., Overman, H.G., Rossi-Hansberg, E. and Schmidheiny, K. (2008) The effect of information and communication technologies on urban structure. *Economic Policy*, April 2008: 201-242.

Ingene, C.A. and Ghosh, A. (1990) Consumer and producer behavior in a multipurpose shopping environment. *Geographical Analysis*, 22: 70-93.

Irwin, I. and Hughes, M. (1992) Centrality and the structure of urban interaction. *Social Forces*, 71: 17-51.

Isard, W. (1954) Location theory and trade theory: short run analysis. *Quarterly Journal of Economics*, 68: 305-22.

Isard, W. (1956) *Location and Space Economy*. Cambridge, MA: MIT Press.

Isard, W. (1960) *Methods of Regional Analysis*. Cambridge, MA: MIT Press.

Jacobs, J. (1969) *The Economy of Cities*. London: Jonathan Cape.

Jenkins, R. (2008) Measuring the competitive threat from China for other southern exporters. *The World Economy*, 31: 1351-1366.

Johanson, J. and Vahlne, J.E. (1977) The internationalization process of the firm-a model of knowledge development and increasing foreign market commitments. *Journal of International Business Studies*, 8: 23-32.

Johansson, B. and Quigley, J.M. (2004) Agglomeration and networks in spatial economies. *Papers in Regional Science*, 83: 165-176.

Johnson, N. and Kotz, S. (1969) *Distributions in Statistics-Discrete Distributions*. New York, NY: John Wiley and Sons.

Jones, K. and Simmons, J. (1990) *The Retail Environment*. London: Routledge.

Kamenetsky, I. (1961) *Secret Nazi Plans for Eastern Europe: A Study of Lebensraum Policies*. Opladen: Westdeutscher Verlag.

Kansky, K.J. (1963) *Structure of Transportation Networks: Relationships between Network Geometry and Regional Characteristics*. Research Paper no. 84, Department of Geography, University of Chicago.

Kant, E. (1935) *Bevölkerung und Lebensraum Estlands*. Tartu: Akadeemiline kooperatiiv.

Kellman, M. and Schroder, T. (1983) The export similarity index: some structural tests. *The Economic Journal*, 93: 193-198.

Kerbat, M.C. (1995) *Leçon Littéraire sur la Ville*. Paris: PUF.

Kim, S. (2007) Changes in the nature of urban spatial structure in the United States, 1890-2000. *Journal of Regional Science*, 47: 273-287.

King, L.J. (1976) Alternatives to a positive economic geography. *Annals of the Association of American Geographers*, 66: 615–632.

King, L.J. and Golledge, R.G. (1978) *Cities, Space, and Behavior: The Elements of Urban Geography*. Englewood Cliffs, NJ: Prentice Hall.

King, G. (1988) Statistical models for political science event counts: bias in conventional procedures and evidence for the exponential Poisson regression model. *American Journal of Political Science*, 32: 838-863.

Kitson, M., Martin, R. and Tyler, P. (2004) Regional competiveness: an elusive yet key concept. *Regional Studies*, 38: 991-999.

Kloosterman, R.C. and Lambregts, B. (2001) Clustering of Economic Activities in Polycentric Urban Regions: The Case of the Randstad. *Urban Studies*, 38: 717-732.

Kloosterman, R.C. and Lambregts, B. (2007) Between accumulation and concentration of capital: toward a framework for comparing long-term trajectories of urban systems. *Urban Geography*, 28: 54-73.

Kloosterman, R.C. and Musterd, S. (2001) The polycentric urban region: towards a research agenda. *Urban Studies*, 38: 623-633.

Kohl, J.G. (1841), *Der Verkehr und die Ansiedlungen der Menschen in ihrer Abhängigkeit des Gestaltung der Erdoberfläsche*. Dresden/Leipzig, Arnold.

Kolko, J. (2002) Silicon mountains, silicon molehills: geographic concentration and convergence of internet industries in the US. *Information Economics and Policy,* 14: 211-32.

Krakover, S. (1987) Cluster of cities versus city region in regional planning. *Environment and Planning A*, 19: 1375-1386.

Krätke, S. (2001) Strengthening the Polycentric Urban System in Europe: Conclusions from the ESDP. *European Planning Studies*, 9: 105-116.

Kresl, P.K. and Singh, B. (1999) Competitiveness and the urban economy: twenty-four large US metropolitan areas. *Urban Studies*, 36: 1017-1027.

Krugman, P. (1991) *Geography and Trade*. Cambridge, MA: MIT Press.

Krugman, P. (1996) *The Self-Organizing Economy*. Oxford, UK: Blackwell.

Kunzmann, K. (2006) The Europeanization of spatial planning. In: Adams, N., Alden, J. and Harris, N. (eds) *Regional Development and Spatial Planning in an Enlarged European Union*, pp. 43-64. Aldershot: Ashgate.

Lall, S. and Pietrobelli, C. (2005) *Failing to Compete. Technology Development and Technology Systems in Africa*. Cheltenham, UK: Edward Elgar.

Lambert, D. (1992) Zero-inflated Poisson regression with an application to defects in manufacturing. *Technometrics*, 34: 1-14.

Lambooy, J.G. (1998) Polynucleation and economic development: the Randstad. *European Planning Studies*, 6: 457-466.

Lambregts, B. (2008) Geographies of knowledge formation in mega-city regions: some evidence from the Dutch Randstad. *Regional Studies*, 42:1173-1186.

Lambregts, B. (2009) *The Polycentric Metropolis Unpacked: Concepts, Trends and Policy in the Randstad Holland*. Amsterdam: Amsterdam Institute for Metropolitan and International Development Studies.

Lambregts, B., Janssen-Jansen, L. and Haran, N. (2008) Effective governance for competitive regions in Europe: the difficult case of the Randstad, *GeoJournal*, 72, 45-57.

Lambregts, B., Kloosterman, R.C. and Van der Werff, M. (2005) Polycentricity and the eye of the beholder: A multi-layered analysis of spatial patterns in the Dutch Randstad. *Romanian Economic Journal*, 8: 19-34.

Lambregts, B., Kloosterman, R., Van der Werff, M., Roling, R. and Kapoen, L. (2006) Randstad Holland: multiple faces of a polycentric role model, in: Hall, P. and Pain, K. (Eds) *The Polycentric Metropolis: Learning from Mega-City Regions in Europe*, pp. 137-145. London: Earthscan.

Lambregts, B. and Zonneveld, W. (2004) From Randstad to Deltametropolis: changing attitudes towards the scattered metropolis. *European Planning Studies*, 12: 299-323.

Lang, R.E. (2003) *Edgeless Cities: Exploring the Elusive Metropolis*. Washington DC: Brookings Institution Press.

LDA (2007*) Report: Greater South East-Update on Joint Boards Meeting, part 2 item 4.2*. London: London Development Agency.

Lee, B. (2007) Edge or edgeless cities? Urban spatial structure in U.S. metropolitan areas, 1980 to 2000. *Journal of Regional Science*, 47: 479-515.

Lee, B. and Gordon, P. (2007) Urban spatial structure and economic growth in US Metropolitan Areas. Paper presented at the 46th annual meeting of the Western Regional Science Association, Newport Beach, CA.

Lee, D.B. (1973) Requiem for large-scale models. *Journal of the American Institute of Planners*, 39: 163-178.

LeRoy, G. (2005) *The Great American Job Scam: Corporate Tax Dodging and the Myth of Job Creation*. San Francisco, CA: Berett-Koehler Publishers.

Lever, W.F. (1999) Competitive cities in Europe. *Urban Studies*, 36: 935-948.

Limtanakool, N., Dijst, M. and Schwanen, T. (2006) On the participation in medium- and long-distance travel: a decomposition analysis for the UK and the Netherlands. *Tijdschrift voor Economische en Sociale Geografie*, 97: 389-404.

Limtanakool, N., Dijst, M. and Schwanen, T. (2007) A theoretical framework and methodology for characterizing national urban systems on the basis of flows of people: empirical evidence for France and Germany. *Urban Studies*, 44: 2123-2145.

Limtanakool, N., Schwanen, T. and Dijst, M. (2008) Ranking metropolitan areas: a comparison of interaction and node attribute data. *Cities*, 27: 26-42.

Limtanakool, N., Schwanen, T. and Dijst, M. (2009) Developments in the Dutch urban system on the basis of flows. *Regional Studies*, 43: 179-196.

Lin, G. (1999) Assessing changes in interstate migration patterns of the United States elderly population 1965-1990. *International Journal of Population Geography*, 5: 411-424.

Linders, G.J.M. and De Groot, H.F.L. (2006) Estimation of the gravity Equation in the Presence of Zero Flows. *Tinbergen Institute Discussion Paper*, 2006-072/3.

Linders, G.J.M., Burger, M.J. and Van Oort, F.G. (2008) A rather empty world: the many faces of distances and the persistent resistance to international trade. *Cambridge Journal of Regions, Economy and Society*, 1: 439-458.

Liu, W.S. and Cela, J. (2008) Count data models in SAS. SAS 2008 Global Forum, Paper 371-2008.

Long, J.S. (1997) *Regression Models for Categorical and Limited Dependent Variables*. Thousand Oaks: Sage.

Longley, P., Batty, M., Shepherd, J. and Sadler, G. (1992) Do Green Belts change the shape of urban areas? A preliminary analysis of the settlement geography of South East England. *Regional Studies*, 26: 437-452.

Lösch, A. (1944) *Die Räumliche Ordnung der Wirtschaft*. Jena: Gustav Fischer.

Loungani, P., Mody, A., and Razin, A. (2002) The global disconnect: the role of transactional distance and scale economies in gravity equations. *Scottish Journal of Political Economy*, 49: 526-543.

Lovett, A. and Flowerdew, R. (1989) Analysis of count data using Poisson regression. *Professional Geographer*, 41: 190-198.

Low, N. (1975) Centrism and the provision of services in residential areas. *Urban Studies*, 12: 177-191.

Lühti, S., Thierstein, A. and Goebel, V. (2010) Intra-firm and extra-firm linkages in the knowledge economy: the case of the emerging mega-city region of Munich. *Global Networks*, 10: 114-137.

Lukermann, F. (1966) Empirical expressions of nodality and hierarchy in a circulation manifold. *East Lakes Geographer*, 2: 17-44.

Luque-Martínez, T. and Muñoz-Leiva, F. (2005) City benchmarking: a methodological proposal referring specifically to Granada. *Cities*, 22: 411-423.

Malecki, E.J. (2002) Hard and soft networks for urban competitiveness. *Urban Studies*, 39: 929-945.

Malecki, E.J. (2004) Jockeying for position: what it means and why it matters to regional development policy when places compete. *Regional Studies*, 38: 1101-1120.

Markusen, A. (1996) Sticky places in slippery space: a typology of industrial districts. *Economic Geography*, 72: 293-313.

Markusen, A. (2003) Fuzzy concepts, scanty evidence, policy distance: the case for rigour and policy relevance in critical regional studies. *Regional Studies*, 6-7: 701-717.

Markusen, A. and Schrock, G. (2006) The distinctive city: divergent patterns in growth, hierarchy and specialization. *Urban Studies*, 43: 1301-1323.

Markusen, A. and Schrock, G. (2009) Consumption-driven urban development. *Urban Geography*, 30: 1-24.

Markusen, A.R. and Nesse, K. (2007) Institutional and political determinants of incentive competition. In: Markusen, A.R. (Ed.) *Reining in the Competition for Capital*, pp. 1-42. Kalamazoo, MI: W.E. Upjohn Institute for Employment Research.

Márquez, M.A. and Hewings, G.J.D. (2003) Geographical competition between regional economies: the case of Spain. *Annals of Regional Science*, 37: 559-580.

Marshall, J.U. (1989) *The Structure of Urban Systems*. Toronto: University of Toronto Press.

Martinez-Zarzoso, I., Nowak-Lehman, D., and Vollmer, S. (2007) The log of gravity revisited. CeGE Discussion Paper 64, University of Gottingen.

Masser, I. (1972), *Analytical Models for Urban and Regional Planning*. Newton Abbott: David & Charles.

Mataloni Jr., R.J. (2011) The structure of location choice for new U.S. manufacturing investments in Asia-Pacific. *Journal of World Business*, 46: 154-165.

Matyas, L. (1998) The gravity model: some econometric considerations. *The World Economy*, 21: 397–401.

Mayer, J.D. (1980) Urban ecology and location theory: dominance and territory. *Geoforum*, 11: 399-407.

McCann, E.J. (2004) 'Best places': interurban competition, quality of life and popular media discourse. *Urban Studies*, 41: 1909-1929.

McCann, P. (2008) Globalization and economic geography: the world is curved, not flat. *Cambridge Journal of Regions, Economy and Society*, 1: 351-370.

McCann, P. (2011) International business and economic geography: knowledge, time and transactions costs. *Journal of Economic Geography*, 11: 309-317.

McKenzie, S. (1933) *The Metropolitan Community*. New York, NY: Russell & Russell.

McLafferty, S. and Ghosh, A. (1986) Multipurpose shopping and the location of retail firms. *Geographical Analysis*, 18: 215-226.

McPherson, J.C. (1981) The implications of central place theory for urban structure in a declining region: the North American Experience. *Papers of the Regional Science Association*, 47: 35-43.

Meijers, E.J. (2005) Polycentric urban regions and the quest for synergy: is a network of cities more than the sum of the parts? *Urban Studies*, 42: 765-781.

Meijers, E. (2007) From a central place to a network model: theory and evidence of a paradigm change. *Tijdschrift voor Economische en Sociale Geografie*, 98: 245-259.

Meijers, E. (2008a) Summing small cities does not make a large city: polycentric urban regions and the provision of cultural, leisure and sports amenities. *Urban Studies*, 45: 2323-2342.

Meijers, E.J. (2008b) Measuring polycentricity and its promises. *European Planning Studies*, 16: 1313-1323.

Meijers, E. and Burger, M.J. (2010) Spatial structure and productivity in US metropolitan areas. *Environment and Planning A*, 42: 1383-1402.

Meijers, E., Hoekstra, J. and Aguado, R. (2008) Strategic planning for city networks: the emergence of a Basque global city? *International Planning Studies*, 13: 239-259.

Meijers, E. and Romein, A. (2003) Realizing potential: building regional organizing capacity in polycentric urban regions. *European Urban and Regional Studies*, 10: 173-186.

Meijers, E. and Sandberg, K. (2008) Reducing regional disparities by means of polycentric development: panacea or placebo? *Scienze Regionali, 7*: 71-96.

Meijers, E.J., Waterhout, B. and Zonneveld, W.A.M. (2007) Closing the GAP: Territorial cohesion through polycentric development. *European Journal of Spatial Development*, 24, October 2007.

Melo, P.C., Graham, D.J. and Noland, R.B. (2009) A meta-analysis of estimates of urban agglomeration economies. *Regional Science and Urban Economics*, 39: 332-342.

Mencinger, J. (2008) Does foreign investment always enhance economic growth? *Kyklos* 56, 491-508.

Meyer, D.R. (1986) The world system of cities: relations between international financial metropolises and South American cities. *Social Forces,* 64: 553–581.

Mori, T. (1997) A modeling of megalopolis formation: the maturing of city systems. *Journal of Urban Economics*, 42: 133-157

Mullahy, J. (1986) Specification and testing of some modified count models. *Journal of Econometrics*, 33: 341-65.

Mulligan, G.F. (1984) Agglomeration and central place theory: a review of the literature. *International Regional Science Review*, 9: 1-42.

Mushinski, D. and Weiler, S. (2002) A note on the geographical interdependencies of retail market areas. *Journal of Regional Science*, 42: 75-86.

Muth, R.F. (1961) The spatial structure of the housing market. *Papers in Regional Science*, 7: 207-220.

Narula, R. and Bellak, C. (2009) EU enlargement and consequences for FDI assisted industrial development. *Transnational Corporations*, 18: 69-90.

Neal, Z. (2011) From central place to network bases: a transition in the U.S. urban hierarchy, 1900-2000. *City & Community*, 10: 49-70.

Neffke, F.H.M. and Henning, M. (2009) Skill relatedness and firm diversification. *Strategic Management Journal* (forthcoming).

Nielsen, T.A.S. and Hovgesen, H.H. (2005) Urban field in the making: new evidence from a Danish context. *Tijdschrift voor Economische en Sociale Geografie*, 96: 515-528.

Nielsen, T.A.S. and Hovgesen, H.H. (2008) Exploratory mapping of commuter flows in England and Wales. *Journal of Transport Geography*, 16: 90-99.

Nitsch, V. (2003) Does history matter for urban primacy? The case of Vienna. *Regional Science and Urban Economics*, 33: 401-418.

Nooteboom, B. (1999) *Inter-firm Alliances: Analysis and Design*. London: Routledge.

Nordregio (2004) *ESPON 1.1.1: Potentials for polycentric development in Europe*. Stockholm/Luxembourg: Nordregio/ESPON Monitoring Committee.

Nystuen, J.D. and Dacey, M.F. (1961) A graph theory interpretation of nodal regions. *Papers of the Regional Science Association*, 7: 29-42.

O'Kelly, M.E. (1981) A model of the demand for retail facilities, incorporating multistop, multipurpose trips. *Geographical Analysis*, 13: 134-148.

ODPM (2003) *Sustainable Communities: Building for the Future.* London: Office of the Deputy Prime Minister.

Office of Management and Budget (OMB) (2000) *Standards for defining Metropolitan and Micropolitan Regions*. Federal Register, 65, No.249.

Overman, H., Redding, S., and Venables, T. (2003) The economic geography of trade, production, and income: a survey of the empirics. In: Harrigan, J. and Choi, K. (Eds.) *The Handbook of International Trade*, pp. 353-387. London: Blackwell Publishers.

Paddison, R. (1993) City marketing, image reconstruction and urban regeneration. *Urban Studies*, 30: 339-349.

Pain, K. (2008) Examining 'core-periphery' relationships in a mega-city region: the case of London and South East England. *Regional Studies*, 42: 1161-1172.

Parr, J.B. (1969) City hierarchies and the distribution of city size. A reconsideration of Beckmann's contribution. *Journal of Regional Science*, 15: 1-8.

Parr, J.B. (1970) Models of city size in an urban system. *Papers of the Regional Science Association*, 25: 221-253.

Parr, J.B. (1978) Models of the urban system: a more general approach. *Urban Studies*, 15: 35-49.

Parr, J.B. (1987) Interaction in an urban system: aspects of trade and commuting. *Economic Geography*, 63: 223-240.

Parr, J.B. (1995) Alternative approaches to market-area structure in the urban system. *Urban Studies*, 32: 1317-1329.

Parr, J.B. (1999) Growth-pole strategies in regional economic planning: a retrospective view. *Urban Studies*, 36: 1195-216.

Parr, J.B. (2002) Agglomeration economies: ambiguities and confusions. *Environment and Planning A*, 34: 717-731.

Parr, J.B. (2004) The polycentric urban region: a closer inspection. *Regional Studies*, 38: 231-240.

Parr, J.B. (2005) Perspectives on the City-Region. *Regional Studies*, 39: 555-566.

Parr, J.B. (2008) Cities and regions: problems and potentials. *Environment and Planning A*, 40: 3009-3026.

Parr, J.B. and Denike, K.G. (1970) Theoretical problems in central place analysis. *Economic Geography*, 46: 568-586.

Parr, J. and Hewings, G. (2007) Spatial interdependence in a metropolitan setting. *Spatial Economic Analysis*, 2: 8-22.

Patuelli, R., Reggiani, A., Nijkamp, P. and Bade, F.J. (2010) The evolution of the commuting network in Germany: spatial and connectivity patterns. *Journal of Transport and Land Use*, 2: 5-37.

Pawson, E. (2008) Gottman J. 1961: Megalopolis. The urbanized northeastern seaboard of the United States. New York: The Twentieth Century Fund. *Progress in Human Geography*, 32: 441-444.

Perroux, F. (1955) Notes sur la notion de 'pôle de croissance'. *Économie Appliquée*, 7 : 307-320.

Phelps, N.A., Fallon, R. J. and Williams, C.L. (2001) Small Firms, Borrowed Size and the Urban-Rural Shift. *Regional Studies*, 35: 613-624.

Phelps, N.A. and Ozawa, T. (2003) Contrasts in agglomeration: proto-industrial, industrial and post-industrial forms compared. *Progress in Human Geography*, 27: 583–604.

Phelps, N. and Raines, P. (2003) Conclusions: who's competing with whom? In: Phelps, N. and Raines, P. (eds) *The New Competition for Inward Investment*, pp. 213-221. Cheltenham, UK: Edward Elgar.

Phelps, N.A. and Fuller, C. (2000) Multinationals, intracorporate competition and regional development. *Economic Geography*, 76: 224-243.

Podolny, J.M, Stuart, T.E. and Hannan, M.T. (1996) Networks knowledge and niches competition in the worldwide semiconductor industry 1984-1991. *American Journal of Sociology*, 102: 659-689.

Poot, J. (2000) Reflections on local and economy-wide effects of territorial competition. In: Friedrich, P. and Batey, P.W.J. (Eds) *Regional Competition*, pp. 205-230. Heidelberg: Springer.

Porter (1990) *The Competitive Advantage of Nations*. New York, NY: Free Press.

Porter (2000) Location, competition, and economic development: local clusters in a global economy. *Economic Development Quarterly*, 14: 15-34.

Pred, A. (1973) *Urban Growth and the Circulation of Information: the United States System of Cities 1790-1840*. Cambridge, MA: Harvard University Press.

Pred, A. (1977) *City Systems in Advanced Economies: Past Growth, Present Processes and Future Development Options*. London: Hutchinson.

Preston, R.E. (1971) The structure of central place systems. *Economic Geography*, 47: 136-155.

Preston, R.E. (1975) A comparison of five measures of central place importance and of settlement size. *Tijdschrift voor Economische en Sociale Geografie*, 66: 178-187.

Preston, R.E. (1992) Christaller's research on the geography of administrative areas. *Progress in Human Geography* 16: 523-539.

Preston, R.E. (2009) Walter Christaller's research on regional development and rural development planning during World War II. METAR-Papers in Metropolitan Studies, volume 52, Institut für Geographische Wissenschaften, Freie Universität Berlin.

Puga, D. (2010) The magnitude an causes of agglomeration economies. *Journal of Regional Science*, 50: 203-220.

Raines, P. (2003) Flows and territories: the new geography of competition for mobile investment in Europe, in: Phelps, N. and Raines, P. (Eds) *The New Competition for Inward Investment*, pp. 119-136. Cheltenham, UK: Edward Elgar.

Rauch, J.E. (1999) Networks versus markets in international trade. *Journal of International Economics*, 48: 7-35.

Ravenstein, E.G. (1885) The laws of migration. *Journal of the Statistical Society*, 48: 167-235.

Reilly, W.J. (1931) *The Law of Retail Gravitation*. New York, NY: Knickerbocker Press.

Reggiani, A. and Nijkamp, P. (2007) Transport networks and metropolitan development: new analytical departures. *Networks and Spatial Economics*, 7: 297-300.

Reggiani, A. and Schintler, L.A. (eds) (2005) *Methods and Models in Transport and Communications: Cross Atlantic Perspectives*. Berlin: Springer.

Reggiani, A., Bucci, P. and Russo, G. (2011) Accessibility and impedance forms: empirical applications to the German commuting network. *International Regional Science Review*, 34: 230-252.

Renkow, M. and Hoover, D.M. (2000) Commuting, migration and rural-urban population dynamics. *Journal of Regional Science*, 40: 261-287.

Reynaud J. (1841) Villes, In: *Encyclopédie Nouvelle, t. VIII*, *Gosselin*, 670-687.

Richardson, H.W. (1972) Optimality in city size, systems of cities and urban policy: a sceptic's view. *Urban Studies* 9: 29-48.

Richardson, H.W. (1988) Monocentric vs. polycentric models: the future of urban economics. *Annals of Regional Science*, 32: 1-12.

Richardson, H.W. (1995) Economies and diseconomies of agglomeration. In: Giersch, H. (Ed.) *Urban agglomeration and economic growth*, pp 123-155. Berlin: Springer.

Ritsema van Eck, J., Van Oort, F.G., Raspe, O., Daalhuizen, F. and Van Brussel, J. (2006) *Vele steden maken nog geen Randstad*. Rotterdam/Den Haag: NAi Uitgevers.

Robson, B., Barr, R., Lymperopoulo, K. Ress, J. and Coombes, M.G. (2006) *A Framework for City Regions-Working Paper 1: Mapping City-Regions*. London: Office of the Deputy Prime Minister, London.

Rogerson, R.J. (1999) Quality of life and city competitiveness. *Urban Studies*, 36: 969-985.

Romein A. (2004) Spatial planning in competitive urban regions: some practical lessons from Northwest Europe. In: Hambleton R. and Smith, J. (Eds) *City Futures: An International Conference on Globalism and Urban Change*. Chicage, IL: University of Illinois.

Rosenthal, S.S. and Strange, W.C. (2003) Geography, industrial organization, and agglomeration. *Review of Economics and Statistics*, 85: 377-393.

Rosenthal, S.S, and Strange, W.C. (2004) Evidence on the nature and sources of agglomeration economies. In: Henderson, J.V. and Thisse, J-F (Eds) *Handbook of Regional Science and Urban Economics, Vol. 4 Cities and Geography*, pp 2119-2171. Amsterdam: Elsevier.

Ross, C. (1992) *The Urban System and Networks of Corporate Control*. Greenwich, CT: JAI Press.'

Rössler, M. (1989) Applied geography and area research in Nazi society: central place theory and planning, 1933 to 1945. *Environment and Planning D: Society and Space*, 7: 419-431.

Rouwendal, J. (1999) Spatial job search and commuting distances. *Regional Science and Urban Economics*, 29: 491-517.

Rugman, A.M. and Verbeke, A. (2005) Towards a theory of regional multinationals: a transaction cost economics approach. *Management International Review*, Special Issue 2005/1: 5-17.

Rushton, G. (1971) Postulates of central place theory and the properties central place systems. *Geographical Analysis*, 3: 140-156.

Sabre (2007) Roaders Digest, http://www.sabre-roads.org.uk/roadlists/. Accessed on 30/04/2008.

Sachar, A. (1994) Randstad Holland: a world city? *Urban Studies*, 31: 381-400.

Saey, P. (1973) Three fallacies in the literature on central place theory: central place patterns in areas of variable population density. *Tijdschrift voor Economische en Sociale Geografie*, 64: 181-194.

Santos Silva, J.C.M. and Tenreyro, S. (2006) The log of gravity. *The Review of Economics and Statistics*, 88: 641-58.

Sassen, S. (1991) *The Global City: New York, London, Tokyo.* Princeton, NJ: Princeton University Press.

Sassen, S. (2007) Megaregions: Benefits Beyond Sharing Trains and Parking Lots? In: Goldfeld, K.S. (Ed.) *The Economic Geography of Mega-Regions*, pp. 59-83. Princeton, NJ: The Policy Research Institute for the Region.

Sassen, S. (1991) *The Global City: New York, London, Tokyo*. Princeton, NJ: Princeton University Press.

Schintler, L.A. and Kulkarni, R.G. (2002) The emergence of small world phenomenon in urban transportation networks: an exploratory analysis. In: Reggiani, A. (ed.) *Spatial Economic Science: New Frontiers in Theory and Methodology*, pp. 419-434. Berlin: Springer.

Schwanen, T., Dieleman, F.M. and Dijst, M.J. (2003) Car use in Netherlands Daily Urban Systems: does polycentrism result in lower commute times? *Urban Geography*, 24: 340-360.

Schwanen, T., Dieleman, F.M. and Dijst, M.J. (2004) The impact of metropolitan structure on commute behavior in the Netherlands: a multilevel approach. *Growth and Change*, 35: 304-334.

Schwanen, T. and Dijst, M.J. (2002) Travel-time ratios for visits to the workplace: the relationship between commuting time and work duration. *Transportation Research Part A: Policy and Practice*, 36: 573-592.

Scott, A.J. (1988) *Metropolis: From the Division of Labor to Urban Form*. Berkeley, CA: University of California Press.

Scott, A.J. (2000) Economic geography: the great half-century. *Cambridge Journal of Economics*, 24: 483-504.

Scott, A. J., Agnew, J., Soja, E. and Storper, M. (2001) Global city-regions. In: Scott, A.J. (Ed.) *Global City-Regions; Trends, Theory, Policy*, pp. 11-30. Oxford, UK: Oxford University Press.

Scott, A. and Storper, M. (2007) Regions, globalization and development. *Regional Studies*, 41: 191-205.

SEEDA (2005) *The UK's Engine for Growth and Prosperity: A Case for Targeted Investment in the Greater South East*. Guildford, UK: South East England Development Agency, East of England Development Agency, and London Development Agency.

SEEDA (2006) *A Clear Vision for the South East: the South East Plan, Executive Summary*. Guildford, UK: South East England Development Agency.

Sen, A. and Smith, T.E. (1995) *Gravity Models of Spatial Interaction Behaviour*. Heidelberg: Springer.

Senior, M.L. (1979) From gravity modelling to entropy maximizing. *Progress in Human Geography*, 3: 175-210.

Shonkwiler, J.S. and Harris, T.R. (1998) Rural retail business thresholds and interdependencies. *Journal of Regional Science*, 36: 617-630.

Short, J.R. (2004) Black holes and loose connections in a global urban network. *Professional Geographer*, 56: 295-302.

Siegel, P., Johnson, T. and Alwang, J. (1995) Regional Economic Diversity and Diversification. *Growth and Change*, 26: 261-284.

Simmie, J., Sennett, J., Wood, D. and Hart, D. (2002) Innovation in Europe: a tale of networks, knowledge and trade in five cities. *Regional Studies*, 36: 47-64.

Simmons, J.W. (1978) The organization of the urban system. In: Bourne, L.S. and Simmons, J.W. (Eds) *Systems of Cities: Readings on Structure, Growth, and Policy*, pp. 61-69. New York, NY: Oxford University Press.

Small, K. and Song, S. (1994) Population and employment densities: structure and change. *Journal of Urban Economics*, 36: 292-313.

Smith, D.A. and Timberlake, M.F. (2001) World city networks and hierarchies: an empirical analysis of global air travel links. *American Behavioral Scientist*, 44: 1656-1678.

Smith, D.M. (1971) *Industrial Location: An Economic Geographical Analysis*. New York, NY: Wiley.

Sohn, J. (2004) Are commuting patterns a good indicator of urban spatial structure? *Journal of Transport Geography*, 13: 306-317.

Sonis, M. and Hewings, G.J.D. (2000) Regional competition and complementarity; comparative advantages/disadvantages and increasing/dimininshing returns in discrete relative spatial dynamics. In: Friedrich, P. and Batey, P.W.J. (Eds.) *Regional Competition*, pp. 139-158. Heidelberg: Springer.

Spiekermann, K. and Wegener, M. (2004) How to Measure Polycentricity? Paper presented at ESPON 1.1.3 Project Meeting, Warsaw, Poland, June 2004.

Stavins, R.N. and Jaffe, A.B. (1990) Unintended impacts of public investments on private decisions: the depletion of forested wetlands. *American Economic Review*, 80: 337-52.

Stein, C. (1964) *Regional City*. Baltimore, MD: Johns Hopkins University Press.

Stewart J.Q. (1948) Demographic gravitation: evidence and applications. *Sociometry*, 11: 31-58.

Stock, J.H. and Yogo, M. (2005) Testing for weak instruments in linear IV regression, in: Andrews, D.W.K. and Stock, J.H. (Eds) *Identification and inference for econometric* *models: essays in honor of Thomas Rothenberg*, pp 80-108. Cambridge: Cambridge University Press.

Storper, M. (1997) *The Regional World: Territorial Development in a Global Economy*. London and New York: Guilford Press.

Stover, J.F. (1961) *American Railroads*. Chicago: The University of Chicago Press.

Sullivan, A.M. (1986) A general equilibrium model with agglomerative economies and decentralized employment. *Journal of Urban Economics*, 50: 338-366.

Tabuchi, T. and Yoshida, A. (2000) Separating agglomeration economies in consumption and production. *Journal of Urban Economics*, 48: 70-84.

Taylor, P.J. (2004) *World City Network: A Global Urban Analysis*. London: Routledge.

Taylor, P.J. (2009) Urban economics in thrall to Christaller: a misguided search for city hierarchies in external urban relations. *Environment and Planning A*, 41: 2550-2555.

Taylor, P.J. (2010) Competition and Cooperation between Cities in Globalization. *GaWC Research Bulletin* 351.

Taylor, P.J. and Aranya, R. (2008) A global 'urban roller coaster'? Connectivity changes in the world city network, 2000-2004. *Regional Studies*, 42: 1-16.

Taylor, P.J., Hoyler, M., Verbruggen, R. (2010) External urban relational process: introducing central flow theory to complement central place theory. *Urban Studies* 47: 2803-2818.

Taylor, P.J. and Lang, R.E. (2004) The shock of the new: 100 concepts describing recent urban change. *Environment and Planning A*, 36: 951-958.

Theil, H. (1958) *Economic Forecasts and Policy.* Amsterdam: North Holland.

Thilmany, D., McKenney, N., Mushinski, D. and Weiler, S. (2005) Beggar-thy-neighbor economic development: a note on the effect of geographic interdependencies in rural retail markets. *The Annals of Regional Science*, 39: 593-605.

Thissen, M., Van Oort, F.G. and Ruijs, A. (2011) Revealed competition and comparative advantage of European regions. Working paper, Netherlands Environmental Assessment Agency, The Hague.

Thompson, D. (1974) Spatial interaction data. *Annals of the Association of American Geographers*, 64: 560-575.

Thrift, N. (1977) *An Introduction to Time Geography*. Norwich: Geo Abstracts.

Tinbergen, J. (1960) The spatial dispersion of production: a hypothesis. *Schweizerische Zeitschrift für Volkswirtschaft und Statistik*, 97: 412-419.

Tinbergen, J. (1962) *Shaping the World Economy*. New York: The Twentieth Century Fund.

Tosics, I. (2004) European urban development: Sustainability and the role of housing. *Journal of Housing and the Built Environment*, 19: 67-90.

Transportation Research Board (2002) *Costs of Sprawl-2000*. Washington, DC: National Academy Press.

Turner, T. and Niemeier, D. (1997) Travel to work and household responsibility: new evidence. *Transportation*, 24: 397-419.

Turok, I. (2004) Cities, regions and competitiveness. *Regional Studies*, 38: 1069-1083.

Turok, I. (2009) The distinctive city: pitfalls in the pursuit of differential advantage. *Urban Studies*, 41: 13-30.

Turok, I. and Bailey, N. (2004) The theory of polynuclear urban regions and its application to Central Scotland. *European Planning Studies*, 12: 371-389.

Ullman, E.L. (1941) A theory of location for cities. *American Journal of Sociology*, 46: 853-864.

Ullman, E.L. (1954) Geography as spatial interaction, in: Rezvan, D. and Engelbert, E.S. (Eds.) *Interregional Linkages, Proceedings of the Western Committee on Regional Economic Analysis*, pp. 63-71. Berkeley, CA: UCLA.

UNCTAD (2001) *World Investment Report 2001: Promoting Linkages*. New York, NY: United Nations.

Urry J. (2004) Social networks, travel and talk. *British Journal of Sociology*, 54: 155-175.

Van der Berg, L. and Braun, E. (1999) Urban competitiveness, marketing and the need for organising capacity. *Urban Studies*, 36: 987-999.

Van der Berg, L., Drewett, R., Klaasen, L.H., Rossi, A. and Vijverberg, C.H.T. (1982) *Urban Europe: a Study of Growth and Decline*. Oxford: Pergamon Press.

Van der Burg, A.J. and Dieleman, F.M. (2004) Dutch urbanisation policies: from 'compact city' to 'urban network'. *Tijdschrift voor Economische en Sociale Geografie*, 95: 108-116.

Van der Knaap, G.A. (1980) *Population Growth and Urban Systems Development*. Dordrecht: Martinus Nijhoff Publishing.

Van der Knaap, G.A. (2002) *Stedelijke Bewegingsruimte: Over Veranderingen in Stad en Land*. Den Haag: SdU Uitgevers.

Van der Knaap. G.A. and Wall, R.S. (2003) Linking scales and urban network development. In: Van Dijk, H. (ed.) *The European Metropolis 1920-2000*. Rotterdam: ESHCC.

Van der Knaap, G.A. (2007) Urban network formation under conditions of uncertainty. In: P.J. Taylor, B. Derudder, P. Saey and F. Witlox (Eds) *Cities in Globalization: Practices, Policies and Theories*, pp. 84-101. London: Routledge.

Van der Laan, L. (1998) Changing urban systems: an empirical analysis at two spatial levels. *Regional Studies*, 32: 235-247.

Van der Laan, L., Vogelzang, J. and Schalke, R. (1998) Commuting in multimodal urban systems: an empirical comparison of three alternative models. *Tijdschrift voor Economische en Sociale Geografie*, 89: 384-400.

Van Ham, M. (2002) *Job Access, Workplace Mobility, and Occupational Achievement*. Delft: Eburon Publishers.

Van Houtum, H. and Lagendijk, A. (2001) Contextualising regional identity and imagination in the construction of Polycentric Urban Regions: the cases of the Ruhr Area and the Basque Country. *Urban Studies*, 38: 747-767.

Van Nuffel, N. and Saey, P. (2005) Commuting, hierarchy and networks: the case of Flanders. *Tijdschrift voor Economische en Sociale Geografie*, 96: 313-327.

Van Oort, F.G. (2004) *Urban Growth and Innovation, Spatially Bounded Externalities in the Netherlands*. Aldershot: Ashgate.

Van Oort, F.G. (2007) Spatial and sectoral composition effects of agglomeration economies in the Netherlands. *Papers in Regional Science*, 86: 5-30.

Van Oort, F.G., Burger, M.J. and Raspe, O. (2010) On the economic foundation of the urban network paradigm. Spatial integration, functional integration and urban complementarities within the Dutch Randstad. *Urban Studies*, 47: 725-748.

Vance Jr., J.E. (1964) *Geography and Urban Evolution in the San Francisco Bay Area*. Berkeley, CA: University of California, Institute of Governmental Studies.

Vandermotten, C., Halbert, L., Roelandts, M. and Cornut, P. (2008) European planning and the polycentric consensus: wishful thinking? *Regional Studies*, 42: 1205-1217.

Vining, R. (1955) A description of certain spatial aspects of an economic system. *Economic development and cultural change*, 3: 147-195.

Von Bertalanffy, L. (1950) An outline of General Systems Theory. *The British Journal for the Philosophy of Science*, I: 134-165.

Von Böventer, E. (1964) Spatial organization theory as a basis for regional planning. *Journal of the American Planning Association*, 30: 90-100.

Von Thünen, J. (1826) *Der Isolierte Staat in Beziehung der Landwirtschaft und Nationalökonomie*. Hamburg: Perthes.

VROM (2008) *Structural Vision Randstad 2040. Towards a sustainable and competitive European top region*. The Hague: Ministry of Spatial Planning and the Environment (VROM).

Vuong Q.H. (1989) Likelihood ratio tests for model selection and non-nested hypotheses. *Econometrica*, 57: 307-333.

Wall, R.S. (2009) The relative importance of Randstad cities within worldwide comparative corporate networks. *Tijdschrift voor Economische en Sociale Geografie*, 100: 250-259.

Wall, R.S., Burger, M.J. and Van der Knaap, G.A. (2011) The geography of global corporate networks: the poor, the rich and the happy few countries, *Environment and Planning A*, 43: 904-927.

Wall, R.S. and Van der Knaap, G.A. (2011) Sectoral differentiation and network structure within contemporary worldwide corporate networks. *Economic Geography*, 87:267-308.

Wasserman, S. and Faust, K. (1994) *Social Network Analysis: Methods and Applications*. Cambridge, UK: Cambridge University Press.

Waterhout, B. (2002) Polycentric development: what is behind it? In: Faludi, A. (Ed.) *European Spatial Planning,* pp. 83-103. Cambridge, MA: Lincoln Institute of Land Policy.

Waterhout, B., Zonneveld, W. and Meijers, E.J. (2005) Polycentric development policies in Europe: overview and debate. *Built Environment*, 31: 163-173.

Weber, A. (1909) *Über den Standort der Industrien*. Tübingen: J.C.B. Mohr.

Webber, M.M. (1964) The urban place and the non-place urban realm. In: Webber, M.M., Dyckman, J.W., Foley, D.L., Guttenberg, A.Z., Wheaton, W.L.C. and Wurster, C.B. (eds) *Exploration into Urban Structure*, pp. 79-153. Philadelphia, PA: University of Pennsylvania Press.

Wehrwein, G.S. (1942) The rural-urban fringe. *Economic Geography*, 18: 217-228.

Weltevreden, J., Atzema, O. and Frenken, K. (2005) Evolution of city centre retailing: the case of Utrecht (1974-2003). *International Journal of Retail and Distribution Management*, 33: 824-841.

Wensley, M.R.D. and Stabler, J.C. (1998) Demand-threshold estimation for business activities in rural Saskatchewan. *Journal of Regional Science*, 38: 155-177.

Werkcommissie Westen des Lands (1958) *De Ontwikkeling van het Westen des Lands*. The Hague: Staatsuitgeverij.

West, D.S. (1992) An empirical analysis of retail chains and shopping center similarity. *Journal of Industrial Economics*, 40: 201-221.

West, D.S., Von Hohenbalken, B. and Kroner, K. (1985) Tests of intraurban central place theories. *The Economic Journal*, 95: 101-117.

White, M.J. (1976) Firm suburbanization and urban subcentres. *Journal of Urban Economics*, 3: 323-343.

White, M.J. (1988) Location choice and commuting behaviour in cities with decentralized employment. *Journal of Urban Economics*, 24: 129-152.

Winsborough, H.H. (1960) Variations in industrial composition with city size. *Papers and Proceedings of the Regional Science Association*, 5: 121-132.

Woldenberg, M.J. (1968) Energy flow and spatial order: mixed hexagonal hierarchies of central places. *Geographical Review*, 58: 552-574.

Woolridge, J.M. (2006) *Introductory Econometrics: A Modern Approach*. Mason, OH: Thomson South-Western Educational Publishing.

Wright, F.L (1935) Broadacre city: a new community plan. *Architectural Record*, 77: 243-254.

Wurster, C.B. (1963) The form and structure of the future urban complex. In: Wingo, L. (ed.) *Cities and Space*, pp. 73-102. Baltimore, MD: Johns Hopkins University Press.

Yeates, M. (1990) *The North American City*, 4th edition. New York, NY: Harper & Row Publishers.

Yeates, M., Charles, A. and Jones, K. (2001) Anchors and externalities. *Canadian Journal of Regional Science*, 24: 465-484.

Zipf, G.K. (1949) *Human Behaviour and the Principle of Least Effort*. Cambridge, MA: Addison-Wesley Press.

ERASMUS RESEARCH INSTITUTE OF MANAGEMENT (ERIM)

ERIM PH.D. SERIES
RESEARCH IN MANAGEMENT

ERIM Electronic Series Portal: http://hdl.handle.net/1765/1

Acciaro, M., *Bundling Strategies in Global Supply Chains,* Promotor: Prof.dr. H.E. Haralambides, EPS-2010-197-LIS, ISBN: 978-90-5892-240-3, http://hdl.handle.net/1765/19742

Agatz, N.A.H., *Demand Management in E-Fulfillment*, Promotor: Prof.dr.ir. J.A.E.E. van Nunen, EPS-2009-163-LIS, ISBN: 978-90-5892-200-7, http://hdl.handle.net/1765/15425

Alexiev, A., *Exploratory Innovation: The Role of Organizational and Top Management Team Social Capital,* Promotors: Prof.dr. F.A.J. van den Bosch & Prof.dr. H.W. Volberda, EPS-2010-208-STR, ISBN: 978-90-5892-249-6, http://hdl.handle.net/1765/20632

Althuizen, N.A.P., *Analogical Reasoning as a Decision Support Principle for Weakly Structured Marketing Problems*, Promotor: Prof.dr.ir. B. Wierenga, EPS-2006-095-MKT, ISBN: 90-5892-129-8, http://hdl.handle.net/1765/8190

Alvarez, H.L., *Distributed Collaborative Learning Communities Enabled by Information Communication Technology*, Promotor: Prof.dr. K. Kumar, EPS-2006-080-LIS, ISBN: 90-5892-112-3, http://hdl.handle.net/1765/7830

Appelman, J.H., *Governance of Global Interorganizational Tourism Networks: Changing Forms of Co-ordination between the Travel Agency and Aviation Sector*, Promotors: Prof.dr. F.M. Go & Prof.dr. B. Nooteboom, EPS-2004-036-MKT, ISBN: 90-5892-060-7, http://hdl.handle.net/1765/1199

Asperen, E. van, *Essays on Port, Container, and Bulk Chemical Logistics Optimization***, Pr**omotor: Prof.dr.ir. R. Dekker, EPS-2009-181-LIS, ISBN: 978-90-5892-222-9, http://hdl.handle.net/1765/17626

Assem, M.J. van den, *Deal or No Deal? Decision Making under Risk in a Large-Stake TV Game Show and Related Experiments***, Pr**omotor: Prof.dr. J. Spronk, EPS-2008-138-F&A, ISBN: 978-90-5892-173-4, http://hdl.handle.net/1765/13566

Baquero, G, *On Hedge Fund Performance, Capital Flows and Investor Psychology*, **Pr**omotor: Prof.dr. M.J.C.M. Verbeek, EPS-2006-094-F&A, ISBN: 90-5892-131-X, http://hdl.handle.net/1765/8192

Benning, T.M., *A Consumer Perspective on Flexibility in Health Care: Priority Access Pricing and Customized Care*, Promotor: Prof.dr.ir. B.G.C. Dellaert, EPS-2011-241-MKT, ISBN: 978-90-5892-280-9, http://hdl.handle.net/1765/23670

Berens, G., *Corporate Branding: The Development of Corporate Associations and their Influence on Stakeholder Reactions*, Promotor: Prof.dr. C.B.M. van Riel, EPS-2004-039-ORG, ISBN: 90-5892-065-8, http://hdl.handle.net/1765/1273

Berghe, D.A.F. van den, *Working Across Borders: Multinational Enterprises and the Internationalization of Employment*, Promotors: Prof.dr. R.J.M. van Tulder & Prof.dr. E.J.J. Schenk, EPS-2003-029-ORG, ISBN: 90-5892-05-34, http://hdl.handle.net/1765/1041

Berghman, L.A., *Strategic Innovation Capacity: A Mixed Method Study on Deliberate Strategic Learning Mechanisms*, Promotor: Prof.dr. P. Mattyssens, EPS-2006-087-MKT, ISBN: 90-5892-120-4, http://hdl.handle.net/1765/7991

Bezemer, P.J., *Diffusion of Corporate Governance Beliefs: Board Independence and the Emergence of a Shareholder Value Orientation in the Netherlands,* Promotors: Prof.dr.ing. F.A.J. van den Bosch & Prof.dr. H.W. Volberda, EPS-2009-192-STR, ISBN: 978-90-5892-232-8, http://hdl.handle.net/1765/18458

Bijman, W.J.J., *Essays on Agricultural Co-operatives: Governance Structure in Fruit and Vegetable Chains*, Promotor: Prof.dr. G.W.J. Hendrikse, EPS-2002-015-ORG, ISBN: 90-5892-024-0, http://hdl.handle.net/1765/867

Binken, J.L.G., *System Markets: Indirect Network Effects in Action, or Inaction?,* Promotor: Prof.dr. S. Stremersch, EPS-2010-213-MKT, ISBN: 978-90-5892-260-1, http://hdl.handle.net/1765/21186

Blitz, D.C., *Benchmarking Benchmarks,* Promotors: Prof.dr. A.G.Z. Kemna & Prof.dr. W.F.C. Verschoor, EPS-2011-225-F&A, ISBN: 978-90-5892-268-7, http://hdl.handle.net/1765/22624

Bispo, A., *Labour Market Segmentation: An investigation into the Dutch hospitality industry*, Promotors: Prof.dr. G.H.M. Evers & Prof.dr. A.R. Thurik, EPS-2007-108-ORG, ISBN: 90-5892-136-9, http://hdl.handle.net/1765/10283

Blindenbach-Driessen, F., *Innovation Management in Project-Based Firms*, Promotor: Prof.dr. S.L. van de Velde, EPS-2006-082-LIS, ISBN: 90-5892-110-7, http://hdl.handle.net/1765/7828

Boer, C.A., *Distributed Simulation in Industry,* Promotors: Prof.dr. A. de Bruin & Prof.dr.ir. A. Verbraeck, EPS-2005-065-LIS, ISBN: 90-5892-093-3, http://hdl.handle.net/1765/6925

Boer, N.I., *Knowledge Sharing within Organizations: A situated and Relational Perspective,* Promotor: Prof.dr. K. Kumar, EPS-2005-060-LIS, ISBN: 90-5892-086-0, http://hdl.handle.net/1765/6770

Boer-Sorbán, K., *Agent-Based Simulation of Financial Markets: A modular, Continuous-Time Approach,* Promotor: Prof.dr. A. de Bruin, EPS-2008-119-LIS, ISBN: 90-5892-155-0, http://hdl.handle.net/1765/10870

Boon, C.T., *HRM and Fit: Survival of the Fittest!?,* Promotors: Prof.dr. J. Paauwe & Prof.dr. D.N. den Hartog, EPS-2008-129-ORG, ISBN: 978-90-5892-162-8, http://hdl.handle.net/1765/12606

Borst, W.A.M., *Understanding Crowdsourcing: Effects of Motivation and Rewards on Participation and Performance in Voluntary Online Activities,* Promotors: Prof.dr.ir. J.C.M. van den Ende & Prof.dr.ir. H.W.G.M. van Heck, EPS-2010-221-LIS, ISBN: 978-90-5892-262-5, http://hdl.handle.net/1765/ 21914

Braun, E., *City Marketing: Towards an Integrated Approach,* Promotor: Prof.dr. L. van den Berg, EPS-2008-142-MKT, ISBN: 978-90-5892-180-2, http://hdl.handle.net/1765/13694

Brito, M.P. de, *Managing Reverse Logistics or Reversing Logistics Management?* Promotors: Prof.dr.ir. R. Dekker & Prof.dr. M. B. M. de Koster, EPS-2004-035-LIS, ISBN: 90-5892-058-5, http://hdl.handle.net/1765/1132

Brohm, R., *Polycentric Order in Organizations: A Dialogue between Michael Polanyi and IT-Consultants on Knowledge, Morality, and Organization,* Promotors: Prof.dr. G. W. J. Hendrikse & Prof.dr. H. K. Letiche, EPS-2005-063-ORG, ISBN: 90-5892-095-X, http://hdl.handle.net/1765/6911

Brumme, W.-H., *Manufacturing Capability Switching in the High-Tech Electronics Technology Life Cycle,* Promotors: Prof.dr.ir. J.A.E.E. van Nunen & Prof.dr.ir. L.N. Van Wassenhove, EPS-2008-126-LIS, ISBN: 978-90-5892-150-5, http://hdl.handle.net/1765/12103

Budiono, D.P., *The Analysis of Mutual Fund Performance: Evidence from U.S. Equity Mutual Funds,* Promotor: Prof.dr. M.J.C.M. Verbeek, EPS-2010-185-F&A, ISBN: 978-90-5892-224-3, http://hdl.handle.net/1765/18126

Burger, M.J., *Structure and Cooptition in Urban Networks*. Promotors: Prof. dr. G.A. van der Knaap & Prof. dr. H.R. Commandeur, EPS-2011-243-ORG, ISBN: 978-90-5892-288-5.

Burgers, J.H., *Managing Corporate Venturing: Multilevel Studies on Project Autonomy, Integration, Knowledge Relatedness, and Phases in the New Business Development Process,* Promotors: Prof.dr.ir. F.A.J. Van den Bosch & Prof.dr. H.W. Volberda, EPS-2008-136-STR, ISBN: 978-90-5892-174-1, http://hdl.handle.net/1765/13484

Camacho, N.M., *Health and Marketing; Essays on Physician and Patient Decision-making*, Promotor: Prof.dr. S. Stremersch, EPS-2011-237-MKT, ISBN: 978-90-5892-284-7, http://hdl.handle.net/1765/23604

Campbell, R.A.J., *Rethinking Risk in International Financial Markets*, Promotor: Prof.dr. C.G. Koedijk, EPS-2001-005-F&A, ISBN: 90-5892-008-9, http://hdl.handle.net/1765/306

Carvalho de Mesquita Ferreira, L., *Attention Mosaics: Studies of Organizational Attention*, Promotors: Prof.dr. P.M.A.R. Heugens & Prof.dr. J. van Oosterhout, EPS-2010-205-ORG,
ISBN: 978-90-5892-242-7, http://hdl.handle.net/1765/19882

Chen, C.-M., *Evaluation and Design of Supply Chain Operations Using DEA*, Promotor: Prof.dr. J.A.E.E. van Nunen, EPS-2009-172-LIS, ISBN: 978-90-5892-209-0, http://hdl.handle.net/1765/16181

Chen, H., *Individual Mobile Communication Services and Tariffs*, Promotor: Prof.dr. L.F.J.M. Pau, EPS-2008-123-LIS, ISBN: 90-5892-158-1, http://hdl.handle.net/1765/11141

Chen, Y., *Labour Flexibility in China's Companies: An Empirical Study*, Promotors: Prof.dr. A. Buitendam & Prof.dr. B. Krug, EPS-2001-006-ORG, ISBN: 90-5892-012-7, http://hdl.handle.net/1765/307

Damen, F.J.A., *Taking the Lead: The Role of Affect in Leadership Effectiveness*, Promotor: Prof.dr. D.L. van Knippenberg, EPS-2007-107-ORG, http://hdl.handle.net/1765/10282

Daniševská, P., *Empirical Studies on Financial Intermediation and Corporate Policies*, Promotor: Prof.dr. C.G. Koedijk, EPS-2004-044-F&A, ISBN: 90-5892-070-4, http://hdl.handle.net/1765/1518

Defilippi Angeldonis, E.F., *Access Regulation for Naturally Monopolistic Port Terminals: Lessons from Regulated Network Industries,* Promotor: Prof.dr. H.E. Haralambides, EPS-2010-204-LIS, ISBN: 978-90-5892-245-8, http://hdl.handle.net/1765/19881

Delporte-Vermeiren, D.J.E., *Improving the Flexibility and Profitability of ICT-enabled Business Networks: An Assessment Method and Tool*, Promotors: Prof. mr. dr. P.H.M. Vervest & Prof.dr.ir. H.W.G.M. van Heck, EPS-2003-020-LIS, ISBN: 90-5892-040-2, http://hdl.handle.net/1765/359

Derwall, J.M.M., *The Economic Virtues of SRI and CSR*, Promotor: Prof.dr. C.G. Koedijk, EPS-2007-101-F&A, ISBN: 90-5892-132-8, http://hdl.handle.net/1765/8986

Desmet, P.T.M., *In Money we Trust? Trust Repair and the Psychology of Financial Compensations*, Promotors: Prof.dr. D. De Cremer & Prof.dr. E. van Dijk, EPS-2011-232-ORG, ISBN: 978-90-5892-274-8, http://hdl.handle.net/1765/23268

Diepen, M. van, *Dynamics and Competition in Charitable Giving*, Promotor: Prof.dr. Ph.H.B.F. Franses, EPS-2009-159-MKT, ISBN: 978-90-5892-188-8, http://hdl.handle.net/1765/14526

Dietvorst, R.C., *Neural Mechanisms Underlying Social Intelligence and Their Relationship with the Performance of Sales Managers,* Promotor: Prof.dr. W.J.M.I. Verbeke, EPS-2010-215-MKT, ISBN: 978-90-5892-257-1, http://hdl.handle.net/1765/21188

Dietz, H.M.S., *Managing (Sales)People towards Perfomance: HR Strategy, Leadership & Teamwork*, Promotor: Prof.dr. G.W.J. Hendrikse, EPS-2009-168-ORG, ISBN: 978-90-5892-210-6, http://hdl.handle.net/1765/16081

Dijksterhuis, M., *Organizational Dynamics of Cognition and Action in the Changing Dutch and US Banking Industries*, Promotors: Prof.dr.ir. F.A.J. van den Bosch & Prof.dr. H.W. Volberda, EPS-2003-026-STR, ISBN: 90-5892-048-8, http://hdl.handle.net/1765/1037

Eijk, A.R. van der, *Behind Networks: Knowledge Transfer, Favor Exchange and Performance*, Promotors: Prof.dr. S.L. van de Velde & Prof.dr.drs. W.A. Dolfsma, EPS-2009-161-LIS, ISBN: 978-90-5892-190-1, http://hdl.handle.net/1765/14613

Elstak, M.N., *Flipping the Identity Coin: The Comparative Effect of Perceived, Projected and Desired Organizational Identity on Organizational Identification and Desired Behavior*, Promotor: Prof.dr. C.B.M. van Riel, EPS-2008-117-ORG, ISBN: 90-5892-148-2, http://hdl.handle.net/1765/10723

Erken, H.P.G., *Productivity, R&D and Entrepreneurship*, Promotor: Prof.dr. A.R. Thurik, EPS-2008-147-ORG, ISBN: 978-90-5892-179-6, http://hdl.handle.net/1765/14004

Essen, M. van, *An Institution-Based View of Ownership*, Promotos: Prof.dr. J. van Oosterhout & Prof.dr. G.M.H. Mertens, EPS-2011-226-ORG, ISBN: 978-90-5892-269-4, http://hdl.handle.net/1765/22643

Fenema, P.C. van, *Coordination and Control of Globally Distributed Software Projects*, Promotor: Prof.dr. K. Kumar, EPS-2002-019-LIS, ISBN: 90-5892-030-5, http://hdl.handle.net/1765/360

Feng, L., *Motivation, Coordination and Cognition in Cooperatives,* Promotor: Prof.dr. G.W.J. Hendrikse, EPS-2010-220-ORG, ISBN: 90-5892-261-8, http://hdl.handle.net/1765/21680

Fleischmann, M., *Quantitative Models for Reverse Logistics*, Promotors: Prof.dr.ir. J.A.E.E. van Nunen & Prof.dr.ir. R. Dekker, EPS-2000-002-LIS, ISBN: 35-4041-711-7, http://hdl.handle.net/1765/1044

Flier, B., *Strategic Renewal of European Financial Incumbents: Coevolution of Environmental Selection, Institutional Effects, and Managerial Intentionality*, Promotors: Prof.dr.ir. F.A.J. van den Bosch & Prof.dr. H.W. Volberda, EPS-2003-033-STR, ISBN: 90-5892-055-0, http://hdl.handle.net/1765/1071

Fok, D., *Advanced Econometric Marketing Models*, Promotor: Prof.dr. Ph.H.B.F. Franses, EPS-2003-027-MKT, ISBN: 90-5892-049-6, http://hdl.handle.net/1765/1035

Ganzaroli, A., *Creating Trust between Local and Global Systems*, Promotors: Prof.dr. K. Kumar & Prof.dr. R.M. Lee, EPS-2002-018-LIS, ISBN: 90-5892-031-3, http://hdl.handle.net/1765/361

Gertsen, H.F.M., *Riding a Tiger without Being Eaten: How Companies and Analysts Tame Financial Restatements and Influence Corporate Reputation*, Promotor: Prof.dr. C.B.M. van Riel, EPS-2009-171-ORG, ISBN: 90-5892-214-4, http://hdl.handle.net/1765/16098

Gilsing, V.A., *Exploration, Exploitation and Co-evolution in Innovation Networks*, Promotors: Prof.dr. B. Nooteboom & Prof.dr. J.P.M. Groenewegen, EPS-2003-032-ORG, ISBN: 90-5892-054-2, http://hdl.handle.net/1765/1040

Gijsbers, G.W., *Agricultural Innovation in Asia: Drivers, Paradigms and Performance,* Promotor: Prof.dr. R.J.M. van Tulder, EPS-2009-156-ORG, ISBN: 978-90-5892-191-8, http://hdl.handle.net/1765/14524

Gong, Y., *Stochastic Modelling and Analysis of Warehouse Operations*, Promotors: Prof.dr. M.B.M. de Koster & Prof.dr. S.L. van de Velde, EPS-2009-180-LIS, ISBN: 978-90-5892-219-9, http://hdl.handle.net/1765/16724

Govers, R., *Virtual Tourism Destination Image: Glocal Identities Constructed, Perceived and Experienced*, Promotors: Prof.dr. F.M. Go & Prof.dr. K. Kumar, EPS-2005-069-MKT, ISBN: 90-5892-107-7, http://hdl.handle.net/1765/6981

Graaf, G. de, *Tractable Morality: Customer Discourses of Bankers, Veterinarians and Charity Workers*, Promotors: Prof.dr. F. Leijnse & Prof.dr. T. van Willigenburg, EPS-2003-031-ORG, ISBN: 90-5892-051-8, http://hdl.handle.net/1765/1038

Greeven, M.J., *Innovation in an Uncertain Institutional Environment: Private Software Entrepreneurs in Hangzhou, China*, Promotor: Prof.dr. B. Krug, EPS-2009-164-ORG, ISBN: 978-90-5892-202-1, http://hdl.handle.net/1765/15426

Groot, E.A. de, *Essays on Economic Cycles*, Promotors: Prof.dr. Ph.H.B.F. Franses & Prof.dr. H.R. Commandeur, EPS-2006-091-MKT, ISBN: 90-5892-123-9, http://hdl.handle.net/1765/8216

Guenster, N.K., *Investment Strategies Based on Social Responsibility and Bubbles*, Promotor: Prof.dr. C.G. Koedijk, EPS-2008-175-F&A, ISBN: 978-90-5892-206-9, http://hdl.handle.net/1765/1

Gutkowska, A.B., *Essays on the Dynamic Portfolio Choice*, Promotor: Prof.dr. A.C.F. Vorst, EPS-2006-085-F&A, ISBN: 90-5892-118-2, http://hdl.handle.net/1765/7994

Hagemeijer, R.E., *The Unmasking of the Other*, Promotors: Prof.dr. S.J. Magala & Prof.dr. H.K. Letiche, EPS-2005-068-ORG, ISBN: 90-5892-097-6, http://hdl.handle.net/1765/6963

Hakimi, N.A, *Leader Empowering Behaviour: The Leader's Perspective: Understanding the Motivation behind Leader Empowering Behaviour*, Promotor: Prof.dr. D.L. van Knippenberg, EPS-2010-184-ORG, http://hdl.handle.net/1765/17701

Halderen, M.D. van, *Organizational Identity Expressiveness and Perception Management: Principles for Expressing the Organizational Identity in Order to Manage the Perceptions and Behavioral Reactions of External Stakeholders*, Promotor: Prof.dr. S.B.M. van Riel, EPS-2008-122-ORG, ISBN: 90-5892-153-6, http://hdl.handle.net/1765/10872

Hartigh, E. den, *Increasing Returns and Firm Performance: An Empirical Study*, Promotor: Prof.dr. H.R. Commandeur, EPS-2005-067-STR, ISBN: 90-5892-098-4, http://hdl.handle.net/1765/6939

Hensmans, M., *A Republican Settlement Theory of the Firm: Applied to Retail Banks in England and the Netherlands (1830-2007)*, Promotors: Prof.dr. A. Jolink& Prof.dr. S.J. Magala, EPS-2010-193-ORG, ISBN 90-5892-235-9, http://hdl.handle.net/1765/19494

Hermans. J.M., *ICT in Information Services; Use and Deployment of the Dutch Securities Trade, 1860-1970,* Promotor: Prof.dr. drs. F.H.A. Janszen, EPS-2004-046-ORG, ISBN 90-5892-072-0, http://hdl.handle.net/1765/1793

Hernandez Mireles, C., *Marketing Modeling for New Products,* Promotor: Prof.dr. P.H. Franses, EPS-2010-202-MKT, ISBN 90-5892-237-3, http://hdl.handle.net/1765/19878

Hessels, S.J.A., *International Entrepreneurship: Value Creation Across National Borders*, Promotor: Prof.dr. A.R. Thurik, EPS-2008-144-ORG, ISBN: 978-90-5892-181-9, http://hdl.handle.net/1765/13942

Heugens, P.P.M.A.R., *Strategic Issues Management: Implications for Corporate Performance*, Promotors: Prof.dr.ir. F.A.J. van den Bosch & Prof.dr. C.B.M. van Riel, EPS-2001-007-STR, ISBN: 90-5892-009-9, http://hdl.handle.net/1765/358

Heuvel, W. van den, *The Economic Lot-Sizing Problem: New Results and Extensions*, Promotor: Prof.dr. A.P.L. Wagelmans, EPS-2006-093-LIS, ISBN: 90-5892-124-7, http://hdl.handle.net/1765/1805

Hoedemaekers, C.M.W., *Performance, Pinned down: A Lacanian Analysis of Subjectivity at Work*, Promotors: Prof.dr. S. Magala & Prof.dr. D.H. den Hartog, EPS-2008-121-ORG, ISBN: 90-5892-156-7, http://hdl.handle.net/1765/10871

Hooghiemstra, R., *The Construction of Reality: Cultural Differences in Self-serving Behaviour in Accounting Narratives*, Promotors: Prof.dr. L.G. van der Tas RA & Prof.dr. A.Th.H. Pruyn, EPS-2003-025-F&A, ISBN: 90-5892-047-X, http://hdl.handle.net/1765/871

Hu, Y., *Essays on the Governance of Agricultural Products: Cooperatives and Contract Farming*, Promotors: Prof.dr. G.W.J. Hendrkse & Prof.dr. B. Krug, EPS-2007-113-ORG, ISBN: 90-5892-145-1, http://hdl.handle.net/1765/10535

Huang, X., *An Analysis of Occupational Pension Provision: From Evaluation to Redesigh,* Promotors: Prof.dr. M.J.C.M. Verbeek & Prof.dr. R.J. Mahieu, EPS-2010-196-F&A, ISBN: 90-5892-239-7, http://hdl.handle.net/1765/19674

Huij, J.J., *New Insights into Mutual Funds: Performance and Family Strategies*, Promotor: Prof.dr. M.C.J.M. Verbeek, EPS-2007-099-F&A, ISBN: 90-5892-134-4, http://hdl.handle.net/1765/9398

Huurman, C.I., *Dealing with Electricity Prices*, Promotor: Prof.dr. C.D. Koedijk, EPS-2007-098-F&A, ISBN: 90-5892-130-1, http://hdl.handle.net/1765/9399

Iastrebova, K, *Manager's Information Overload: The Impact of Coping Strategies on Decision-Making Performance*, Promotor: Prof.dr. H.G. van Dissel, EPS-2006-077-LIS, ISBN: 90-5892-111-5, http://hdl.handle.net/1765/7329

Iwaarden, J.D. van, *Changing Quality Controls: The Effects of Increasing Product Variety and Shortening Product Life Cycles,* Promotors: Prof.dr. B.G. Dale & Prof.dr. A.R.T. Williams, EPS-2006-084-ORG, ISBN: 90-5892-117-4, http://hdl.handle.net/1765/7992

Jalil, M.N., *Customer Information Driven After Sales Service Management: Lessons from Spare Parts Logistics,* Promotor: Prof.dr. L.G. Kroon, EPS-2011-222-LIS, ISBN: 978-90-5892-264-9, http://hdl.handle.net/1765/22156

Jansen, J.J.P., *Ambidextrous Organizations*, Promotors: Prof.dr.ir. F.A.J. Van den Bosch & Prof.dr. H.W. Volberda, EPS-2005-055-STR, ISBN: 90-5892-081-X, http://hdl.handle.net/1765/6774

Jaspers, F.P.H., *Organizing Systemic Innovation*, Promotor: Prof.dr.ir. J.C.M. van den Ende, EPS-2009-160-ORG, ISBN: 978-90-5892-197-), http://hdl.handle.net/1765/14974

Jennen, M.G.J., *Empirical Essays on Office Market Dynamics*, Promotors: Prof.dr. C.G. Koedijk & Prof.dr. D. Brounen, EPS-2008-140-F&A, ISBN: 978-90-5892-176-5, http://hdl.handle.net/1765/13692

Jiang, T., *Capital Structure Determinants and Governance Structure Variety in Franchising*, Promotors: Prof.dr. G. Hendrikse & Prof.dr. A. de Jong, EPS-2009-158-F&A, ISBN: 978-90-5892-199-4, http://hdl.handle.net/1765/14975

Jiao, T., *Essays in Financial Accounting*, Promotor: Prof.dr. G.M.H. Mertens, EPS-2009-176-F&A, ISBN: 978-90-5892-211-3, http://hdl.handle.net/1765/16097

Jong, C. de, *Dealing with Derivatives: Studies on the Role, Informational Content and Pricing of Financial Derivatives*, Promotor: Prof.dr. C.G. Koedijk, EPS-2003-023-F&A, ISBN: 90-5892-043-7, http://hdl.handle.net/1765/1043

Kaa, G. van, *Standard Battles for Complex Systems: Empirical Research on the Home Network,* Promotors: Prof.dr.ir. J. van den Ende & Prof.dr.ir. H.W.G.M. van Heck, EPS-2009-166-ORG, ISBN: 978-90-5892-205-2, http://hdl.handle.net/1765/16011

Kagie, M., *Advances in Online Shopping Interfaces: Product Catalog Maps and Recommender Systems,* Promotor: Prof.dr. P.J.F. Groenen, EPS-2010-195-MKT, ISBN: 978-90-5892-233-5, http://hdl.handle.net/1765/19532

Kappe, E.R., *The Effectiveness of Pharmaceutical Marketing*, Promotor: Prof.dr. S. Stremersch, EPS-2011-239-MKT, ISBN: 978-90-5892-283-0, http://hdl.handle.net/1765/23610

Karreman, B., *Financial Services and Emerging Markets,* Promotors: Prof.dr. G.A. van der Knaap & Prof.dr. H.P.G. Pennings, EPS-2011-223-ORG, ISBN: 978-90-5892-266-3, http://hdl.handle.net/1765/ 22280

Keizer, A.B., *The Changing Logic of Japanese Employment Practices: A Firm-Level Analysis of Four Industries,* Promotors: Prof.dr. J.A. Stam & Prof.dr. J.P.M. Groenewegen, EPS-2005-057-ORG, ISBN: 90-5892-087-9, http://hdl.handle.net/1765/6667

Kijkuit, R.C., *Social Networks in the Front End: The Organizational Life of an Idea,* Promotor: Prof.dr. B. Nooteboom, EPS-2007-104-ORG, ISBN: 90-5892-137-6, http://hdl.handle.net/1765/10074

Kippers, J., *Empirical Studies on Cash Payments,* Promotor: Prof.dr. Ph.H.B.F. Franses, EPS-2004-043-F&A, ISBN: 90-5892-069-0, http://hdl.handle.net/1765/1520

Klein, M.H., *Poverty Alleviation through Sustainable Strategic Business Models: Essays on Poverty Alleviation as a Business Strategy,* Promotor: Prof.dr. H.R. Commandeur, EPS-2008-135-STR, ISBN: 978-90-5892-168-0, http://hdl.handle.net/1765/13482

Knapp, S., *The Econometrics of Maritime Safety: Recommendations to Enhance Safety at Sea*, Promotor: Prof.dr. Ph.H.B.F. Franses, EPS-2007-096-ORG, ISBN: 90-5892-127-1, http://hdl.handle.net/1765/7913

Kole, E., *On Crises, Crashes and Comovements*, Promotors: Prof.dr. C.G. Koedijk & Prof.dr. M.J.C.M. Verbeek, EPS-2006-083-F&A, ISBN: 90-5892-114-X, http://hdl.handle.net/1765/7829

Kooij-de Bode, J.M., *Distributed Information and Group Decision-Making: Effects of Diversity and Affect*, Promotor: Prof.dr. D.L. van Knippenberg, EPS-2007-115-ORG, http://hdl.handle.net/1765/10722

Koppius, O.R., *Information Architecture and Electronic Market Performance*, Promotors: Prof.dr. P.H.M. Vervest & Prof.dr.ir. H.W.G.M. van Heck, EPS-2002-013-LIS, ISBN: 90-5892-023-2, http://hdl.handle.net/1765/921

Kotlarsky, J., *Management of Globally Distributed Component-Based Software Development Projects,* Promotor: Prof.dr. K. Kumar, EPS-2005-059-LIS, ISBN: 90-5892-088-7, http://hdl.handle.net/1765/6772

Krauth, E.I., *Real-Time Planning Support: A Task-Technology Fit Perspective,* Promotors: Prof.dr. S.L. van de Velde & Prof.dr. J. van Hillegersberg, EPS-2008-155-LIS, ISBN: 978-90-5892-193-2, http://hdl.handle.net/1765/14521

Kuilman, J., *The Re-Emergence of Foreign Banks in Shanghai: An Ecological Analysis,* Promotor: Prof.dr. B. Krug, EPS-2005-066-ORG, ISBN: 90-5892-096-8, http://hdl.handle.net/1765/6926

Kwee, Z., *Investigating Three Key Principles of Sustained Strategic Renewal: A Longitudinal Study of Long-Lived Firms,* Promotors: Prof.dr.ir. F.A.J. Van den Bosch & Prof.dr. H.W. Volberda, EPS-2009-174-STR, ISBN: 90-5892-212-0, http://hdl.handle.net/1765/16207

Lam, K.Y., *Reliability and Rankings*, Promotor: Prof.dr. P.H.B.F. Franses, EPS-2011-230-MKT, ISBN: 978-90-5892-272-4, http://hdl.handle.net/1765/22977

Langen, P.W. de, *The Performance of Seaport Clusters: A Framework to Analyze Cluster Performance and an Application to the Seaport Clusters of Durban, Rotterdam and the Lower Mississippi*, Promotors: Prof.dr. B. Nooteboom & Prof. drs. H.W.H. Welters, EPS-2004-034-LIS, ISBN: 90-5892-056-9, http://hdl.handle.net/1765/1133

Langhe, B. de, *Contingencies: Learning Numerical and Emotional Associations in an Uncertain World*, Promotors: Prof.dr.ir. B. Wierenga & Prof.dr. S.M.J. van Osselaer, EPS-2011-236-MKT, ISBN: 978-90-5892-278-6, http://hdl.handle.net/1765/1

Larco Martinelli, J.A., *Incorporating Worker-Specific Factors in Operations Management Models,* Promotors: Prof.dr.ir. J. Dul & Prof.dr. M.B.M. de Koster, EPS-2010-217-LIS, ISBN: 90-5892-263-2, http://hdl.handle.net/1765/21527

Le Anh, T., *Intelligent Control of Vehicle-Based Internal Transport Systems*, Promotors: Prof.dr. M.B.M. de Koster & Prof.dr.ir. R. Dekker, EPS-2005-051-LIS, ISBN: 90-5892-079-8, http://hdl.handle.net/1765/6554

Le-Duc, T., *Design and Control of Efficient Order Picking Processes*, Promotor: Prof.dr. M.B.M. de Koster, EPS-2005-064-LIS, ISBN: 90-5892-094-1, http://hdl.handle.net/1765/6910

Leeuwen, E.P. van, *Recovered-Resource Dependent Industries and the Strategic Renewal of Incumbent Firm: A Multi-Level Study of Recovered Resource Dependence Management and Strategic Renewal in the European Paper and Board Industry*, Promotors: Prof.dr.ir. F.A.J. Van den Bosch & Prof.dr. H.W. Volberda, EPS-2007-109-STR, ISBN: 90-5892-140-6, http://hdl.handle.net/1765/10183

Lentink, R.M., *Algorithmic Decision Support for Shunt Planning*, Promotors: Prof.dr. L.G. Kroon & Prof.dr.ir. J.A.E.E. van Nunen, EPS-2006-073-LIS, ISBN: 90-5892-104-2, http://hdl.handle.net/1765/7328

Li, T., *Informedness and Customer-Centric Revenue Management,* Promotors: Prof.dr. P.H.M. Vervest & Prof.dr.ir. H.W.G.M. van Heck, EPS-2009-146-LIS, ISBN: 978-90-5892-195-6, http://hdl.handle.net/1765/14525

Liang, G., *New Competition: Foreign Direct Investment and Industrial Development in China,* Promotor: Prof.dr. R.J.M. van Tulder, EPS-2004-047-ORG, ISBN: 90-5892-073-9, http://hdl.handle.net/1765/1795

Liere, D.W. van, *Network Horizon and the Dynamics of Network Positions: A Multi-Method Multi-Level Longitudinal Study of Interfirm Networks,* Promotor: Prof.dr. P.H.M. Vervest, EPS-2007-105-LIS, ISBN: 90-5892-139-0, http://hdl.handle.net/1765/10181

Loef, J., *Incongruity between Ads and Consumer Expectations of Advertising*, Promotors: Prof.dr. W.F. van Raaij & Prof.dr. G. Antonides, EPS-2002-017-MKT, ISBN: 90-5892-028-3, http://hdl.handle.net/1765/869

Londoño, M. del Pilar, *Institutional Arrangements that Affect Free Trade Agreements: Economic Rationality Versus Interest Groups*, Promotors: Prof.dr. H.E. Haralambides & Prof.dr. J.F. Francois, EPS-2006-078-LIS, ISBN: 90-5892-108-5, http://hdl.handle.net/1765/7578

Lovric, M., *Behavioral Finance and Agent-Based Artificial Markets*, Promotors: Prof.dr. J. Spronk & Prof.dr.ir. U. Kaymak, EPS-2011-229-F&A, ISBN: 978-90-5892-258-8, http://hdl.handle.net/1765/ 22814

Maas, A.A., van der, *Strategy Implementation in a Small Island Context: An Integrative Framework,* Promotor: Prof.dr. H.G. van Dissel, EPS-2008-127-LIS, ISBN: 978-90-5892-160-4, http://hdl.handle.net/1765/12278

Maas, K.E.G., *Corporate Social Performance: From Output Measurement to Impact Measurement,* Promotor: Prof.dr. H.R. Commandeur, EPS-2009-182-STR, ISBN: 978-90-5892-225-0, http://hdl.handle.net/1765/17627

Maeseneire, W., de, *Essays on Firm Valuation and Value Appropriation,* Promotor: Prof.dr. J.T.J. Smit, EPS-2005-053-F&A, ISBN: 90-5892-082-8, http://hdl.handle.net/1765/6768

Mandele, L.M., van der, *Leadership and the Inflection Point: A Longitudinal Perspective*, Promotors: Prof.dr. H.W. Volberda & Prof.dr. H.R. Commandeur, EPS-2004-042-STR, ISBN: 90-5892-067-4, http://hdl.handle.net/1765/1302

Markwat, T.D., *Extreme Dependence in Asset Markets Around the Globe*, Promotor: Prof.dr. D.J.C. van Dijk, EPS-2011-227-F&A, ISBN: 978-90-5892-270-0, http://hdl.handle.net/1765/22744

Meer, J.R. van der, *Operational Control of Internal Transport*, Promotors: Prof.dr. M.B.M. de Koster & Prof.dr.ir. R. Dekker, EPS-2000-001-LIS, ISBN: 90-5892-004-6, http://hdl.handle.net/1765/859

Mentink, A., *Essays on Corporate Bonds*, Promotor: Prof.dr. A.C.F. Vorst, EPS-2005-070-F&A, ISBN: 90-5892-100-X, http://hdl.handle.net/1765/7121

Meuer, J., *Configurations of Inter-Firm Relations in Management Innovation: A Study in China's Biopharmaceutical Industry*, Promotor: Prof.dr. B. Krug, EPS-2011-228-ORG, ISBN: 978-90-5892-271-1, http://hdl.handle.net/1765/22745

Meyer, R.J.H., *Mapping the Mind of the Strategist: A Quantitative Methodology for Measuring the Strategic Beliefs of Executives*, Promotor: Prof.dr. R.J.M. van Tulder, EPS-2007-106-ORG, ISBN: 978-90-5892-141-3, http://hdl.handle.net/1765/10182

Miltenburg, P.R., *Effects of Modular Sourcing on Manufacturing Flexibility in the Automotive Industry: A Study among German OEMs*, Promotors: Prof.dr. J. Paauwe & Prof.dr. H.R. Commandeur, EPS-2003-030-ORG, ISBN: 90-5892-052-6, http://hdl.handle.net/1765/1039

Moerman, G.A., *Empirical Studies on Asset Pricing and Banking in the Euro Area,* Promotor: Prof.dr. C.G. Koedijk, EPS-2005-058-F&A, ISBN: 90-5892-090-9, http://hdl.handle.net/1765/6666

Moitra, D., *Globalization of R&D: Leveraging Offshoring for Innovative Capability and Organizational Flexibility,* Promotor: Prof.dr. K. Kumar, EPS-2008-150-LIS, ISBN: 978-90-5892-184-0, http://hdl.handle.net/1765/14081

Mol, M.M., *Outsourcing, Supplier-relations and Internationalisation: Global Source Strategy as a Chinese Puzzle*, Promotor: Prof.dr. R.J.M. van Tulder, EPS-2001-010-ORG, ISBN: 90-5892-014-3, http://hdl.handle.net/1765/355

Mom, T.J.M., *Managers' Exploration and Exploitation Activities: The Influence of Organizational Factors and Knowledge Inflows*, Promotors: Prof.dr.ir. F.A.J. Van den Bosch & Prof.dr. H.W. Volberda, EPS-2006-079-STR, ISBN: 90-5892-116-6, http://hdl.handle.net/1765

Moonen, J.M., *Multi-Agent Systems for Transportation Planning and Coordination*, Promotors: Prof.dr. J. van Hillegersberg & Prof.dr. S.L. van de Velde, EPS-2009-177-LIS, ISBN: 978-90-5892-216-8, http://hdl.handle.net/1765/16208

Mulder, A., *Government Dilemmas in the Private Provision of Public Goods*, Promotor: Prof.dr. R.J.M. van Tulder, EPS-2004-045-ORG, ISBN: 90-5892-071-2, http://hdl.handle.net/1765/1790

Muller, A.R., *The Rise of Regionalism: Core Company Strategies Under The Second Wave of Integration*, Promotor: Prof.dr. R.J.M. van Tulder, EPS-2004-038-ORG, ISBN: 90-5892-062-3, http://hdl.handle.net/1765/1272

Nalbantov G.I., *Essays on Some Recent Penalization Methods with Applications in Finance and Marketing*, Promotor: Prof. dr P.J.F. Groenen, EPS-2008-132-F&A, ISBN: 978-90-5892-166-6, http://hdl.handle.net/1765/13319

Nederveen Pieterse, A., *Goal Orientation in Teams: The Role of Diversity*, Promotor: Prof.dr. D.L. van Knippenberg, EPS-2009-162-ORG, http://hdl.handle.net/1765/15240

Nguyen, T.T., *Capital Structure, Strategic Competition, and Governance*, Promotor: Prof.dr. A. de Jong, EPS-2008-148-F&A, ISBN: 90-5892-178-9, http://hdl.handle.net/1765/14005

Nielsen, L.K., *Rolling Stock Rescheduling in Passenger Railways: Applications in Short-term Planning and in Disruption Management*, Promotor: Prof.dr. L.G. Kroon, EPS-2011-224-LIS, ISBN: 978-90-5892-267-0, http://hdl.handle.net/1765/22444

Niesten, E.M.M.I., *Regulation, Governance and Adaptation: Governance Transformations in the Dutch and French Liberalizing Electricity Industries*, Promotors: Prof.dr. A. Jolink & Prof.dr. J.P.M. Groenewegen, EPS-2009-170-ORG, ISBN: 978-90-5892-208-3, http://hdl.handle.net/1765/16096

Nieuwenboer, N.A. den, *Seeing the Shadow of the Self*, Promotor: Prof.dr. S.P. Kaptein, EPS-2008-151-ORG, ISBN: 978-90-5892-182-6, http://hdl.handle.net/1765/14223

Nijdam, M.H., *Leader Firms: The Value of Companies for the Competitiveness of the Rotterdam Seaport Cluster,* Promotor: Prof.dr. R.J.M. van Tulder, EPS-2010-216-ORG, ISBN: 978-90-5892-256-4, http://hdl.handle.net/1765/21405

Ning, H., *Hierarchical Portfolio Management: Theory and Applications*, Promotor: Prof.dr. J. Spronk, EPS-2007-118-F&A, ISBN: 90-5892-152-9, http://hdl.handle.net/1765/10868

Noeverman, J., *Management Control Systems, Evaluative Style, and Behaviour: Exploring the Concept and Behavioural Consequences of Evaluative Style*, Promotors: Prof.dr. E.G.J. Vosselman & Prof.dr. A.R.T. Williams, EPS-2007-120-F&A, ISBN: 90-5892-151-2, http://hdl.handle.net/1765/10869

Noordegraaf-Eelens, L.H.J., *Contested Communication: A Critical Analysis of Central Bank Speech,* Promotor: Prof.dr. Ph.H.B.F. Franses, EPS-2010-209-MKT, ISBN: 978-90-5892-254-0, http://hdl.handle.net/1765/21061

Nuijten, I., *Servant Leadership: Paradox or Diamond in the Rough? A Multidimensional Measure and Empirical Evidence*, Promotor: Prof.dr. D.L. van Knippenberg, EPS-2009-183-ORG, http://hdl.handle.net/1765/21405

Oosterhout, J., van, *The Quest for Legitimacy: On Authority and Responsibility in Governance*, Promotors: Prof.dr. T. van Willigenburg & Prof.mr. H.R. van Gunsteren, EPS-2002-012-ORG, ISBN: 90-5892-022-4, http://hdl.handle.net/1765/362

Oosterhout, M., van, *Business Agility and Information Technology in Service Organizations,* Promotor: Prof,dr.ir. H.W.G.M. van Heck, EPS-2010-198-LIS, ISBN: 90-5092-236-6, http://hdl.handle.net/1765/19805

Oostrum, J.M., van, *Applying Mathematical Models to Surgical Patient Planning*, Promotor: Prof.dr. A.P.M. Wagelmans, EPS-2009-179-LIS, ISBN: 978-90-5892-217-5, http://hdl.handle.net/1765/16728

Osadchiy, S.E., *The Dynamics of Formal Organization: Essays on Bureaucracy and Formal Rules*, Promotor: Prof.dr. P.P.M.A.R. Heugens, EPS-2011-231-ORG, ISBN: 978-90-5892-273-1, http://hdl.handle.net/1765/23250

Otgaar, A.H.J., *Industrial Tourism: Where the Public Meets the Private,* Promotor: Prof.dr. L. van den Berg, EPS-2010-219-ORG, ISBN: 90-5892-259-5, http://hdl.handle.net/1765/21585

Ozdemir, M.N., *Project-level Governance, Monetary Incentives and Performance in Strategic R&D Alliances*, Promoror: Prof.dr.ir. J.C.M. van den Ende, EPS-2011-235-LIS, ISBN: 978-90-5892-282-3, http://hdl.handle.net/1765/23550

Paape, L., *Corporate Governance: The Impact on the Role, Position, and Scope of Services of the Internal Audit Function*, Promotors: Prof.dr. G.J. van der Pijl & Prof.dr. H. Commandeur, EPS-2007-111-MKT, ISBN: 90-5892-143-7, http://hdl.handle.net/1765/10417

Pak, K., *Revenue Management: New Features and Models*, Promotor: Prof.dr.ir. R. Dekker, EPS-2005-061-LIS, ISBN: 90-5892-092-5, http://hdl.handle.net/1765/362/6771

Pattikawa, L.H, *Innovation in the Pharmaceutical Industry: Evidence from Drug Introduction in the U.S.*, Promotors: Prof.dr. H.R.Commandeur, EPS-2007-102-MKT, ISBN: 90-5892-135-2, http://hdl.handle.net/1765/9626

Peeters, L.W.P., *Cyclic Railway Timetable Optimization*, Promotors: Prof.dr. L.G. Kroon & Prof.dr.ir. J.A.E.E. van Nunen, EPS-2003-022-LIS, ISBN: 90-5892-042-9, http://hdl.handle.net/1765/429

Pietersz, R., *Pricing Models for Bermudan-style Interest Rate Derivatives*, Promotors: Prof.dr. A.A.J. Pelsser & Prof.dr. A.C.F. Vorst, EPS-2005-071-F&A, ISBN: 90-5892-099-2, http://hdl.handle.net/1765/7122

Pince, C., *Advances in Inventory Management: Dynamic Models,* Promotor: Prof.dr.ir. R. Dekker,
EPS-2010-199-LIS, ISBN: 978-90-5892-243-4, http://hdl.handle.net/1765/19867

Poel, A.M. van der, *Empirical Essays in Corporate Finance and Financial Reporting*, Promotors: Prof.dr. A. de Jong & Prof.dr. G.M.H. Mertens, EPS-2007-133-F&A, ISBN: 978-90-5892-165-9, http://hdl.handle.net/1765/13320

Popova, V., *Knowledge Discovery and Monotonicity*, Promotor: Prof.dr. A. de Bruin, EPS-2004-037-LIS, ISBN: 90-5892-061-5, http://hdl.handle.net/1765/1201

Potthoff, D., *Railway Crew Rescheduling: Novel Approaches and Extensions,* Promotors: Prof.dr. A.P.M. Wagelmans & Prof.dr. L.G. Kroon, EPS-2010-210-LIS, ISBN: 90-5892-250-2, http://hdl.handle.net/1765/21084

Pouchkarev, I., *Performance Evaluation of Constrained Portfolios*, Promotors: Prof.dr. J. Spronk & Dr. W.G.P.M. Hallerbach, EPS-2005-052-F&A, ISBN: 90-5892-083-6, http://hdl.handle.net/1765/6731

Prins, R., *Modeling Consumer Adoption and Usage of Value-Added Mobile Services*, Promotors: Prof.dr. Ph.H.B.F. Franses & Prof.dr. P.C. Verhoef, EPS-2008-128-MKT, ISBN: 978/90-5892-161-1, http://hdl.handle.net/1765/12461

Puvanasvari Ratnasingam, P., *Interorganizational Trust in Business to Business E-Commerce*, Promotors: Prof.dr. K. Kumar & Prof.dr. H.G. van Dissel, EPS-2001-009-LIS, ISBN: 90-5892-017-8, http://hdl.handle.net/1765/356

Quak, H.J., *Sustainability of Urban Freight Transport: Retail Distribution and Local Regulation in Cities*, Promotor: Prof.dr. M.B.M. de Koster, EPS-2008-124-LIS, ISBN: 978-90-5892-154-3, http://hdl.handle.net/1765/11990

Quariguasi Frota Neto, J., *Eco-efficient Supply Chains for Electrical and Electronic Products*, Promotors: Prof.dr.ir. J.A.E.E. van Nunen & Prof.dr.ir. H.W.G.M. van Heck, EPS-2008-152-LIS, ISBN: 978-90-5892-192-5, http://hdl.handle.net/1765/14785

Radkevitch, U.L, *Online Reverse Auction for Procurement of Services*, Promotor: Prof.dr.ir. H.W.G.M. van Heck, EPS-2008-137-LIS, ISBN: 978-90-5892-171-0, http://hdl.handle.net/1765/13497

Rijsenbilt, J.A., *CEO Narcissism; Measurement and Impact*, Promotors: Prof.dr. A.G.Z. Kemna & Prof.dr. H.R. Commandeur, EPS-2011-238-STR, ISBN: 978-90-5892-281-6, http://hdl.handle.net/1765/ 23554

Rinsum, M. van, *Performance Measurement and Managerial Time Orientation*, Promotor: Prof.dr. F.G.H. Hartmann, EPS-2006-088-F&A, ISBN: 90-5892-121-2, http://hdl.handle.net/1765/7993

Roelofsen, E.M., *The Role of Analyst Conference Calls in Capital Markets*, Promotors: Prof.dr. G.M.H. Mertens & Prof.dr. L.G. van der Tas RA, EPS-2010-190-F&A, ISBN: 978-90-5892-228-1, http://hdl.handle.net/1765/18013

Romero Morales, D., *Optimization Problems in Supply Chain Management*, Promotors: Prof.dr.ir. J.A.E.E. van Nunen & Dr. H.E. Romeijn, EPS-2000-003-LIS, ISBN: 90-9014078-6, http://hdl.handle.net/1765/865

Roodbergen, K.J., *Layout and Routing Methods for Warehouses*, Promotors: Prof.dr. M.B.M. de Koster & Prof.dr.ir. J.A.E.E. van Nunen, EPS-2001-004-LIS, ISBN: 90-5892-005-4, http://hdl.handle.net/1765/861

Rook, L., *Imitation in Creative Task Performance*, Promotor: Prof.dr. D.L. van Knippenberg, EPS-2008-125-ORG, http://hdl.handle.net/1765/11555

Rosmalen, J. van, *Segmentation and Dimension Reduction: Exploratory and Model-Based Approaches*, Promotor: Prof.dr. P.J.F. Groenen, EPS-2009-165-MKT, ISBN: 978-90-5892-201-4, http://hdl.handle.net/1765/15536

Roza, M.W., *The Relationship between Offshoring Strategies and Firm Performance: Impact of Innovation, Absorptive Capacity and Firm Size,* Promotors: Prof.dr. H.W. Volberda & Prof.dr.ing. F.A.J. van den Bosch, EPS-2011-214-STR, ISBN: 978-90-5892-265-6, http://hdl.handle.net/1765/22155

Rus, D., *The Dark Side of Leadership: Exploring the Psychology of Leader Self-serving Behavior*, Promotor: Prof.dr. D.L. van Knippenberg, EPS-2009-178-ORG, http://hdl.handle.net/1765/16726

Samii, R., *Leveraging Logistics Partnerships: Lessons from Humanitarian Organizations,* Promotors: Prof.dr.ir. J.A.E.E. van Nunen & Prof.dr.ir. L.N. Van Wassenhove, EPS-2008-153-LIS, ISBN: 978-90-5892-186-4, http://hdl.handle.net/1765/14519

Schaik, D. van, *M&A in Japan: An Analysis of Merger Waves and Hostile Takeovers,* Promotors: Prof.dr. J. Spronk & Prof.dr. J.P.M. Groenewegen, EPS-2008-141-F&A, ISBN: 978-90-5892-169-7, http://hdl.handle.net/1765/13693

Schauten, M.B.J., *Valuation, Capital Structure Decisions and the Cost of Capital,* Promotors: Prof.dr. J. Spronk & Prof.dr. D. van Dijk, EPS-2008-134-F&A, ISBN: 978-90-5892-172-7, http://hdl.handle.net/1765/13480

Schellekens, G.A.C., *Language Abstraction in Word of Mouth,* Promotor: Prof.dr.ir. A. Smidts, EPS-2010-218-MKT, ISBN: 978-90-5892-252-6, http://hdl.handle.net/1765/21580

Schramade, W.L.J., *Corporate Bonds Issuers,* Promotor: Prof.dr. A. De Jong, EPS-2006-092-F&A, ISBN: 90-5892-125-5, http://hdl.handle.net/1765/8191

Schweizer, T.S., *An Individual Psychology of Novelty-Seeking, Creativity and Innovation,* Promotor: Prof.dr. R.J.M. van Tulder, EPS-2004-048-ORG, ISBN: 90-5892-077-1, http://hdl.handle.net/1765/1818

Six, F.E., *Trust and Trouble: Building Interpersonal Trust Within Organizations*, Promotors: Prof.dr. B. Nooteboom & Prof.dr. A.M. Sorge, EPS-2004-040-ORG, ISBN: 90-5892-064-X, http://hdl.handle.net/1765/1271

Slager, A.M.H., *Banking across Borders*, Promotors: Prof.dr. R.J.M. van Tulder & Prof.dr. D.M.N. van Wensveen, EPS-2004-041-ORG, ISBN: 90-5892-066–6, http://hdl.handle.net/1765/1301

Sloot, L., *Understanding Consumer Reactions to Assortment Unavailability*, Promotors: Prof.dr. H.R. Commandeur, Prof.dr. E. Peelen & Prof.dr. P.C. Verhoef, EPS-2006-074-MKT, ISBN: 90-5892-102-6, http://hdl.handle.net/1765/7438

Smit, W., *Market Information Sharing in Channel Relationships: Its Nature, Antecedents and Consequences*, Promotors: Prof.dr.ir. G.H. van Bruggen & Prof.dr.ir. B. Wierenga, EPS-2006-076-MKT, ISBN: 90-5892-106-9, http://hdl.handle.net/1765/7327

Sonnenberg, M., *The Signalling Effect of HRM on Psychological Contracts of Employees: A Multi-level Perspective*, Promotor: Prof.dr. J. Paauwe, EPS-2006-086-ORG, ISBN: 90-5892-119-0, http://hdl.handle.net/1765/7995

Sotgiu, F., *Not All Promotions are Made Equal: From the Effects of a Price War to Cross-chain Cannibalization,* Promotors: Prof.dr. M.G. Dekimpe & Prof.dr.ir. B. Wierenga, EPS-2010-203-MKT, ISBN: 978-90-5892-238-0, http://hdl.handle.net/1765/19714

Speklé, R.F., *Beyond Generics: A closer Look at Hybrid and Hierarchical Governance*, Promotor: Prof.dr. M.A. van Hoepen RA, EPS-2001-008-F&A, ISBN: 90-5892-011-9, http://hdl.handle.net/1765/357

Srour, F.J., *Dissecting Drayage: An Examination of Structure, Information, and Control in Drayage Operations*, Promotor: Prof.dr. S.L. van de Velde, EPS-2010-186-LIS, http://hdl.handle.net/1765/18231

Stam, D.A., *Managing Dreams and Ambitions: A Psychological Analysis of Vision Communication*, Promotor: Prof.dr. D.L. van Knippenberg, EPS-2008-149-ORG, http://hdl.handle.net/1765/14080

Stienstra, M., *Strategic Renewal in Regulatory Environments: How Inter- and Intra-organisational Institutional Forces Influence European Energy Incumbent Firms,* Promotors: Prof.dr.ir. F.A.J. Van den Bosch & Prof.dr. H.W. Volberda, EPS-2008-145-STR, ISBN: 978-90-5892-184-0, http://hdl.handle.net/1765/13943

Sweldens, S.T.L.R., *Evaluative Conditioning 2.0: Direct versus Associative Transfer of Affect to Brands,* Promotor: Prof.dr. S.M.J. van Osselaer, EPS-2009-167-MKT, ISBN: 978-90-5892-204-5, http://hdl.handle.net/1765/16012

Szkudlarek, B.A., *Spinning the Web of Reentry: [Re]connecting reentry training theory and practice*, Promotor: Prof.dr. S.J. Magala, EPS-2008-143-ORG, ISBN: 978-90-5892-177-2, http://hdl.handle.net/1765/13695

Tempelaar, M.P., *Organizing for Ambidexterity: Studies on the Pursuit of Exploration and Exploitation through Differentiation, Integration, Contextual and Individual Attributes,* Promotors: Prof.dr.ing. F.A.J. van den Bosch & Prof.dr. H.W. Volberda, EPS-2010-191-STR, ISBN: 978-90-5892-231-1, http://hdl.handle.net/1765/18457

Teunter, L.H., *Analysis of Sales Promotion Effects on Household Purchase Behavior*, Promotors: Prof.dr.ir. B. Wierenga & Prof.dr. T. Kloek, EPS-2002-016-MKT, ISBN: 90-5892-029-1, http://hdl.handle.net/1765/868

Tims, B., *Empirical Studies on Exchange Rate Puzzles and Volatility*, Promotor: Prof.dr. C.G. Koedijk, EPS-2006-089-F&A, ISBN: 90-5892-113-1, http://hdl.handle.net/1765/8066

Tiwari, V., *Transition Process and Performance in IT Outsourcing: Evidence from a Field Study and Laboratory Experiments,* Promotors: Prof.dr.ir. H.W.G.M. van Heck & Prof.dr. P.H.M. Vervest, EPS-2010-201-LIS, ISBN: 978-90-5892-241-0, http://hdl.handle.net/1765/19868

Tröster, C., *Nationality Heterogeneity and Interpersonal Relationships at Work*, Promotor: Prof.dr. D.L. van Knippenberg, EPS-2011-233-ORG, http://hdl.handle.net/1765/23298

Tuk, M.A., *Is Friendship Silent When Money Talks? How Consumers Respond to Word-of-Mouth Marketing*, Promotors: Prof.dr.ir. A. Smidts & Prof.dr. D.H.J. Wigboldus, EPS-2008-130-MKT, ISBN: 978-90-5892-164-2, http://hdl.handle.net/1765/12702

Tzioti, S., *Let Me Give You a Piece of Advice: Empirical Papers about Advice Taking in Marketing,* Promotors: Prof.dr. S.M.J. van Osselaer & Prof.dr.ir. B. Wierenga, EPS-2010-211-MKT, ISBN: 978-90-5892-251-9, hdl.handle.net/1765/21149

Vaccaro, I.G., *Management Innovation: Studies on the Role of Internal Change Agents,* Promotors: Prof.dr. F.A.J. van den Bosch & Prof.dr. H.W. Volberda, EPS-2010-212-STR, ISBN: 978-90-5892-253-3, hdl.handle.net/1765/21150

Valck, K. de, *Virtual Communities of Consumption: Networks of Consumer Knowledge and Companionship*, Promotors: Prof.dr.ir. G.H. van Bruggen & Prof.dr.ir. B. Wierenga, EPS-2005-050-MKT, ISBN: 90-5892-078-X, http://hdl.handle.net/1765/6663

Valk, W. van der, *Buyer-Seller Interaction Patterns During Ongoing Service Exchange*, Promotors: Prof.dr. J.Y.F. Wynstra & Prof.dr.ir. B. Axelsson, EPS-2007-116-MKT, ISBN: 90-5892-146-8, http://hdl.handle.net/1765/10856

Verheijen, H.J.J., *Vendor-Buyer Coordination in Supply Chains,* Promotor: Prof.dr.ir. J.A.E.E. van Nunen, EPS-2010-194-LIS, ISBN: 90-5892-234-2, http://hdl.handle.net/1765/19594

Verheul, I., *Is There a (Fe)male Approach? Understanding Gender Differences in Entrepreneurship*, Promotor: Prof.dr. A.R. Thurik, EPS-2005-054-ORG, ISBN: 90-5892-080-1, http://hdl.handle.net/1765/2005

Verwijmeren, P., *Empirical Essays on Debt, Equity, and Convertible Securities*, Promotors: Prof.dr. A. de Jong & Prof.dr. M.J.C.M. Verbeek, EPS-2009-154-F&A, ISBN: 978-90-5892-187-1, http://hdl.handle.net/1765/14312

Vis, I.F.A., *Planning and Control Concepts for Material Handling Systems*, Promotors: Prof.dr. M.B.M. de Koster & Prof.dr.ir. R. Dekker, EPS-2002-014-LIS, ISBN: 90-5892-021-6, http://hdl.handle.net/1765/866

Vlaar, P.W.L., *Making Sense of Formalization in Interorganizational Relationships: Beyond Coordination and Control,* Promotors: Prof.dr.ir. F.A.J. Van den Bosch & Prof.dr. H.W. Volberda, EPS-2006-075-STR, ISBN 90-5892-103-4, http://hdl.handle.net/1765/7326

Vliet, P. van, *Downside Risk and Empirical Asset Pricing*, Promotor: Prof.dr. G.T. Post, EPS-2004-049-F&A, ISBN: 90-5892-07-55, http://hdl.handle.net/1765/1819

Vlist, P. van der, *Synchronizing the Retail Supply Chain*, Promotors: Prof.dr.ir. J.A.E.E. van Nunen & Prof.dr. A.G. de Kok, EPS-2007-110-LIS, ISBN: 90-5892-142-0, http://hdl.handle.net/1765/10418

Vries-van Ketel E. de, *How Assortment Variety Affects Assortment Attractiveness: A Consumer Perspective*, Promotors: Prof.dr. G.H. van Bruggen & Prof.dr.ir. A. Smidts, EPS-2006-072-MKT, ISBN: 90-5892-101-8, http://hdl.handle.net/1765/7193

Vromans, M.J.C.M., *Reliability of Railway Systems*, Promotors: Prof.dr. L.G. Kroon, Prof.dr.ir. R. Dekker & Prof.dr.ir. J.A.E.E. van Nunen, EPS-2005-062-LIS, ISBN: 90-5892-089-5, http://hdl.handle.net/1765/6773

Vroomen, B.L.K., *The Effects of the Internet, Recommendation Quality and Decision Strategies on Consumer Choice*, Promotor: Prof.dr. Ph.H.B.F. Franses, EPS-2006-090-MKT, ISBN: 90-5892-122-0, http://hdl.handle.net/1765/8067

Waal, T. de, *Processing of Erroneous and Unsafe Data*, Promotor: Prof.dr.ir. R. Dekker, EPS-2003-024-LIS, ISBN: 90-5892-045-3, http://hdl.handle.net/1765/870

Waard, E.J. de, *Engaging Environmental Turbulence: Organizational Determinants for Repetitive Quick and Adequate Responses*, Promotors: Prof.dr. H.W. Volberda & Prof.dr. J. Soeters, EPS-2010-189-STR, ISBN: 978-90-5892-229-8, http://hdl.handle.net/1765/18012

Wall, R.S., *Netscape: Cities and Global Corporate Networks,* Promotor: Prof.dr. G.A. van der Knaap, EPS-2009-169-ORG, ISBN: 978-90-5892-207-6, http://hdl.handle.net/1765/16013

Watkins Fassler, K., *Macroeconomic Crisis and Firm Performance,* Promotors: Prof.dr. J. Spronk & Prof.dr. D.J. van Dijk, EPS-2007-103-F&A, ISBN: 90-5892-138-3, http://hdl.handle.net/1765/10065

Weerdt, N.P. van der, *Organizational Flexibility for Hypercompetitive Markets: Empirical Evidence of the Composition and Context Specificity of Dynamic Capabilities and Organization Design Parameters,* Promotor: Prof.dr. H.W. Volberda, EPS-2009-173-STR, ISBN: 978-90-5892-215-1, http://hdl.handle.net/1765/16182

Wennekers, A.R.M., *Entrepreneurship at Country Level: Economic and Non-Economic Determinants,* Promotor: Prof.dr. A.R. Thurik, EPS-2006-81-ORG, ISBN: 90-5892-115-8, http://hdl.handle.net/1765/7982

Wielemaker, M.W., *Managing Initiatives: A Synthesis of the Conditioning and Knowledge-Creating View*, Promotors: Prof.dr. H.W. Volberda & Prof.dr. C.W.F. Baden-Fuller, EPS-2003-28-STR, ISBN: 90-5892-050-X, http://hdl.handle.net/1765/1042

Wijk, R.A.J.L. van, *Organizing Knowledge in Internal Networks: A Multilevel Study*, Promotor: Prof.dr.ir. F.A.J. van den Bosch, EPS-2003-021-STR, ISBN: 90-5892-039-9, http://hdl.handle.net/1765/347

Wolters, M.J.J., *The Business of Modularity and the Modularity of Business*, Promotors: Prof. mr. dr. P.H.M. Vervest & Prof.dr.ir. H.W.G.M. van Heck, EPS-2002-011-LIS, ISBN: 90-5892-020-8, http://hdl.handle.net/1765/920

Wubben, M.J.J., *Social Functions of Emotions in Social Dilemmas*, Promotors: Prof.dr. D. De Cremer & Prof.dr. E. van Dijk, EPS-2009-187-ORG, http://hdl.handle.net/1765/18228

Xu, Y., *Empirical Essays on the Stock Returns, Risk Management, and Liquidity Creation of Banks*, Promotor: Prof.dr. M.J.C.M. Verbeek, EPS-2010-188-F&A, http://hdl.handle.net/1765/18125

Yang, J., *Towards the Restructuring and Co-ordination Mechanisms for the Architecture of Chinese Transport Logistics*, Promotor: Prof.dr. H.E. Harlambides, EPS-2009-157-LIS, ISBN: 978-90-5892-198-7, http://hdl.handle.net/1765/14527

Yu, M., *Enhancing Warehouse Perfromance by Efficient Order Picking*, Promotor: Prof.dr. M.B.M. de Koster, EPS-2008-139-LIS, ISBN: 978-90-5892-167-3, http://hdl.handle.net/1765/13691

Zhang, X., *Strategizing of Foreign Firms in China: An Institution-based Perspective*, Promotor: Prof.dr. B. Krug, EPS-2007-114-ORG, ISBN: 90-5892-147-5, http://hdl.handle.net/1765/10721

Zhang, X., *Scheduling with Time Lags,* Promotor: Prof.dr. S.L. van de Velde, EPS-2010-206-LIS,
ISBN: 978-90-5892-244-1, http://hdl.handle.net/1765/19928

Zhou, H., *Knowledge, Entrepreneurship and Performance: Evidence from Country-level and Firm-level Studies,* Promotors: Prof.dr. A.R. Thurik & Prof.dr. L.M. Uhlaner, EPS-2010-207-ORG, ISBN: 90-5892-248-9, http://hdl.handle.net/1765/20634

Zhu, Z., *Essays on China's Tax System*, Promotors: Prof.dr. B. Krug & Prof.dr. G.W.J. Hendrikse, EPS-2007-112-ORG, ISBN: 90-5892-144-4, http://hdl.handle.net/1765/10502

Zwan, P.W. van der, *The Entrepreneurial Process: An International Analysis of Entry and Exit*, EPS-2011-234-ORG, ISBN: 978-90-5892-277-9, http://hdl.handle.net/1765/23422

Zwart, G.J. de, *Empirical Studies on Financial Markets: Private Equity, Corporate Bonds and Emerging Markets*, Promotors: Prof.dr. M.J.C.M. Verbeek & Prof.dr. D.J.C. van Dijk, EPS-2008-131-F&A, ISBN: 978-90-5892-163-5, http://hdl.handle.net/1765/12703

About the Author

Martijn Burger was born in Groningen, the Netherlands on the 14th of June 1982. He spent his childhood in Sauwerd and Haren, and later in Baarn. In 2003, he received his BA (with honours) from University College Utrecht in Social Science. After his undergraduate studies he obtained cum laude the MSc in Economics and Business at the Erasmus University Rotterdam and cum laude the Research MSc in Sociology and Social Research at Utrecht University.

Martijn's main research interests are in the field of spatial economics, with a particular focus on urban systems, foreign direct investment, and urban and regional development. He presented his papers at various international conferences and published work in internationally-refereed journals such as *Environment and Planning A*, *Regional Studies, Urban Studies, Cambridge Journal of Regions, Economy and Society, Cities, Eurasian Geography and Economics, Italian Journal of Regional Science, Journal of Economic and Social Geography, Social Networks, Spatial Economic Analysis,* and *Town and Country Planning*. In 2009-2010, he worked as a guest researcher at the Netherlands Environmental Assessment Agency. During his PhD, he also organized several workshops and carried out contract research for the Dutch Ministry of Economic Affairs and the municipality of Almere.

At present, Martijn holds a position as an assistant professor at the Department of Applied Economics, Erasmus University Rotterdam. He teaches courses on urban economics, multinational strategy, and business networks. Since 2010, he is also member of the board of the Dutch Regional Science Association and co-organiser of the Regional Studies research network on Urban Systems.

List of Publications

Articles in Refereed International Journals

1. "Form follows function? Linking morphological and functional polycentricity". Accepted and forthcoming in *Urban Studies* (with Evert Meijers).

2. "The geography of global corporate control networks: the poor, the rich, and the happy few countries", 2011, *Environment and Planning A*, 43(4), 904-927 (with Ronald Wall and Bert van der Knaap).

3. "Heterogeneous development of metropolitan spatial structure: evidence from commuting patterns in English and Welsh city-regions, 1981-2001", 2011, *Cities*, 28(2), 160-170 (with Bastiaan de Goei, Lambert van der Laan and Fieke Huisman).

4. "Functional polycentrism and urban network development in the Greater South East, United Kingdom: Evidence from commuting patterns, 1981-2001", 2010, *Regional Studies*, 42(9), 1149-1170 (with Bastiaan de Goei, Frank van Oort and Michael Kitson).

5. "Spatial structure and productivity in U.S. metropolitan areas", 2010, *Environment and Planning A*, 42(6), 1383-1402 (with Evert Meijers).

6. "A treatise of the geographical scale of agglomeration externalities and the MAUP", 2010, *Scienze Regionali - Italian Journal of Regional Science*, 9(1), 19-39 (with Frank van Oort and Bert van der Knaap).

7. "The geography of Chinese and Indian greenfield investments in Europe', 2010, *Eurasian Geography and Economics*, 51(2), 254-273 (with Matthias Brienen and Frank van Oort).

8. "On the economic foundations of the urban network paradigm. Spatial integration, functional integration and urban complementarities within the Dutch Randstad", 2010, *Urban Studies*, 47(4), 725-748 (with Frank van Oort and Otto Raspe).

9. "Featured graph: Worldwide differences in executive pay, culture, well-being and economic growth", 2010, *Environment and Planning A*, 42(2), 255-256 (with Bas Karreman).

10. "On the specification of the gravity model of trade: zeros, excess zeros and zero-inflated estimation", 2009, *Spatial Economic Analysis*, 4(2), 167-190 (with Frank van Oort and Gert-Jan Linders).

11. "Networks and economic agglomerations", 2009, *Tijdschrift voor Economische en Sociale Geografie - Journal of Economic and Social Geography*, 100(2), 139-144 (with Frank van Oort, Koen Frenken and Bert van der Knaap).

12. "Social context and network formation: an experimental study", 2009, *Social Networks*, 31(1), 63-75 (with Vincent Buskens).

13. "Testing the super-region", 2008, *Town and Country Planning*, 77(11), 458-464 (with Bastiaan de Goei, Frank van Oort and Michael Kitson).

14. "A rather empty world: the many faces of distance and the persistent resistance to international trade", 2008, *Cambridge Journal of Regions, Economy and Society*, 1(3), 439-458 (with Gert-Jan Linders and Frank van Oort).

International Books and Contributions to Edited Volumes

1. "Agglomeration and new establishment survival: a mixed hierarchical and cross-classified model". Accepted and forthcoming in Karima Kourtit, Peter Nijkamp and Roger Stough (eds), *Drivers of Entrepreneurship, Innovation and Regional Dynamics*, Berlin: Springer, Chapter 3, pp. 45-64 (with Frank van Oort and Otto Raspe).

2. "Inter-firm relations and economic clustering in the Dutch Randstad region", in Uwe Blien & Gunther Maier (eds), *The Economics of Regional Clusters: Networks, Technology and Policy*, Cheltenham, UK: Edward Elgar, Chapter 9, pp. 145-165 (with Frank van Oort and Otto Raspe).

Book Reviews

1. Book Review on "Peter Buckley (2010), China, Foreign Direct Investment and the World Economy", 2010, *Regional Studies*, 44(9), 1302-1304 (with Bas Karreman).

2. Book Review on "Peter van Bergeijk & Steven Brakman (2010), The Gravity Model in International Trade: Advances and Applications", *Economisch Statistische Berichten*, 4599, 766 (in Dutch) (with Frank van Oort).

Publications in Refereed Dutch Journals

1. "Huizenprijzen, luchtbellen en stedelijke groei", 2010, *Tijdschrift voor Politieke Economie – Digitaal*, 4(2), 73-92 (with Mark Thissen and Frank van Oort).

2. "De ontwikkeling van economische specialisaties en complementariteit in de Randstad in de periode 1963-2004", *Holland Historisch Tijdschrift*, 41(3), 240-252 (with Frank van Oort, Mark Thissen and Evert-Jan Visser) .

3. “De vele gezichten van afstand in internationale handelsrelaties”, *Tijdschrift voor Politieke Ekonomie - Digitaal*, 2(4), 106-124 (with Frank van Oort and Gert-Jan Linders).

4. “Economische netwerken en stedelijke complementariteit in de Randstad”, *Kwartaalschrift Economie*, 4(1), 11-25 (with Frank van Oort and Otto Raspe).

Professional Publications

1. “Economische waarde van kunst en cultuur”, *EconomieOpinie.nl*, January 2011 (with Frank Neffke).

2. “Chinese investeringen in Europa en Nederland”, *Economisch Statistische Berichten*, 4602, 74-76 (with Matthias Brienen and Bas Karreman).

3. “Randstad, Groot-Amsterdam of de Vleugels?’, *Rooilijn*, 41(6), 428-433 (with Evert Meijers).

4. “Metropool aan de macht: lessen uit de grote wereld”, *FD Outlook*, November 2008, 53-59 (with Frank van Oort and Ronald Wall).

5. “De Randstad hangt als los zand aaneen”, *Economisch Statistische Berichten*, 4510, 292-295 (with Frank van Oort, Otto Raspe and Jan Ritsema van Eck).

6. “Steden in de netwerkeconomie”, *Geografie*, 16(4), 34-36 (with Frank van Oort, Otto Raspe and Bert van der Knaap).

Reports

1. “De Evolutie van Gerelateerde Sectoren en Steden: Kansen en Bedreigingen in de Noordvleugel van de Randstad”. Den Haag: Ministerie van Economische Zaken (with Frank Neffke, Frank van Oort and Ron Boschma).

2. “Internationale Positie Noordvleugel”. Den Haag: Ministerie van Economische Zaken (with Ernst & Young and Frank van Oort).

3. “De Positie van de Noordvleugel in Europese M&A Netwerken”. Den Haag: Ministerie van Economische Zaken (with Ronald Wall).

4. ‘Clusters en Netwerkeconomie in de Noordvleugel van de Randstad”. Den Haag: Ministerie van Economische Zaken (with Frank van Oort, Irina van Aalst, Bart Lambregts and Evert Meijers).

5. “Netprint Almere: Almere’s City Hierarchy and Urban Performance in a World City Network”. Rotterdam: Wall Research Design / Erasmus University Rotterdam (with Ronald Wall).

6. “Economische Netwerken in de Regio”, Den Haag/Rotterdam: Ruimtelijk Planbureau/NAI Uitgevers (with Frank van Oort, Judith van Brussel, Otto Raspe, Jacques van Dinteren and Bert van der Knaap).

Working Papers

1. “The magnitude and distance decay of trade in goods and services: new evidence for the European Union” (with Mark Thissen, Frank van Oort and Dario Diodato).

2. “Revealed competition for greenfield investments between European regions” (with Bert van der Knaap and Ronald Wall).

3. “Polycentricity and the multiplexity of urban networks” (with Bert van der Knaap and Ronald Wall).

4. “Collaboration networks as carriers of knowledge spillovers in the semiconductor and biotechnology industry: evidence from EU-27 regions” (with Frank van Oort, Jarno Hoekman and Koen Frenken).

5. “Proximity and alliances in the biopharmaceutical industry” (with Sandra Phlippen).

6. “House prices, bubbles and city size” (with Mark Thissen and Frank van Oort).

7. “Regional spatial structure and retail amenities in Dutch regions” (with Evert Meijers and Frank van Oort).

8. “Spatial and temporal variation in hysterectomy rates and surgical routes for benign diseases in the Netherlands, 1995-2005” (with Mirjam Hanstede, Anne Timmermans and Matthé Burger).

Erasmus Research Institute of Management - ERiM

STRUCTURE AND COOPTITION IN URBAN NETWORKS

Over the past decades, demographic changes, advances in transportation and communication technology, and the growth of the service sector have had a significant impact on the spatial structure of regions. Monocentric cities are disappearing and developing into polycentric metropolitan areas, while at the same time, social and economic processes are taking place at an ever larger geographical scale, beyond that of the city, in which historically separate metropolitan areas are becoming increasingly functionally connected to form polycentric urban regions. Such urban networks are characterised by the lack of an urban hierarchy, a significant degree of spatial integration between different cities and, complementary relationships between centres, in that cities and towns have different economic specialisations.

The growing literature on changing urban systems coincides with the increasing popularity of the urban network concept in contemporary spatial planning and policy, in which urban networks are often seen as a panacea for regional economic development problems. Polycentricity and spatial integration have become catchphrases, where polycentric development policies have been introduced to support territorial cohesion and cooperation as well as higher levels of urban and regional competitiveness. Despite the enthusiasm for the ideas of a polycentric and networked spatial organisation, the assessment of the urban network concept leaves much to be desired. To what extent are regions becoming more polycentric and spatially integrated? Are relationships between cities in polycentric, spatially integrated regions complementary rather than competitive? And are polycentric, spatially integrated regions more economically efficient than their monocentric, non-integrated counterparts? In this study, these questions will be addressed.

ERiM

The Erasmus Research Institute of Management (ERIM) is the Research School (Onderzoekschool) in the field of management of the Erasmus University Rotterdam. The founding participants of ERIM are the Rotterdam School of Management (RSM), and the Erasmus School of Economics (ESE). ERIM was founded in 1999 and is officially accredited by the Royal Netherlands Academy of Arts and Sciences (KNAW). The research undertaken by ERIM is focused on the management of the firm in its environment, its intra- and interfirm relations, and its business processes in their interdependent connections.

The objective of ERIM is to carry out first rate research in management, and to offer an advanced doctoral programme in Research in Management. Within ERIM, over three hundred senior researchers and PhD candidates are active in the different research programmes. From a variety of academic backgrounds and expertises, the ERIM community is united in striving for excellence and working at the forefront of creating new business knowledge.

ERIM PhD Series
Research in Management

Erasmus Research Institute of Management - ERiM
Rotterdam School of Management (RSM)
Erasmus School of Economics (ESE)
Erasmus University Rotterdam (EUR)
P.O. Box 1738, 3000 DR Rotterdam,
The Netherlands

Tel. +31 10 408 11 82
Fax +31 10 408 96 40
E-mail info@erim.eur.nl
Internet www.erim.eur.nl

Design & layout: B&T Ontwerp en advies (www.b-en-t.nl) Print: Haveka (www.haveka.nl)