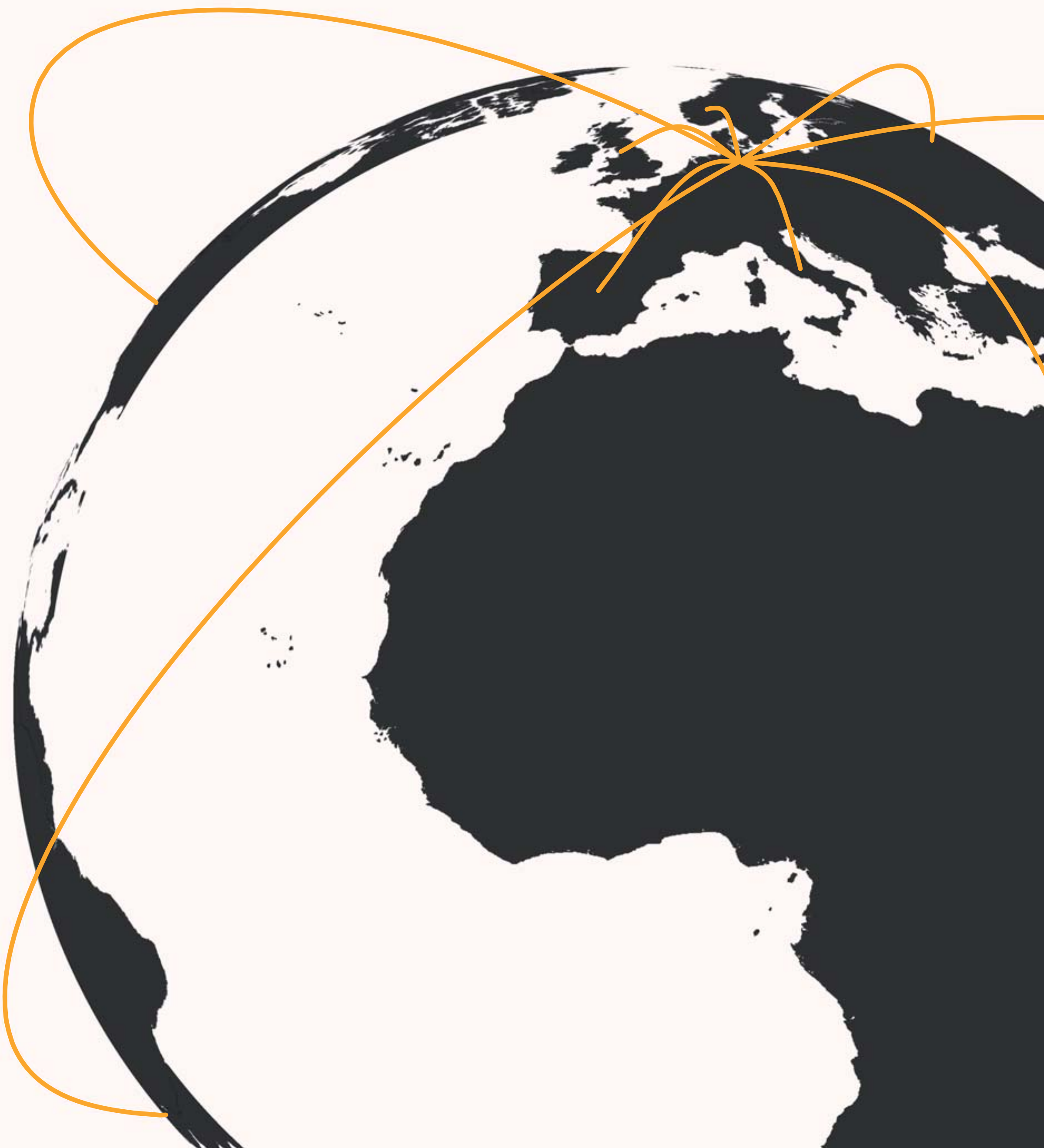
INTERLOCKING FIRM NETWORKS AND EMERGING MEGA-CITY REGIONS

The Relational Geography of the Knowledge Economy in Germany

PhD Thesis

Stefan Lüthi



TECHNISCHE UNIVERSITÄT MÜNCHEN

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Summary

Globalisation has entailed a reorganisation of spatial development processes on global, national and regional scales. Cities and metropolitan areas are increasingly connected to other places in the world in many different ways and through many different actors. The result is a multi-faceted city network on a global scale that significantly impacts – and is in turn shaped by – the *knowledge economy*. The latter is defined as an interdependent system of Advanced Producer Services (APS) and High-Tech firms, combining highly specialised knowledge and skills from different parts of their value chain in order to create innovations and sustain a competitive advantage. Because these firms are engaged in innovation processes, they need to constantly create new knowledge and manage knowledge resources in appropriate organisational structures. These knowledge creation and management processes have led many large corporations to extend their intra-firm and extra-firm networks as part of their overall business strategies. The challenge thereby is to choose a location that optimally satisfies the present and future requirements of the company. In making this choice, *geographical proximity*, based on co-location of firms in the same area, and *relational proximity*, based on accessibility and the organisational ability of firms to facilitate interaction, are crucial to creating new knowledge and sustaining competitive advantage. Geographical proximity induces *agglomeration economies* and facilitates communication and learning patterns, as well as the sharing of localised knowledge and the innovation capabilities of knowledge-intensive firms (Howells 2000). Relational proximity, on the other hand, evokes *global network economies* and enables companies to spread activities globally to source inputs and to gain access to new markets. Recent studies show that, at the intersection of agglomeration economies and global network economies, a new form of urbanisation is emerging in advanced economies: polycentric Mega-City Regions, defined as a series of ten to fifty cities and towns physically separated but functionally networked and thereby drawing enormous economic strength from a new functional division of labour (Hall and Pain 2006). These Mega-City Regions represent a rescaling of the strategic locations of the knowledge economy, by which firms reap the benefits of both local agglomerations and global-scale production networks. Against this backdrop, spatial development policies in Germany were reformulated relatively early to respond to the emerging phenomenon of polycentric Mega-City Regions. In 1995, German policy-makers decided to determine six Mega-City Regions – Berlin-Brandenburg, Hamburg, Munich, Rhine-Main, Rhine-Ruhr and Stuttgart – as engines of social, economic and cultural development with international importance. Later, further Mega-City Regions were added: the Saxony Triangle, Nuremberg, Bremen-Oldenburg, Hanover-Braunschweig-Göttingen-Wolfsburg and Rhine-Neckar.

The purpose of this thesis is to elaborate on the question of how German cities are integrated into the world city network by the functional logic of the knowledge economy and, based on this information, to evaluate the connectivity patterns within and beyond the politically designated Mega-City Regions in Germany. How has the globalisation of economic activity affected the German urban system? What kind of large-scale interlocking networks and functional urban hierarchies can be observed? Do global network economies increase disparities within the German national urban system? In order to analyse these questions, a mix of three different research methods has been applied. Firstly, the *interlocking network model* of Taylor (2004) was used to analyse how multi-branch, multi-location APS and High-Tech firms develop their intra-firm networks on various spatial scales. Secondly – using a web survey – a *value chain analysis* was applied to identify the partners with whom these firms have working relationships along individual chains of value and the location

of these partners. Finally, a series of *face-to-face interviews* with managing directors was conducted, in order to reveal softer case study evidence of the strategic networking of knowledge-intensive enterprises. The analytical building blocks of this research approach were 338 Functional Urban Areas (FUAs) in Germany, including adjacent agglomerations in Germany's neighbouring countries. This made it possible to identify and contextualise large-scale and cross-border urban geographies of knowledge-intensive firms and their emerging spatial hierarchies. The empirical findings were analysed and interpreted on three spatial scales: global, national and regional. On the regional scale, the metropolitan regions of Munich, Rhine-Ruhr and Upper Rhine served as case studies.

Relational patterns on the global scale: The connectivity patterns on the global scale indicate that knowledge-intensive firms located in Germany – especially High-Tech firms – spread their activities globally, which results in an international division of labour whose main agents are multi-branch, multi-location firms with complex organisational structures. These organisational structures are influenced by a number of strategic business activities, such as sourcing localised knowledge, entering into emerging markets and decreasing production costs. In the High-Tech sector, the fragmentation of the value chain across various locations has given rise to considerable restructuring in firms, including moving certain business functions offshore (OECD 2008). The empirical findings show that South America and East Asia tend to be important *farshoring* destinations for Germany-based High-Tech firms, whereas Central and Eastern Europe provide alternative *nearshoring* locations. In the APS sector, by contrast, the interlocking firm networks are strongly focused on the German and Western European space economy. Especially cultural and linguistic requirements as well as specific national and European regulations have been stated as major reasons for this strategy, enabling APS firms to benefit from detailed knowledge of the existing regulative system.

Relational patterns on the national scale: On the national scale, the interlocking network analysis reveals a geography of APS and High-Tech connectivity that is polycentric in character, especially compared with countries such as the UK or France, where economic activities are strongly concentrated in London and Paris respectively. Nevertheless, the functional-urban hierarchy in Germany proves to be steeper than is claimed by the federal structure and the political debate on German Mega-City Regions. A maximum of six Mega-City Regions – Munich, Rhine-Main, Hamburg, Rhine-Ruhr, Stuttgart, and to a lesser extent Berlin – can be regarded as strategic nodes of the knowledge economy with international importance. Here, the mere size of an agglomeration does not necessarily correlate with its position in the functional urban hierarchy. Urban size is an important condition, but not the only one, for achieving a top position with regards to economic connectivity. Berlin, for example, indicates an unexpected deficiency of connectivity even though it is the biggest German agglomeration by far in terms of inhabitants and jobs. This finding is also supported by the spatial analysis based on value-added relations, in which Munich and Rhine-Ruhr prove to be the top Mega-City Regions in terms of density and variety of value-added expertise, followed by Stuttgart, Hamburg and Frankfurt. In these Mega-City Regions, many elements of the value chain are strongly represented, making them sophisticated localised systems of value chains. Companies located in these areas are potentially able to source many inputs of their value chain on a regional scale, especially activities requiring up-to-date knowledge such as R&D, financing and marketing.

Relational patterns in the Mega-City Region of Munich: The interlocking network analysis indicates that the Greater Munich area can be understood as a *functionally-monocentric* and hierarchically-organised Mega-City Region, in which intra-firm linkages of APS and High-Tech firms are concentrated to a considerable extent. In general, the intra-firm analysis reveals an urban core network – composed of the FUAs of Munich, Augsburg, Regensburg and Ulm – and an extended city network, which includes additional agglomerations depending on whether APS or High-Tech networks are considered: for example Freising and Kempten in the APS sector; Ingolstadt, Rosenheim and Heidenheim in the High-Tech sector. Thus, the economic dynamic of the Mega-City Region of Munich can be attributed to the combination of both urbanisation economies of the FUA of Munich and localisation economies of the secondary FUAs around Munich. The airport location near Freising, for example, is emerging as a highly significant APS centre, whereas other secondary FUAs provide local High-Tech expertise that is highly beneficial for the Mega-City Region as a whole. Similarly, the analysis based on business relations along the value chain shows that knowledge-intensive firms in the Greater Munich area source the largest part of their value-added services on the Mega-City Region scale. In the APS sector, for example, 54 per cent of all business relations are concentrated on the regional scale; 40 per cent are focused on the national scale and 6 per cent on the European scale – less than 1 per cent of the value-added relations mentioned in the web survey are globally orientated.

Relational patterns in the Mega-City Region of Rhine-Ruhr: In contrast to the Mega-City Region of Munich, Rhine-Ruhr is identified as a highly *polycentric* Mega-City Region, not only in geographical, but also in relational terms. The intra-regional connectivities between the FUAs of the Rhine-Ruhr region tend to be stronger than the connections with neighbouring agglomerations. Düsseldorf emerges as the main gateway, not only for global and national networks, but also for regional networks of the knowledge economy, forming a kind of functional bridge between the Ruhr area and the Rhine-axis. In fact, these two apparently competing urban regions prove to be economically closely interrelated in a complex system of value chains, making the whole Mega-City Region a potential laboratory of knowledge creation and innovation. In terms of the business relations along the value chain, Rhine-Ruhr emerges as a highly interconnected value-added system with strong relations on the regional and the national scale. In the APS sector, 49 per cent of all the value-added relations stated in the web survey are focused on the regional, 37 per cent on the national, 9 per cent on the European and only 5 per cent on the global scale. In the High-Tech sector, the business relations show a relatively strong national orientation: 29 per cent are concentrated on the regional, 41 per cent on the national, 17 per cent on the European and 13 per cent on the global scale.

Relational patterns in the Upper Rhine region: The Upper Rhine region is a strategically well-positioned economic area with clear strengths in value-added intensive sectors of industry, such as chemicals and pharmaceuticals (BAK 2006). The interlocking network analysis shows that the relatively modest number of headquarters – especially in the APS sector – is compensated for by intensive intra-firm networking with neighbouring FUAs such as Zurich, Frankfurt and Stuttgart. A considerable city-interlock in both the APS and the High-Tech sector can be observed between Basel and Zurich, which underlines the close functional networking between these two agglomerations in densely-populated Northern Switzerland. However, the strong city-interlocks of the FUAs in the Upper Rhine region with Zurich, Stuttgart and Frankfurt do not mean that there is no networking within the Upper Rhine region itself. Information exchange and business activities not only arise through intra-firm office networks, but also from extra-firm networks along the value chain. To what extent such value-adding networks are concentrated in the Upper Rhine region still has to be clarified. Regarding the functional urban hierarchy built by intra-firm networks of the knowledge economy, Basel is shown to be the main centre for APS activities. High-Tech companies, on the other hand, are distributed more evenly over several parts of the region, especially in Northern Switzerland and the Southern Palatinate. Viewing the total connectivity of the FUAs in perspective with the sum of their population and employment figure brings to light the major significance of strategic alternative locations such as Saint Louis, which is located in immediate vicinity to the Basel airport, or Aarau and Baden, which are located in the wider metropolitan orbit of Zurich and Basel, the two main economic centres in Northern Switzerland.

Overall, although our empirical research provides much evidence that networks of knowledge-intensive businesses concentrate on a large geographical scale, it remains difficult to determine the precise boundaries of an emerging Mega-City Region. Business networks are dynamic, spanning multiple boundaries in a variable geometry of overlapping spaces with flexible and fuzzy contours (Dicken 2007). Therefore, Mega-City Regions should not be interpreted as self-contained urban systems. The emergence of functionally polycentric spatial patterns cannot be explained solely by the intra-regional division of labour, as they develop complementarily to national and international relations along the value chain, especially in economies like Germany's with a strong orientation towards exports. The increasingly rich and diversified infrastructure of global travel and communication tends to qualify the assertion that firms have a strong tendency to locate close to one other because of frequent interactions requiring face-to-face contact. Geographical proximity helps, but is neither a necessary nor a sufficient condition for knowledge creation to take place. The production and application of knowledge in the value creation process requires not only urbanisation economies in the form of dense and diversified regional markets, but also high-quality inter-continental and European accessibility to global knowledge hubs. Mega-City Regions with well-developed international and regional accessibility tends to meet these requirements best because they are able to combine agglomeration economies and global network economies in a multi-scale innovation and production system.

This multi-scale character of Mega-City Regions tears apart previous preconceptions. A central challenge for German policy-makers lies in finding a way out of the conflict between territorial cohesion and economic competitiveness. In fact, the spatial development polices in Germany stand between the conflicting priorities of the functional logic of the knowledge economy, which advances the spatial concentration of high-level economic functions, and the territorial logic of the government system, which aims to provide equivalent living conditions throughout the federal territory. Today, the politically designated Mega-City Regions in Germany have come to cover around half of the German territory. However, the current trends in the knowledge economy show that the majority of the value-adding activities are concentrated only in a minority of highly diversified and globally connected agglomerations. From an analytical perspective, the central idea of the Mega-City Region concept – i.e. the concentration of value-adding relations and economic strengths with global resonance in large-scale polycentric Mega-City Regions – is by definition not suited to pursuing a spatial strategy with blanket coverage. Therefore, it seems reasonable that the hierarchical perspective should be reintroduced in the political debate on German Mega-City Regions. This certainly would be more enlightening than to strive for a balanced urban system of several equivalent and evenly distributed Mega-City Regions in the German territory.

Contents

List of figures and tables

Figures

Tables

List of acronyms and abbreviations

APS	Advanced Producer Services
ARE	Bundesamt für Raumentwicklung
BAK	Basel Economics AG
BBR	Bundesamt für Bauwesen und Raumordnung
BBSR	Bundesinstitut für Bau-, Stadt- und Raumforschung
BFS	Bundesamt für Statistik
CBD	Central Business District
EC	European Commission
EU	European Union
ESDP	European Spatial Development Perspective
ESPON	European Spatial Planning Observation Network
ETH	Swiss Federal Institute of Technology
FDI	Foreign Direct Investment
FUA	Functional Urban Area
GaWC	Globalisation and World Cities
GCC	Global Commodity Chain
GDP	Gross Domestic Product
GEMACA	Group for European Metropolitan Areas Comparative Analysis
GPN	Global Production Network
GVC	Global Value Chain
HQ	Headquarters
ICT	Information and Communication Technology
IHK	Industrie- und Handelskammer
IKM	Initiativkreis Europäische Metropolregionen in Deutschland
INTERREG	EC Community initiative promoting cross-border and inter-regional cooperation
IT	Information Technology
KIBS	Knowledge Intensive Business Services
KIT	Karlsruhe Institute of Technology
LQ	Localisation Quotient
MCR	Mega-City Region
MKRO	Ministerkonferenz für Raumordnung
MNC	Multinational Corporation

NACE	Nomenclature statistique des activités économiques dans la Communauté européenne
NEG	New Economic Geography
NUTS	Nomenclature of Territorial Units for Statistics
NZZ	Neue Züricher Zeitung
OECD	Organisation for Economic Co-operation and Development
PCB	Printed Circuit Board
PUR	Polycentric Urban Region
R&D	Research and Development
RWTH	Rheinisch-Westfälische Technische Hochschule
SME	Small and Medium Sized Enterprises
TIM	Territorial Innovation Model
TNC	Transnational Corporation
UK	United Kingdom
URBACT	EU exchange and learning programme promoting sustainable urban development
USA	United States of America
WZ	Klassifikation der Wirtschaftszweige

1. Setting the scene

The starting point and the main motivation behind this research is the question of how to interpret global trends in spatial development. In this respect, there are two competing hypotheses (Halbert et al. 2006). On the one hand, the New York Times columnist Thomas Friedman (2007) argues that "the world is flat". Thanks to advances in information and communication technology (ICT) the global playing field has been levelled and enables a workforce of millions of well qualified people from various parts of the world to enter global competition; including India, China, Russia and other post-Soviet countries. "In a flat world", Friedman argues, "you can innovate without having to emigrate" (Friedman 2007:216).

In contrast to Friedman, Richard Florida (2008) argues that the world is still a very spiky place, especially because of the growing importance of the knowledge economy and its requirements for talented and creative people. He states that "in terms of sheer economic horsepower and cutting-edge innovation, today's global economy is powered by a surprisingly small number of places. …the playing field shows no sign of levelling. The tallest spikes – the cities and regions that drive the world economy – are growing ever higher, while the valleys – places that boast little, if any, economic activity – mostly languish" (Florida 2008:17). Obviously, although technological developments in ICT have shrunk the world, neither the "end of geography" nor "the death of distance" have come to pass (O´Brien 1992; Cairncross 1997). There is a strong propensity for economic activities to agglomerate in cities and their associated local regions. Geographical concentrations of economic activity still represent the normal state of affairs (Dicken 2007). "Sticky places" continue to exist in "slippery space" (Markusen 1996).

A key driver behind this process is the functional logic of the knowledge economy, which is defined as the interdependent system of Advanced Producer Services (APS) and High-Tech firms combining highly specialised knowledge and skills from different parts of the value chain in order to create innovations and to sustain competitive advantage. Because these firms are engaged in innovation processes, they need to be constantly creating new knowledge and to manage knowledge resources in appropriate organisational structures. These knowledge creation and management processes have led many large corporations to extend their locational networks as part of their overall business strategies in order to compete successfully on global markets. Location-specific factors such as access to information and access to a highly-skilled labour force are becoming increasingly important in corporate decision-making. Knowledge-intensive firms look for high-quality infrastructures, such as universities with excellent reputations or the headquarters of leading global companies, as well as the availability of specialised knowledge and the presence of business partners and customers. The concentration of knowledge in specific places creates a strong incentive for firms to locate their internal operations in such 'knowledge-rich' locations all over the world, where they can establish external networks with suppliers, subcontractors and business clients in order to source local skills and expertise. These linkages are woven across physical space, not only connecting firms and business units together, but also leading to increased connectivity between the cities and towns in which these firms operate (Dicken 2007).

The growing relevance of the knowledge economy and its tendencies towards both spatial concentration and global dispersal have induced new forms of hierarchical and network development, as well as functional differentiation between cities and towns leading to the emergence of polycentric urban regions. Their impact often goes beyond the official spatial development policies of the government system. Scott (2001) and, recently, Hall and Pain (2006) argue that cities cannot be separated from their regional hinterlands as they often compose a functional division of labour in terms of different kinds of services and value chains among firms. Hence, the traditional hierarchical model of a core city dominating its urban hinterland is becoming increasingly obsolete. Instead, a process of selective decentralisation of particular urban functions, and the simultaneous re-concentration of others, has led to the emergence of polycentric hybrid landscapes (Hall and Pain 2006; Scott 2001). According to Hoyler et al. (2008b), this newly-emerging urban form is spread out over a large area containing a number of cities – more or less within commuting distance – and with one or more international airports that link the region with other parts of the world (Hoyler et al. 2008b). Brenner (1999) argues that this re-scaling of cities "constitute an intrinsic moment of the current round of globalisation" (Brenner 1999:431).

Different attempts have been made to handle these extended urban regions analytically and various research projects have been realised in this context (ESPON 2004; Hall and Pain 2006; Thierstein et al. 2006; Lüthi et al. 2010b; Built Environment, 32.2, 2006; Regional Studies, 42.8, 2008). Furthermore, a number of labels have been used to denote the identified new metropolitan form (Hoyler et al. 2008b). For example: polycentric urban regions (Kloosterman and Musterd 2001), global city-regions (Scott 2001) or Mega-City Regions (Hall and Pain 2006). The commonality of all these approaches is that they take into account the vast geographical scale in which new forms of networks and spatial connectivity reintegrate urban space, leading to the emergence of an even larger trans-metropolitan urban structure (Lang and Knox 2009). In this thesis, the notion of *Mega-City Regions (MCR)* is applied as proposed by Peter Hall and Kathy Pain (2006), who define Mega-City Regions as "a series of anything between ten and 50 cities and towns physically separated but functionally networked, clustered around one or more larger central cities, and drawing enormous economic strength from a new functional division of labour" (Hall and Pain 2006:3). The key point of this definition is that Mega-City Regions are not solely characterised by simple city attributes, but as socioeconomic relational processes linking regions to other cities and towns on different spatial scales.

Against this backdrop, spatial development policies in the European Union and in particular Germany have been reformulated in recent years in order to find a balance between spatial cohesion and regional competitiveness. The political discourse in the European Union is based on two strategic programs: *Europe 2020* and the *Territorial Agenda*. *Europe 2020* – the follow-up program of the Lisbon Agenda – is a 10-year strategy proposed by the European Commission on 3 March 2010 for reviving the economy of the European Union. It aims at a "smart, sustainable and inclusive economic growth" with greater coordination of national and European policy (European Commission 2010:3). At the same time, the *Territorial Agenda* promotes a more balanced and sustainable pattern of urban development across Europe by integrating both the former Lisbon and Gothenburg Strategies through an integrated territorial development policy (EU 2007). Unfortunately, the Territorial Agenda hardly addresses the importance of the knowledge economy and the functional division of knowledge-intensive businesses in a spatial perspective. Moreover, it evokes a kind of polycentricism: "a belief that there are benefits to be gained from polycentric development. Such benefits are thought to include increased competitiveness, cohesion and regional balance, parity of access to infrastructure and knowledge, and sustainable development" (Hague and Kirk 2003:35). Thereby, polycentric development is expected to create potentials strong enough to counterbalance the European “Pentagon” – the area bounded by the cities of London, Paris, Hamburg, Munich and Milan (European Commission 1999:20). By combining the strategies of Europe 2020 and the Territorial Agenda, the European policy discussion is facing an overarching dilemma between territorial cohesion and economic competitiveness. There is a mismatch between the political objectives and strategies for balanced spatial development and actual development tendencies. Whereas planning principles rest on a normative and territorial logic, actual spatial development follows a functional logic, largely driven by market forces, which discriminate between more advantageous and less advantageous locations (Gabi et al. 2006:168).

A similar political strategy has long been applied in Germany. In order to promote a balanced spatial development across the country, Germany pursues a policy of spatial cohesion. Since the approval of the Spatial Planning Law in 1965, the Federal Government’s aim has been to provide equivalent living conditions throughout the federal territory (German Bundestag 2010). In order to avoid excessive urbanisation, a system of ‘central places’ – based on Christaller’s central place theory – has been established (Christaller 1933; Blotevogel 2000). In 1995, the Framework for Spatial Planning Policy Implementation (Raumordnungspolitischer Handlungsrahmen) marked a policy shift, delineating six European Mega-City Regions – Berlin-Brandenburg, Hamburg, Munich, Rhine-Main, Rhine-Ruhr and Stuttgart – as the engines of social, economic and cultural development with international importance (MKRO 1995). The urban agglomeration of Halle, Leipzig and Dresden (what is known as the Saxony Triangle) joined this new league of major Mega-City Regions in 1997. In 2005 another four metropolitan regions became members: Rhine-Neckar (Mannheim, Ludwigshafen, and Heidelberg), Bremen-Oldenburg, Nuremberg, and the city triangle of Hanover-Braunschweig-Göttingen (MKRO 2006). In recent years, the political concept of European Mega-City Regions has developed into a powerful communicative instrument in Germany (Blotevogel and Schmitt 2006), even though its analytical foundation remains rather weak. In the course of the globalisation and the European integration, international competition between locations is increasing. It has to be expected that only few German Mega-City Regions will create enough gravitational pull and economic power to succeed in this competition. This might lead to an accentuation of the functional urban hierarchy in the German space economy, in spite of the efforts made by German policy-makers to provide equivalent living conditions in all sub-regions of Germany.

1.1 Aim of the study

The purpose of this study is to analyse emerging Mega-City Regions and functional urban hierarchies in the German space economy from an *analytical* perspective and – based on this information – to evaluate their impact on the politically designated Mega-City Regions in Germany. The main objective is to obtain an in-depth functional-analytical view of the relational map of the German knowledge economy. How has the globalisation of economic activity affected the German urban system? Do global networks create more discontinuity within the German space economy? What kind of large-scale interlocking networks and functional urban hierarchies can be observed? What are the roles of large metropolitan regions as well as the small and medium-sized agglomerations in the context of corporate locational strategies and increasing international competition? And finally, what role do agglomeration economies play in today’s world of globalised economic activities and high-speed networking? Based on the theoretical debate on agglomeration economies and global network economies (see Part 1), three interrelated hypotheses with respect to the German space economy are proposed:

- Hypothesis 1: A multiplicity of high-grade APS and High-Tech locations creates interlinkages between cities and towns on an extended regional scale, leading to a new spatial phenomenon in Germany: polycentric Mega-City Regions.
- Hypothesis 2: Global network economies create a steep functional urban hierarchy in the German space economy, in which only few agglomerations establish substantial international connectivity; in terms of national and regional connectivity this functional urban hierarchy is less pronounced.
- Hypothesis 3: Knowledge-intensive firms choose their locations in order to optimise their intra-firm and extra-firm relations along the value chain and to benefit from geographical and relational proximity to suppliers, customers and knowledge resources.

Each of these hypotheses represents a different dimension of the German space economy. The first hypothesis relates to the *horizontal* dimension, analysing the functional linkages between agglomerations and the spatial spread of the connectivity within and beyond German Mega-City Regions. The second hypothesis refers to the *vertical* dimension by considering the functional urban hierarchy in the context of the knowledge economy. This hypothesis has to be seen in relation to the world city literature, whose central facet has been to rank cities according to their geo-economic power in the global urban system. The third hypothesis represents the *functional* dimension of the German space economy by explaining the strategic behaviour of knowledge-intensive enterprises from a spatial perspective. It underlines the importance of geographical and relational proximity in respect to the knowledge creation of firms engaged in innovation processes.

1.2 Methodological approach

Analysing the functional logic of the knowledge economy requires a network approach. Relational thinking in terms of connections of activities – linked through both physical and non-physical flows – is the key to understanding spatial development processes in the German space economy. According to Dicken (2007:23) the critical point of applying a network approach is that it draws the researcher's attention to the interconnectedness of economic activities across different spatial scales: global, national and regional. In recent years, the research methodology for analysing economic and social networks has grown in sophistication and sensitivity. However, it remains somewhat polarised between quantitative and qualitative approaches (Pike 2007). The challenge of understanding spatial development processes in the German space economy can only be met through quantitative analyses and qualitative studies working in tandem. For this reason, this research uses a mix of three different research methods.

First, the *interlocking network model* of Taylor (2004b) was used to analyse intra-firm networks of Advanced Producer Services (APS) and High-Tech firms on different geographical scales (Taylor 2004b). This approach provides one specific way to address the question of how inter-city relations can be empirically measured based on a theoretically coherent conceptualisation. Secondly, the interlocking network model was complemented by a *value chain analysis* looking at the partners with whom these firms have working relationships and where these partners are located. The main conceptual reason for using this value chain approach is that it avoids both a firm-centric and a region-centric perspective, thus, providing a helpful analytical instrument for the exploration of business organisations and networks that cut across regional, national and international scales (Birch

2008). Finally, a series of *face-to-face interviews* with managing directors were conducted in order to provide softer case study evidence on the strategic networking of knowledge-intensive enterprises. The interview method provided important qualitative evidence that complemented the quantitative data gathered by the other empirical steps taken to support the understanding of the functioning of the German city network from a bottom-up perspective. The spatial analytical building blocks of that research approach were *338 Functional Urban Areas (FUAs)* in Germany, including adjacent agglomerations in Germany's neighbouring countries. This made it possible to identify and contextualise large-scale and cross-border urban geographies of knowledge-intensive firms and their emerging spatial hierarchies. In Chapter 7, for example, connectivity patterns and spatial hierarchies within and beyond the cross-border metropolitan region of the Upper Rhine will be analysed in greater detail.

1.3 Plan of the study

The thesis is structured in four main parts (see Figure 1). The first part focuses on the theoretical background of the Mega-City Region concept by explaining the functional and spatial logic of the knowledge economy.

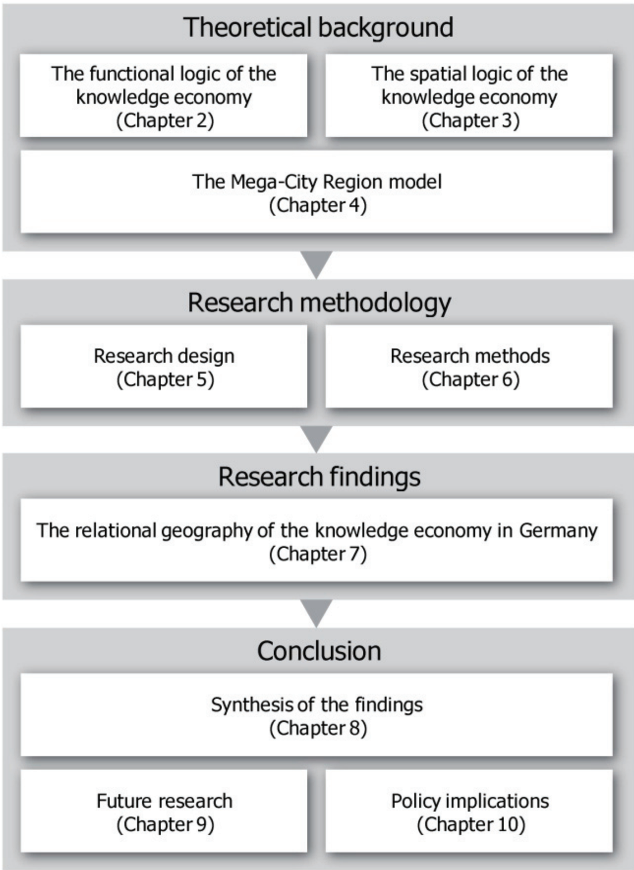


Figure 1: Plan of the study (Author's illustration)

Chapter 2 reveals some basic functional features of the knowledge economy by discussing the *functional* logic of knowledge creation and business organisation as a nexus of intra-firm and extra-firm networks. *Chapter 3* examines the *spatial* logic of the knowledge economy by analysing the spatial patterns of knowledge creation and business organisation, as well as their articulation in agglomeration economies and global network economies. *Chapter 4* elaborates the concept of the Mega-City Region in greater detail by introducing a conceptual Mega-City Region model, presenting the main building blocks of polycentric Mega-City Regions, and suggesting three key hypotheses which form the starting point of the empirical study. The second part of the thesis presents the research methodology. *Chapter 5* illustrates the research design by clarifying the main research perspective, followed by the presentation of the sampling strategy and the spatial setting of the multi-scale analysis. *Chapter 6* discusses the research methods in greater detail, i.e. the interlocking network model, the value chain approach and the qualitative network analysis. The third part of the thesis presents the research findings. *Chapter 7* starts with the connectivity patterns of the German knowledge economy on a global scale, and then zooms in to show the finer-grained hierarchical textures at a national and regional level. The fourth part concludes by synthesising the main findings *(Chapter 8)*, proposing a future research agenda *(Chapter 9)* and discussing some implications for policy *(Chapter 10)*. In the appendix, the empirical data is presented in the form of rankings and tables; and some technical aspects of the data gathering are illustrated in order to make the empirical research process replicable.

Part 1: Theoretical background

2. The functional logic of the knowledge economy

The starting point of the argumentation in this thesis is the functional logic of the knowledge economy. Knowledge-intensive firms and their networking activities in space are at the core of the conceptual framework. The shift towards a knowledge-based economy in advanced countries forces firms to constantly create new knowledge and to manage knowledge resources within an appropriate organisational structure. In the following two sections, we shall deal with these issues by discussing the functional logic of both knowledge creation and business organisation.

2.1 The functional logic of knowledge creation

There is a widespread agreement in the academic literature that knowledge has become the main source of economic development in advanced regions. Storper (1997), for example, notes that knowledge and technological change are important motors of changing spatial patterns and economic development (Storper 1997). According to Tödtling et al. (2006), the rise of knowledge-intensive sectors in production and services can be seen as a main feature of a new era of capitalism and as a role model for the future (Tödtling et al. 2006). Globalisation and the recent tendencies of deregulation and liberalisation are putting increasing pressure on companies to innovate in order to stay competitive (Cooke et al. 2007). In order to develop a better understanding of these processes, the meanings of knowledge and its different approaches have to be analysed in greater detail.

2.1.1 Approaches to knowledge

There have been various attempts to identify and classify different types of knowledge. According to Meusburger (2009), most deficits in research on knowledge in a spatial context can be traced back to an oversimplification of the communication process, a missing distinction between knowledge and information, and an insufficient consideration of different types of knowledge. Defining the concept of knowledge carefully is essential to the understanding of what kinds of knowledge contribute to innovation and why this should have any spatial consequences (Meusburger 2009).

Information and knowledge

Meusburger criticises that many authors treat knowledge and information as one and the same (Meusburger 2009). Especially the rationalistic school in economics often reduces knowledge to a stock of accumulated information (Ancori et al. 2000). With reference to Shannon's communication model (Shannon and Warren 1949), the rationalistic school describes knowledge formation as a linear process of transformation (see Figure 2). Data are thus turned into information, information into knowledge, and finally knowledge is confronted with 'wisdom' encompassing beliefs and judgements. The linear model of knowledge formation sees the processing of information as a critical step in the creation of new knowledge. It presumes that with each step in the model, complexity is increasing. The first step consists of transforming data into structured pieces of information. In a second step, this information is channelled into the search for knowledge. Thus, each piece of information brings with it a “quantum of novelty” leading to an increase of the knowledge stock (Ancori et al. 2000:261).

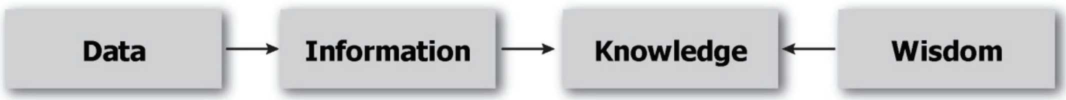


Figure 2: The linear model of knowledge formation (Ancori et al. 2000:262)

A growing number of voices argue that this distinction between information and knowledge is too simplistic and call for a change of paradigm. Already Boulding (1955) underlined that “we cannot regard knowledge as simply the accumulation of information in a stockpile, even though all the messages that are received by the brain may leave some sort of deposit here. Knowledge must itself be regarded as a structure, a very complex and quite loose pattern with its parts connected in various ways by ties of varying degrees of strength. Messages are continually shot into this structure; some of them pass right through its interstices without effecting any perceptible change in it. Sometimes messages ‘stick’ to the structure and become part of it (…). Occasionally, however, a message which is inconsistent with the basic pattern of the mental structure, but which is of such nature that it cannot be disbelieved, hits the structure, which is then forced to undergo a complete reorganisation” (Boulding 1955:103p, quoted in Amin et al. 2004:18p).

The statement of Boulding (1955) shows that there is clearly a need to develop a distinction between knowledge and information that is not restricted to a simple stock distinction. Meusburger (2009), for example, tells us that if we are the communicator of a message, we may end up blurring the boundaries between information and knowledge. If we are receiving a message, however, the difference between both tends to be clear: receiving information is not equivalent to gaining knowledge (Meusburger 2009). According to Picot et al. (2008), information is defined as a purpose-oriented message, whereas knowledge is an action-orientated combination of information that takes personal experiences and cognitive abilities into account. In other words, knowledge can be interpreted as the combination of information that allows a person to take action (Picot et al. 2008). In a similar way, Howells (2002) defines knowledge as “a dynamic framework or structure from which information can be stored, processed and understood (…). Knowledge is, therefore, associated with a process that involves cognitive structures which can assimilate information and put it into a wider context, allowing action to be undertaken from it” (Howells 2002:872). Finally, David and Foray (2003) see knowledge as a cognitive capacity which empowers people to act, whereas information refers to data-sets that remain passive until they are used by those with the knowledge that is required to interpret and process the data (David and Foray 2003).

Individual and collective knowledge

The statement of Boulding (1955) suggests that knowledge is highly personalised and that all individuals create their own knowledge stock. As a consequence, the same information can potentially lead to different interpretations. Ancori et al. (2000) argue that the development of knowledge is dependent on embodied abilities, in which cognitive capabilities strongly determine the way in which knowledge is acquired and accumulated (Ancori et al. 2000). Hence, processing information is strongly dependent on people. According to Meusburger (2009), the cognitive capacities and the willingness of recipients to accept and integrate the available information into their own knowledge structures are important aspects in transmitting information. Furthermore, he argues that the ease of access to information is highly dependent on the cognitive abilities, ideology, interests, motivation, attention, emotions and prejudices of the recipients of information and the milieu in which they are embedded (Meusburger 2009:33). Similarly, Nonaka et al. (2000) emphasise that information does not become knowledge until it is interpreted and anchored in the beliefs and commitments of the individual person (Nonaka et al. 2000).

Over the last half century, advances in certain strands of cognitive psychology have shown that many forms of knowledge are not only embodied in people but also embedded in social and cultural contexts. In developmental psychology, for instance, the pioneering work of Jean Piaget with children showed that “intelligence is internalised action and speech, and that both knowledge and meaning are context dependent” (Nooteboom 2000:71). Hence, knowledge is not only seen as an individual asset, but also as a context-specific and collective resource. Bathelt and Glückler (2003) argue that the context is paramount if we are to analyse the increasing importance of knowledge within the economy. Discovering how people and firms interact with each other is essential in order to reveal the process of knowledge-creation. This interaction, however, is highly influenced by the context, in which the processes of interpreting, integrating and transforming existing knowledge into new knowledge are embedded (Bathelt and Glückler 2003).

According to Nonaka et al. (2000), knowledge is context-specific because it depends on a particular time and space. Without being put into a specific context, knowledge is purely information. For this context, Nonaka et al. (2000) use the notion of ‘ba’. Based on a concept that was originally proposed by Japanese philosophers, ‘ba’ is defined as “a shared context in which knowledge is shared, created and utilised” (Nonaka et al. 2000:14). Here, ‘ba’ does not necessarily mean a physical space. Rather, it combines physical space, virtual space (such as e-mail) and mental space (such as shared ideals) in one concept. Nonaka et al. (2000) argue that the key to understanding the concept of ‘ba’ is interaction. Interaction amongst individuals – rather than individuals operating alone – enables them to create new knowledge. A close physical interaction is important for a group of people to develop a common language and to share the same context (Nonaka et al. 2000). Hence, the concept of ‘ba’ illustrates that knowledge can be interpreted as a highly collective resource, created through social interactions amongst individuals and organisations.

Likewise, Picot et al. (2008) describe collective knowledge as a mosaic, composed of individual elements in order to create a common function: “Individual knowledge is the substance of collective knowledge, but is nevertheless more than just the sum of its parts (…). Just as a mosaic is composed of various stones, collective knowledge is composed of various knowledge building blocks” (Picot et al. 2008:100).

According to Ancori et al. (2000), there are two basic reasons that can be put forward to justify why individual learning has to be enclosed within a collective process. The first reason stems from specialisation in the production process. As specialised activities in the production process require an increase of information exchange, so the specificity of individual knowledge obligates inter-personal interactions. If each individual holds some specialised knowledge there is a need to mobilise all these dispersed elements in order to put it together and to create new knowledge and new products. The second reason is because knowledge is simultaneously an input and an output of the learning process. The way individuals learn starts with, and is continuously shaped by, the pieces of knowledge held by the community in which they are integrated (Ancori et al. 2000).

Explicit and tacit knowledge

An early, but seminal classification of knowledge has been made by Michael Polanyi (1966) who distinguished between explicit (or codified) and tacit knowledge (Polanyi 1966). With his famous phrase “we can know more than we can tell”, Polanyi (1966:4) illustrates the fundamental idea of the distinction between explicit and tacit knowledge (Gertler 2003).

Explicit knowledge can be codified in formal language. It can be processed, transmitted and stored relatively easily in the form of data, scientific formulae, specifications, manuals, blueprints etc. (Nonaka et al. 2000). According to David and Foray (2003), this codification process aims to reduce knowledge to information by decoupling it from the individual person, thus making communication independent of human beings. Furthermore, codification aims to translate knowledge into “symbolic representations so that it can be stored on a particular medium. This creates new cognitive potentialities that remain inconceivable as long as the knowledge is attached to individual human beings” (David and Foray 2003:26). Since it facilitates further communication and learning, the codification process plays a key role for knowledge-intensive enterprises and forms a sound basis for the development of new products and services (David and Foray 2003).

Tacit knowledge, in contrast, refers to knowledge that is highly individual and hard to formalise. According to Nonaka et al. (2000) it comprises “subjective insights, intuitions and hunches”, and it is “deeply rooted in action, procedures, routines, commitment, ideals, values and emotions” (Nonaka et al. 2000:7). Polanyi describes tacit knowledge as an act of indwelling, which describes a process of assimilation to the external environment (Howells 1996). The paradigmatic examples to illustrate this idea is the performance of psychomotor skills such as swimming or riding a bicycle: “If I know how to ride a bicycle or keep afloat when swimming, I may not have the slightest idea of how I do this or even an entirely wrong or grossly imperfect idea of it and yet I merrily go cycling or swimming. Nor can it be said that I know how to bicycle or swim and yet do not how to coordinate the complex patterns of muscular acts when I do my cycling or swimming. I both know how to carry out these performances as a whole and also know how to carry out the elementary acts which constitute them, though I cannot tell what these acts are. This is due to the fact that I am only subsidiarily aware of these things, and our awareness of a thing may not suffice to make it identifiable” (Polanyi 1966:4, quoted in Howells 1996:93). Another example mentioned by Polanyi is the fact that a person is able to recognise another’s face in a crowd of thousands, indeed in a mass of a million others. However, the recogniser is usually unable to say how he recognised the person’s face. Polanyi, therefore, deduces that this knowledge cannot be put into words (Polanyi 1966).

In this context, the question is *why* we can know more than we can tell? According to Gertler (2003), it is a matter of consciousness, as proposed by Polanyi (1966) in his example about swimming or cycling. Tacit knowledge is in the background of our consciousness and thereby enables people to concentrate their attention on a specific task. Furthermore, it is a matter of communication difficulties as proposed by Polanyi (1966:4) in his statement that “we can know more than we can tell”. Even when one has achieved full consciousness, our language can be inadequate for expressing certain forms of knowledge. In some cases, the spoken or written word cannot transfer all of the knowledge necessary for the successful execution of a certain task (Gertler 2003). In the face of such challenges, tacit knowledge is best conveyed through demonstration and practice, as applied in the traditional master-apprentice relationship, which is characterised by "observation, imitation, correction and repetition" in the learning process (Gertler 2003:78) and by an analogue process that requires a kind of "simultaneous processing" (Nonaka et al. 2000:7).

However, the strict distinction between explicit and tacit knowledge is problematic. Howells (2002) emphasises that even Polanyi was at pains to stress that explicit and tacit knowledge should be accepted as the opposite ends of a continuum (Howells 2002). Polanyi saw explicit and tacit knowledge as essentially complementary because all forms of codified knowledge require tacit knowledge in order to be useful (Polanyi 1966). Other authors confirm this view. Nonaka et al. (2000) states that both types of knowledge – explicit and tacit – are essential to knowledge creation (Nonaka et al. 2000). According to Schamp (2003), tacit knowledge and personal experience are necessary in order to make use of codified knowledge in creative and innovative processes (Schamp 2003). Lambregts (2008a) notes that tacit insights are needed to interpret explicit knowledge meaningfully; and that it is often through the interaction between explicit and tacit knowledge that new knowledge is created (Lambregts 2008a). According to Howells (2002), the bi-polar distinction between explicit and tacit knowledge has led to many misleading analyses where it is suggested that knowledge transfer can be separated out into a "local-tacit and global-codified matrix" (Howells 2002:873).

The interplay between explicit and tacit knowledge has been carefully modelled by Nonaka et al. (2000). They view organisations as continuously concerned with creating and recreating knowledge. Knowledge creation is understood as a dynamic process, shaped through the interaction between explicit and tacit knowledge. Nonaka et al. (2000:9p) suggest that this interaction leads to four modes of knowledge conversions: socialisation, externalisation, combination and internalisation (see Figure 3):

- *Socialisation* refers to the process of converting new tacit knowledge through shared experiences occurring in traditional apprenticeship relationships and informal social meetings outside of the workplace. It also occurs beyond organisational boundaries, for example, by close interactions with customers and suppliers.
- *Externalisation* concerns the process of articulating tacit knowledge into explicit knowledge, allowing knowledge to be shared. It happens, for example, in the development of new concepts in the production process, or in quality control circles that allow employees to make improvements in the manufacturing process by articulating their tacit knowledge accumulated on the shop floor.
- *Combination* refers to the process of converting explicit knowledge – which is collected from inside or outside the organisation – into a more complex and systemic set of explicit knowledge. It includes such processes as collecting information from throughout the organisation and putting it together in order to create new, synthesised knowledge in a specific context.
- *Internalisation* is the process where explicit knowledge is assimilated into tacit knowledge. It occurs, for example, by the reading of, and reflecting upon, documents and manuals, which triggers off the learning process.

These four modes of knowledge conversions make clear that "the organisation is not merely an information processing machine, but an entity that creates knowledge through action and interaction" (Nonaka et al. 2000:6).

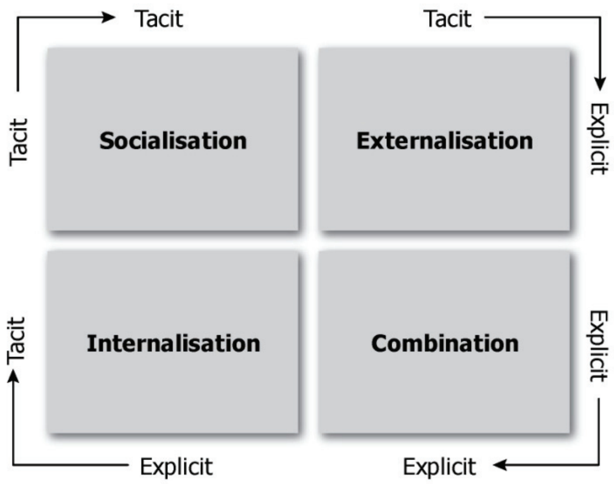


Figure 3: The four modes of knowledge conversion (Nonaka et al. 2000:12)

Synthetic, analytical and symbolic knowledge

The increasing intensity of knowledge in various industries and sectors of the economy makes it clear that knowledge creation has become more and more complex in recent years. According to Asheim et al. (2007b), a wider variety of knowledge sources have to be used by firms whilst more collaboration and division of labour among actors along the value chain are needed to launch innovations and to sustain competitive advantage. Knowledge creation has become increasingly integrated into various forms of business networks at regional, national and international levels (Asheim et al. 2007b). As we have seen above, the process of knowledge creation requires a dynamic interplay between tacit and explicit forms of knowledge as well as a strong interaction of people within organisations and between them. However, as Asheim et al. (2007a) emphasise, "the binary argument of whether knowledge is codified or tacit can be criticised for a restrictively narrow understanding of knowledge, learning and innovation" (Asheim et al. 2007a:8).

One way to overcome this dichotomy is to distinguish between synthetic, analytical and symbolic types of knowledge bases (Laestadius 1998; Asheim and Coenen 2005; Asheim and Gertler 2005; Asheim et al. 2007a; Asheim et al. 2007b; Cooke et al. 2007). With reference to different industrial sectors, Laestadius (1998) was the first to introduce the concepts of analytical and synthetic knowledge bases (Laestadius 1998). In regional science, these concepts have been applied to explain the geographies of innovation for different firms and industries (Asheim and Coenen 2005; Asheim and Gertler 2005). Later, this distinction was expanded with a third category – symbolic knowledge base – which incorporates the growing importance of cultural industries. According to Asheim et al. (2007a), the basic idea behind the knowledge base approach is to characterise the specific nature of knowledge on which activities in the innovation process are based. The distinction between these knowledge bases takes specific account of the rationale of knowledge creation, such as different mixes of tacit and explicit forms of knowledge, different requirements in terms of qualifications and different competitive pressures, which in turn help explain their different sensitivities to geographical distance (Asheim et al. 2007a). Based on the publications indicated above, this typology is further specified in Table 1 and in the following paragraphs.

Table 1: Typology of knowledge bases (Asheim and Gertler 2005, Asheim et al. 2007a)

Analytical (science based)	**Synthetic (engineering based)**	**Symbolic (artistic based)**
Importance of scientific knowledge often based on deductive processes and formal models	Importance of applied, problem-related knowledge often through inductive processes	Importance of reusing or challenging existing conventions through a creative process
Innovation by creation of new knowledge	Innovation by application or novel combination of existing knowledge	Innovation by recombination of existing knowledge in new ways
Collaboration within and between research units	Interactive learning with customers and suppliers	Learning through interaction in the professional community and from street culture
Dominance of codified knowledge due to documentation in patents and publications	Dominance of tacit knowledge due to more concrete knowledge and practical skills	Strong semiotic knowledge content, some forms highly context-specific

Analytical knowledge base refers to activities where scientific knowledge, based on formal models and codification, is highly important, such as in genetics, biotechnology and information technology. This does not mean that tacit knowledge is irrelevant, since there are always both kinds of knowledge involved in the process of knowledge creation. Nevertheless, there are several reasons for the importance of codification. For example, knowledge inputs are often based on reviews of existing studies and on the application of scientific principles and methods. Furthermore, knowledge processes are more formally organised and the outcomes tend to be documented in reports, electronic files or patent descriptions. According to Asheim et al. (2007a), most of these activities require university training and specific qualifications, such as analytical skills, abstraction, theory building and testing. Knowledge creation in the form of generic technological inventions is more important than in the other knowledge types. Partly, these inventions lead to patents and licensing activities (Cooke et al. 2007; Asheim et al. 2007a; Asheim et al. 2007b).

Synthetic knowledge base refers to economic activities where innovation mainly takes place through the application of novel combinations of existing knowledge, for example in plant engineering, advanced industrial machinery production or shipbuilding. Often new knowledge is created by solving specific problems during the interaction process with customers, suppliers or research establishments. University-industry links are based on applied research and development rather than on basic research. Knowledge creation mostly occurs in an inductive process of testing and experimentation or through practical work. Here, tacit knowledge is more important than in the analytical type, particularly because of the fact that knowledge often results from experiences gained at the workplace through learning by doing, using and interacting (Lorenz and Lundvall 2006). Overall, this leads to a rather incremental way of innovation, dominated by the modification of existing products and processes (Cooke et al. 2007; Asheim et al. 2007a; Asheim et al. 2007b).

Symbolic knowledge is related to the aesthetic attributes of products. It involves the creation of designs and images in order to create economic value for cultural artefacts. The dynamic development of cultural industries – such as media, design or fashion – indicates the increasing significance of this type of knowledge. Since a crucial share of knowledge-intensive work is dedicated to the creation of new ideas and images, these industries are becoming more and more design intensive. Therefore, competition increasingly shifts from tangible products to intangible brands (Lash and Urry 1994). This calls for specialised abilities in interpreting cultural symbols and requires an understanding of the habits and norms of the specific social context. Because of this strong cultural embeddedness, this type of knowledge base is characterised by a distinctive tacit dimension. Hence, the process of socialisation – rather than formal university education – is important, not only in terms of know-how, but also in terms of know-who. This provides the necessary knowledge of potential collaborators through informal face-to-face contact within the professional community (Cooke et al. 2007; Asheim et al. 2007a; Asheim et al. 2007b).

Asheim et al. (2007b) emphasise that the distinction between analytical, synthetic and symbolic knowledge refers to ideal-types. In fact, these types have to be understood as being at the opposite ends of a continuum as most industries comprise all three knowledge bases. The degree to which a certain type dominates the innovation process in a firm is related to the characteristics of the corresponding economic sector. In Figure 4, Asheim et al. (2007b) illustrate this fact by different examples of knowledge-intensive industries.

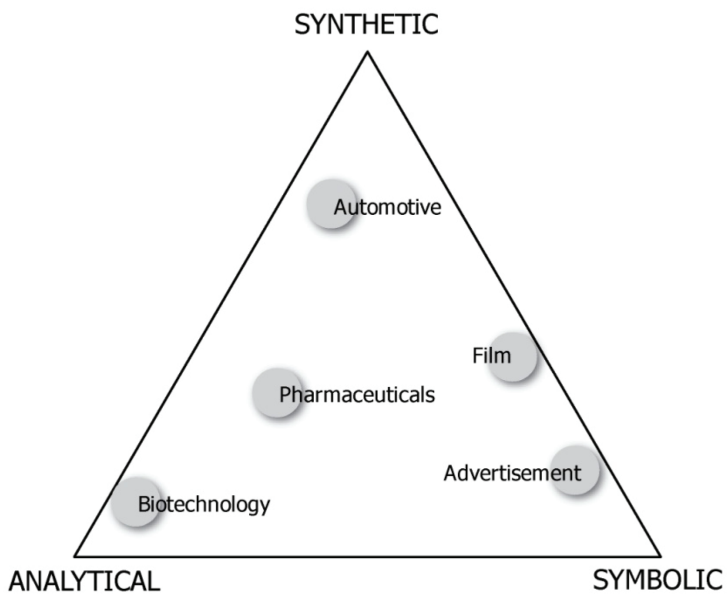


Figure 4: Knowledge bases and industries (Asheim et al. 2007b)

As a result of the growing complexity of knowledge creation and the diversity of knowledge bases, firms increasingly need to acquire new knowledge to supplement their internal knowledge bases by collaborating with external firms. According to Chesborough, the strategy of acquiring and integrating external knowledge bases implies that a shift is taking place from firms' internal knowledge bases to globally distributed knowledge networks (Chesborough 2006). Hence, combining internal and external knowledge bases is an important prerequisite for firms to create innovations and to sustain competitive advantage (see also Section 2.2.4).

Innovation and knowledge

The notion of innovation should not be mixed up with the notion of knowledge or the process of knowledge creation. Nevertheless, innovation is an important concept that highlights the dynamics of market processes and explains the incentives to which knowledge-intensive firms are exposed.

Early theories on innovation are strongly inspired by Joseph Schumpeter who focused initially on the roles of small entrepreneurs who develop particular inventions and turn them into marketable products or services (Simmie 2005). Schumpeter sets *innovation* – the creation of new ways of doing things – at the centre of economic development (Schumpeter 1943). According to Morgan (1997), Schumpeter was a pioneer for his time in recognising that innovation is a crucial source of competitive advantage, especially in capitalist economies (Morgan 1997). Most importantly, Schumpeter distinguished conceptually between invention and innovation. Innovation is much more than a technical invention. Not only does it involve the invention of new things, but also – more importantly – it depends upon the transformation of inventions into marketable products (Dicken 2007). According to Schumpeter, innovation consists of the implementation of new combinations: "recalling that production in the economic sense is nothing but combining productive services, we may express the same thing by saying that innovation combines factors in a new way, or that it consists in carrying out new combinations" (Schumpeter 1939:87p). These new combinations may correspond to the introduction of new products, new production methods, the development of new markets or the implementation of new organisational structures. Or as Schumpeter (1943) puts it: "The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumer goods, the new methods of production or transportation, the new markets, the new forces of industrial organisation that capitalist enterprise creates" (Schumpeter 1943:83). In other words, Schumpeter introduced a comprehensive view of innovation including organisational, managerial, social and technical innovation.

Often, two types of innovations are distinguished: incremental innovations and radical innovations (see Dicken 2007:74p). *Incremental innovations* are small modifications to existing products and processes, based on synthetic knowledge and created through 'learning by doing', 'learning by using' and 'learning by interacting' (Lundvall 1988). Although they are rather small by nature, and often unnoticed, they accumulate over time to create significant technological and societal changes. *Radical innovations*, by contrast, are discontinuous phenomena which may drastically change existing products and processes, for example the development of steam power in the 19^{th} century or the Fordist mass production in the 20^{th} century. However, a single radical innovation does not necessarily have an extensive impact on the worldwide economic development (Dicken 2007). Freeman (1987a), for example, notes that "[the] economic impact [of a radical innovation] remains relatively small and localised unless a whole cluster of radical innovations are linked together in the rise of new industries and services, such as the synthetic materials industry or the semiconductor industry" (Freeman 1987a:129).

Sometimes, clusters of radical and incremental innovations lead to changes in the whole techno-economic paradigm. According to Freeman (1987a), these are truly large-scale revolutionary changes, which are "the 'creative gales of destruction' that are at the heart of Schumpeter's long wave theory. They present those new technology systems which have such pervasive effects on the economy as a whole that they change the 'style' of production and management throughout the system. The introduction of electric or steam power and the electronic computer are examples of such deep-going transformations. A change of this kind carries with it many clusters of radical and incremental innovations. Not only does this… lead to the emergence of a new range of products, services, systems and industries in its own right – it also affects directly or indirectly almost every other branch of the economy" (Freeman 1987a:130).

As it becomes clear by the statement of Freeman (1987a), even today the spirit of Schumpeter is still omnipresent; for example, in areas such as economic and industrial policy, innovation and entrepreneurship studies as well as in the EUROPE 2020 Strategy – the European Union's main development plan (European Commission 2010). The European Commission (1996) for example defines innovation as "the commercially successful exploitation of new technologies, ideas or methods through the introduction of new products or processes, or through the improvement of existing ones. Innovation is a result of an interactive learning process that involves often several actors from inside and outside the companies" (European Commission 1996:54, quoted in Simmie 2005:790). Similarly, in the Oslo Manual, innovation is defined as "the implementation of a new or significantly improved product or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD 2005).

Both of these definitions underline the importance of distinguishing between product and process innovation. *Product innovation* involves "the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specification, components and materials, incorporated software, user friendliness or other functional characteristics" (OECD 2005:48). According to Casson (1983), long-run growth requires either a steady geographical expansion of the market area or a continuous innovation of new products. In the long run, he argues, only product innovation can avoid the constraint imposed by the size of the world market for a given product (Casson 1983). Similarly, Dicken (2007) states that – in an intensely competitive environment – the continuous development of new products and services is essential to a firm's profitability and its ability to sustain competitive advantage (Dicken 2007). *Process innovation*, in contrast, is "the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software" (OECD 2005:49). Dicken (2007) emphasises that product innovation is not enough for a firm's survival and profitability. Rather, it has to produce its products and services as efficiently as possible, for example by optimising the use of ICT in the production process (Dicken 2007).

Who are the key agents of the innovation process? Initially – in the so called Schumpeter I model – Schumpeter admired the individual entrepreneur as the heroic innovator (Schumpeter 1926). It was the entrepreneur who recognises the importance of a particular invention and assembles the resources needed to turn it into a marketable product. With the introduction of an innovation, Schumpeter argued, entrepreneurs benefit from their knowledge advantage. These benefits arise because knowledge is distributed unevenly in the economy, permitting the entrepreneurs to exploit information gaps. As a consequence, for a certain period of time entrepreneurs might be more successful than their competitors. The latter, however, try to participate in this money-making opportunity by imitating the entrepreneurs' innovations. Realising such gains will only be possible as long as the imitators have not eroded the profit margin. Hence, since the introduction of new products or processes alters the economic equilibrium, Schumpeter's entrepreneur can be characterised as a "creative destroyer", which means that an innovation can replace existing economic structures as well as ultimately enabling the emergence of new products and services (Picot et al. 2008).

Later – in the so-called Schumpeter II model – Schumpeter renewed his idea of the individual as a heroic entrepreneur, thereby recognising the significance of Research and Development (R&D) within large firms, where increased R&D activities are able to set up a self-reinforcing circle enabling the continuous development of innovations and leading to an increasing market concentration (Schumpeter 1943). The main incentive for large firms to invest in R&D is the prospect that new products or services create temporary monopoly profits (Romer 1990). Thus, imperfect competition allows these firms to make enough profit to cover the costs of R&D by continually creating new innovations (Simmie 2003).

An evolutionary view of knowledge creation

Schumpeter's ideas were taken up and further developed, for example, by Richard Nelson and Sidney Winter in their work on the *evolutionary theory of economic change* (Nelson and Winter 1982). This new school of evolutionary economic theory – sometimes referred to as 'neo-Schumpeterian' – argues that capitalism is an evolutionary process driven by technical and organisational innovation. In this process "firms face a greater degree of uncertainty and instability than is ever admitted in neoclassical economics" (Morgan 1997:492).

Evolutionary economics differs from the neoclassical equilibrium theory in that the importance of information gaps and incomplete information constitute the starting point for an analysis of market processes (Picot et al. 2008). According to Lambooy and Boschma (2001), neoclassical economics focuses on decision-making within given structures. The principal effort is to show how economic actors deal with changes *within* the structure, such as changes in prices or interest rates. Evolutionary economics, by contrast, deals with the long term processes of *changing* economic structures, particularly with the increasing variety of technology and organisations, as well as with the strategic behaviour of firms in order to adapt to the changing economic environment (Lambooy and Boschma 2001). In this process the evolutionary theory of the firm argues that knowledge accumulates at the firm level through learning-by-doing (Arrow 1962). Nelson and Winter (1982) argue that the accumulation of knowledge in firms is based on the skills of the individual employees and routines in the production process (Nelson and Winter 1982). Organisational routines are considered as the building blocks of "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Amin and Cohendet 2004:6).

In evolutionary economics, the generation of innovation is seen as a cumulative process in which economic actors benefit and learn through communication and interaction processes with other market participants (Graf 2006). Dosi summarises this view of the innovation process in five stylised facts about innovation (Dosi 1988:222p): (1) *Increasing uncertainty*, which involves the lack of information about upcoming events, technological problems whose solutions are unknown, and the inability to predict the consequences of one's actions. (2) *Increasing reliance* upon major breakthroughs in scientific knowledge or technological advancements bringing new opportunities. (3) *Increasing complexity* of R&D activities, which no longer can be carried out by individual innovators, but have to be organised in large interdisciplinary teams comprising both researchers and entrepreneurs. (4) *Increasing experimentation* in the form of learning-by-doing, learning-by-using and learning-by-interacting. (5) *Increasing cumulative innovations* in the form of small-scale modifications to existing products and processes (incremental innovations).

Economic geographers argue that firms constrained by this kind of bounded rationality try to overcome these uncertainties by choosing their locations strategically: “For large firms this usually means establishing a spatial division of labour combined with global scanning for new inventions” (Simmie 2005:796). As a consequence, these firms favour siting their locations in metropolitan regions near decision-making and financing headquarters as well as around international trading nodes with well-developed connections to similar regions and firms worldwide (Simmie 2005).

Another key idea of contemporary evolutionary theory includes the concept of *path dependency*, which assumes that economic change follows historical events of interdependent decisions. Existing technologies are the outcome of past decisions that are made about previous innovations and technologies. Simmie (2005) notes that these decisions create technological trajectories over time, which are said to be path dependent because they are irreversible until they are replaced by another radical innovation (Simmie 2005). This idea has attracted increasing attention from economic geographers as part of their growing interest in the evolution of regional economies (Boschma and Lambooy 1999; Lambooy and Boschma 2001; Boschma and Frenken 2006; Frenken et al. 2007). Martin (2010) points out that, in this literature, path dependency is often interpreted as a stochastic process, in which ‘historical accidents’ have significant long-standing effects in respect to the technological, industrial, and institutional structure of a regional economy. Thus, ‘path dependency’ is said to occur if the incidental accident becomes ‘locked in’ due to the growth of local network externalities. This situation remains stable until an ‘external shock’ disrupts the status quo (Martin 2010).

According to Martin (2010), this understanding of path dependency is problematic. A convincing model of local industrial evolution, he argues, would attempt to provide explanations of ‘why and how’ new local technological paths emerge where they do so. The difficulty with the notion of lock-in is that it overemphasises the steady state of development rather than its evolution: “…the idea of lock-in significantly circumscribes the potential usefulness of path dependency theory as a framework for giving evolutionary intent to the study of the economic landscape” (Martin 2010:22). As an alternative, Martin (2010:21) proposes a path-dependency model based on three phases of path evolution (see Figure 5). In the *preformation phase*, the emergence of a new local industry might not be due to a ‘historical accident’, but rather stimulated by pre-existing resources, competences, skills and experiences that have been inherited from previous patterns of economic development. In the *path creation phase*, these inherited conditions shape the environment in which purposive or intentional experimentation and competition occur among local agents, leading to the local emergence of a new path. Finally, the *path development phase* will stimulate local increasing returns and network externalities that assist the development of the path. After this phase of path evolution, growth may take one or other of two directions. One path leads to a stable, self-reproducing form with the reinforcement of existing technologies, structures and networks leading to a constraining environment for innovation and endogenous change. The second type of trajectory is more open, allowing for endogenous change and evolution enabling incremental evolution and renewal of local industries or technologies.

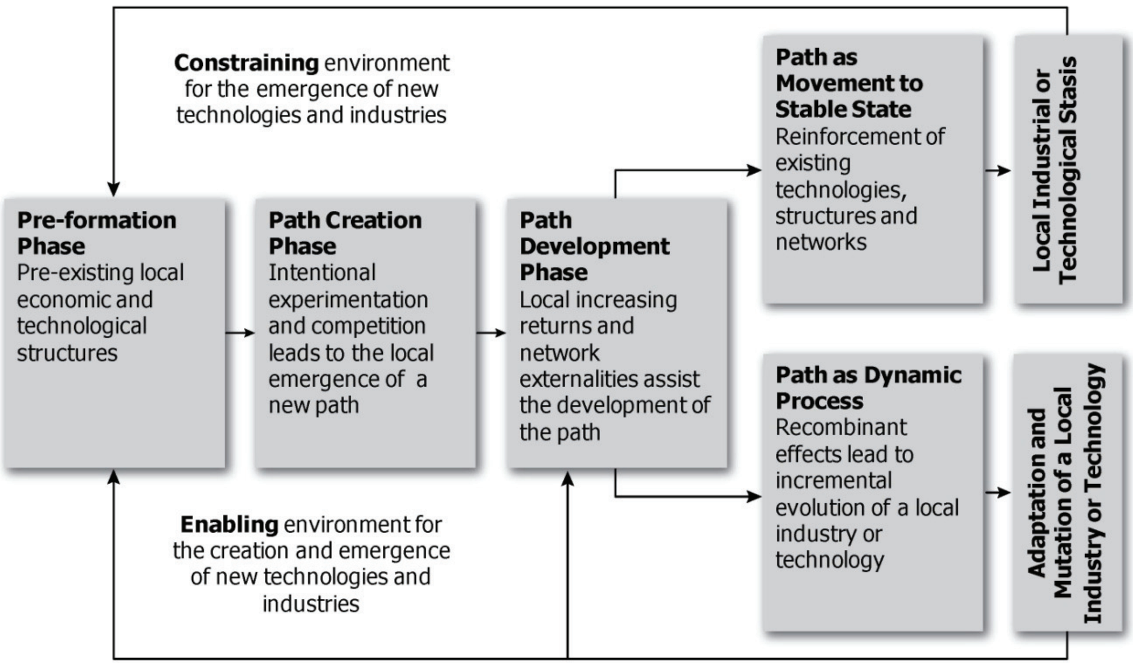


Figure 5: Path dependence model of local industrial evolution (Martin 2010:21)

Martin's (2010) model makes clear that local industrial evolution is about adaptation in response to dynamic markets as well as competitive and regulatory environments. Here, he argues, the role of competition is especially illuminating: "The constant pressure of competition shapes the selection process that determines the success and survival of firms and drives innovation and hence the production of variety" (Martin 2010:22). Indeed, this is one of the most important points in understanding the functional logic of the knowledge economy. Yet it cannot be fully comprehended without understanding how competition influences the strategy of firms and how they respond to changing market conditions (see Section 2.2.1).

2.1.2 The knowledge economy

The statement of Martin (2010) leads us to the notion of the knowledge economy. In recent years a considerable body of work has been developed in order to explain the shift towards a knowledge-based economy (OECD 1996; Dunning 2000b; Amin and Cohendet 2004; Schamp 2003; Cooke 2002; Kujath 2005). The OECD (1999), for example, underlines the fact that the production of goods and services is becoming more and more knowledge-intensive – more science-intensive via the better use of existing stocks of scientific knowledge, more technology-intensive via the diffusion of advanced equipments, as well as more skill-intensive in terms of managing the increasingly complex knowledge base related to productive activities (OECD 1999). Therefore, those sectors using many knowledge inputs such as R&D and skilled labour have grown most rapidly in the last decades (OECD 2000).

Defining the knowledge economy

There is no commonly accepted definition of what the knowledge economy is. According to Cooke et al. (2007), at least four different perspectives can be distinguished (see Cooke et al. 2007:27). The first perspective refers to *knowledge as an input.* This approach recognises that knowledge-inputs into the economy are becoming quantitatively and qualitatively more important than in the past, which is reflected in an increase of knowledge related investments, such as R&D, education as well as information and communication technologies (Cooke et al. 2007). The European Commission (2005) for example measures knowledge input by means of R&D efforts, investment in highly skilled human capital, the capacity and quality of education systems, the purchase of new capital equipment as well as the modernisation of public services (European Commission 2005).

The second perspective to the knowledge economy refers to *knowledge as an output*. In this case, the European Commission (2005) tries to capture the performance of the knowledge economy using indicators such as overall labour productivity, scientific and technological performance, the usage of ICT and the effectiveness of the education system (European Commission 2005). According to van Winden et al. (2007), in both the first and second perspectives, the knowledge economy is seen as the top section of the economy comprising advanced activities in science, technology and innovation. In this perspective, universities and corporate research institutions conducting basic or applied research are among the most important actors in the production process of knowledge that leads to new products, production methods and productivity growth (van Winden et al. 2007).

The third perspective reflects the idea that *knowledge as a product* is becoming more and more important. This process leads to the growth of Advanced Producer Services (APS) and High-Tech industries, which incorporate and apply new knowledge into their products and services. For these firms, competitiveness is becoming more dependent upon the ability to apply new knowledge and technology in their products and production processes. As a consequence, these firms have become more specialised and focused on their core competencies (Cooke et al. 2007).

In the fourth perspective, the *creation of new knowledge* lies at the centre of attention. According to Cooke et al. (2007), not only the use of knowledge is important to define the knowledge economy, but also the knowledge creation process (Cooke et al. 2007). Cooke (2002) argues that “knowledge economies are not defined in terms of their use of scientific and technological knowledge (…). Rather, they are characterised by exploitation of new knowledge in order to create more new knowledge” (Cooke 2002:4p). He illustrates this statement by taking the food industry as an example where he underlines that industries such as food processing are solely *users* of scientific knowledge, replacing experience, rules of thumb and other routines by new scientific findings. The final output, however, is food, and not new knowledge. Hence, the food industry cannot be seen as part of the knowledge economy. Cooke’s (2002) explanation comes quite close to Castells’ (2000:17) insight that “the action of knowledge upon knowledge itself” is the main source of productivity. Castells (2000) argues that in the new, informational mode of development, the main source of productivity lies in the technology of knowledge generation and information processing (Castells 2000). In other words, an important driving force for the creation of new knowledge is technological development in ICT, allowing new forms of knowledge management and exchange. Electronic knowledge management systems, electronic information exchange and the use of the internet are expressions of this new development (Cooke et al. 2007).

Each of the above perspectives has weaknesses if they are applied alone as tools to understand the functional logic of the knowledge economy. Since all these perspectives are strongly related to each other, a combination of them seems to be adequate. Based on Cooke’s (2002) and Castells’ (2000) argument, we suggest a definition of the knowledge economy that additionally accounts for the *strategic* importance of knowledge in the innovation process. Increasing competitive pressure forces firms to optimise their knowledge management by developing location networks as part of their overall business strategy (see Section 3.2.1). It needs to be recognised that the profit imperative is an important logic shared by all knowledge-intensive firms. It is not only the creation of new knowledge that preoccupies their managers, but also the appropriation of surplus value (Sokol et al. 2008). Therefore, we apply the following definition:

> *The knowledge economy is that part of the economy, in which highly specialised knowledge and skills are strategically combined from different parts of the value chain in order to create innovations and to sustain competitive advantage.*

This definition underlines that the knowledge economy is causally determined by four mutually reinforcing attributes (Figure 6). Firstly, the knowledge economy uses highly specialised knowledge and skills based on the combination of scientific knowledge and operating experiences. Therefore, a key component of the knowledge economy is a greater reliance on intellectual capabilities than on physical inputs or natural resources. Secondly, as knowledge and technology have become increasingly complex, the knowledge economy establishes strategic links between firms and other organisations as a way to acquire specialised knowledge from different parts of the value chain. By taking such a network perspective, the knowledge economy is viewed as a dynamic process, characterised by continuous interactions and division of labour within a firm and between different firms of a production network. Thirdly, the outcome of these network activities are innovations in a Schumpeterian sense, that is to create new products, new production methods, new services, new markets or new organisational structures, and – most importantly – to transform them into marketable results. Fourthly, the continuous development of new knowledge and innovations enables the knowledge economy to benefit from temporary monopoly profits and to sustain competitive advantage. This feeds back to the core competencies and knowledge resources of the firm, enhancing the development of new specialised knowledge and skills.

Figure 6: Key attributes of the knowledge economy (Author's illustration)

The knowledge society

The concept of the knowledge economy should not be confused with the notion of the knowledge society. According to the International Encyclopaedia of the Social Sciences, the key characteristics of a knowledge society can be outlined as follows: "(1) the mass and polycentric production, transmission, and application of knowledge is dominant; (2) the price of most commodities is determined by the knowledge needed for their development and sale rather than by the raw material and physical labour that is needed to produce them; (3) a large portion of the population attains higher education; (4) a vast majority of the population have access to information and communication technologies and to the Internet; (5) a large portion of the labour force are *knowledge workers* who need a high degree of education and experience to perform their job well; (6) both individuals and the state invest heavily in education and research and development; and (7) organisations are forced to innovate continually" (Darity 2008:283). This definition makes clear that, in the concept of the knowledge society, knowledge forms a major component of any human activity, including economic, social, cultural and other activities. Drucker (1969), for example, describes the knowledge society as an emerging economic and social phenomenon, in which knowledge is more important for economic growth and social change than labour, capital or natural resources (Drucker 1969). Furthermore, he argues that not only firms, but also schools, universities, hospitals, government agencies etc. have to be competitive on a global scale, even though most of these institutions still focus on a local market (Drucker 2001).

Empirical data of the United Nations (2005) reveal that some countries – especially Scandinavian and West European countries, as well as Japan, the United States, Canada and Australia – have moved toward becoming truly knowledge-driven societies. Many other countries remain in an industrial age, while others are still essentially agrarian (United Nations 2005). The United Nation's analysis (2005) used a synthetic index in order to measure a member state's achievements in respect to its development towards a knowledge society. This index is defined by three dimensions: (1) *assets*, measured by expected schooling, young population, diffusion of newspapers, internet users, phone lines and cellular phones; (2) *advancement*, measured by public health expenditure, research and development expenditure, military expenditure, pupil/teacher ratios and freedom from corruption; (3) and *foresightedness*, measured by child mortality, equality in income distribution, protected areas and CO^2 emissions per capita (United Nations 2005).

This measurement illustrates the broadness of the knowledge society approach. The concept of the knowledge economy, in contrast, focuses particularly on the economic dimension of the society, especially on firms and how they deal with knowledge and information in order to stay competitive in the global economy. Therefore, the knowledge economy can be understood as a specific subset of the knowledge society (see Figure 7). Many dimensions of the knowledge society – such as the educational system, the IT-infrastructure and the political environment – build an important fundament for the activities in the knowledge economy. The common building block of both, however, is knowledge, which is the most important productive factor in order to participate in social and economic life.

Figure 7: Knowledge – knowledge society – knowledge economy (Author's illustration)

The rationale of Advanced Producer Services (APS)

The advanced producer services sector is an important pillar of the knowledge economy and a key shaper of the spatial development in metropolitan regions. In recent years, there has been a significant increase in the attention paid to knowledge-intensive services and their roles and functions in innovation systems (Muller and Doloreux 2007). The importance of knowledge in modern economies and the increasing employment rates justify the growing interest that scholars are taking in studying these newly emerging services. Based on a comprehensive empirical analysis, the OECD (2000), for example, shows that – at least in OECD countries – the most rapidly growing sector is the knowledge-intensive service sector (OECD 2000).

In their seminal work, Friedmann and Wolff (1982) stress that the dynamism of the world city economy results chiefly from the growth of high-level business services, which employ a large number of professionals in sectors such as management, banking and finance, legal services, accounting, technical consulting, telecommunications and computing, international transportation, research and higher education (Friedmann and Wolff 1982). In a similar way, Castells (2000) argues that in the new informational economy, advanced services are the core of all economic processes (Castells 2000). However, the first to clearly articulate the importance of advanced producer services for the understanding of contemporary cities in globalisation was Saskia Sassen (1991) in her seminal work about the 'global city' (see also Section 3.4.1) (Sassen 1991). Sassen argues that advanced producer services firms are the spearheads of today's economy by taking over important intermediary functions for the rising global economic system. These firms are increasingly located in a selected number of key cities – such as New York, London and Tokyo – which are 'global cities' because they are the home to the management and servicing functions that continuously produce the globalisation of economic activities. In the 1980s and 1990s, for example, leading London law firms and New York advertising companies went global in order to extend their professional expertise and to sell high-value knowledge products to their corporate clients operating on a global scale (Sassen 2001b).

Building theoretically on Saskia Sassen's identification of advanced producer services as crucial production process in global cities, Taylor (2004b) investigates how cities are knitted together through business practices of advanced producer services firms. According to Taylor (2004b), business projects that require specialised knowledge combine information from various intra-firm locations worldwide to achieve their goals. Such a use of the geographical spread of professional expertise, he argues, is quite common in advanced producer services firms performing knowledge-intensive services for large business clients. A law firm, for example, may use partners and junior lawyers in several offices worldwide to draw up a particularly complex contract for a major client. According to Taylor (2004b), these business projects create what Castells (1996) calls 'spaces of flows' (Castells 1996), encompassing the movement of ideas, financial data, management instructions, client inputs etc. These flows are supplemented by video conferencing, telephone calls, face-to-face meetings and other internal communication systems and routines in order to support and advance the business project from acquisition to completion. These project-related interactions in multi-branch, multi-location APS firms are important integrators of cities and towns into the world city network (Taylor 2004b).

Generally speaking, two different terms are commonly used to describe knowledge-intensive services. First, there is the notion of Knowledge-Intensive Business Services (KIBS). These are concerned with providing knowledge-intensive inputs into business processes of other organisations (Muller and Doloreux 2007). Depending on the fields of knowledge that underline their service products, they are often divided into technology intensive and non-technology intensive KIBS (Miles et al. 1995; Simmie and Strambach 2006). According to Miles et al. (1995), a principal characteristic of KIBS is that they rely heavily upon professional knowledge. Either they are themselves a primary source of professional knowledge, or they employ knowledge to produce intermediate services for their business clients' production processes (Miles et al. 1995). Along these principals, Den Hertog (2000) defines KIBS as "private companies or organisations which rely heavily on professional knowledge, i.e. knowledge of expertise related to a specific discipline or functional-domain to supply intermediate products and services that are knowledge based" (Hertog 2000:505).

More recently, a second term has emerged to describe knowledge-intensive services: the so called Advanced Producer Services (APS). APS branches can be defined as "a cluster of activities that provide specialised services, embodying professional knowledge and processing specialised information to other service sectors" (Hall and Pain 2006:4). According to Wood (2002), they offer expertise in a wide range of areas: management and administration, production, research, human resources, information and communication, and marketing (Wood 2002). The European research project POLYNET focused on eight core APS branches: accountancy, advertising, banking/finance, design consultancy, insurance, law, logistics services as well as management consultancy/information technology (Hall and Pain 2006). According to Pain and Hall (2008), the essential common characteristic of these branches is that they generate, analyse, exchange and trade information making them key intermediaries in the knowledge economy. Because these services are increasingly created by firms with offices in many cities worldwide, flows of information within transnational APS firms have a crucial role in linking cities and towns to the global economy (Pain and Hall 2008:1068). Banks and financial institutions, for example, enable and manage transnational flows of financial capital (Sassen 2001b). ICT firms facilitate instant exchange of information and data between geographically distant places (Dicken 2007). Third and fourth party logistics fulfil the complex task of just-in-time distribution of goods (Hesse 2006). Advertising firms launch advertising campaigns that are carefully adapted to specific consumer tastes all over the world (Hudson 2008). Law firms not only provide their clients with detailed information on international and local legal frameworks, they also provide tacit knowledge on local political and cultural sensitivities (Beaverstock et al. 1999b).

All in all, compared with the notion of KIBS, Advanced Producer Services (APS) are defined in a much broader conceptual way. Indeed, Knowledge-Intensive Business Services (KIBS) can be understood as a specific subset of Advanced Producer Services (APS). In this contribution, the concept of Advanced Producer Services (APS) as proposed in the POLYNET project is used (Hall and Pain 2006) for two reasons: first, because the picture of knowledge-intensive activities in metropolitan regions should be painted as comprehensively as possible; and secondly, because the results of this analysis should be compared with those of the POLYNET study and other recently finished analyses (Thierstein et al. 2007; Lüthi et al. 2010b).

High-Tech industries

Advanced Producer Services (APS) firms are not the only determining element in the process of structural change towards the knowledge economy. In order to understand the geographies of globalisation processes, one has to account simultaneously for both the APS and the High-Tech-sectors because both of them are integral parts of spatial development. For the European urban system, for example, Krätke (2007) shows that in both the APS and the High-Tech sectors an ongoing process of selective spatial concentration in urban agglomerations and metropolitan regions leads to the development of strong cluster potentials. The majority of these regions are marked by a development path wherein the dynamics of High-Tech manufacturing activities still play a considerable role (Krätke 2007). Castells (2000) argues that what is true for top managerial functions and financial markets is also applicable to High-Tech manufacturing. As in the case of advanced services, he argues, the spatial division of labour that characterises High-Tech manufacturing translates into worldwide connections with a series of intra-firm and extra-firm linkages between different operations in different locations along the production process (Castells 2000).

Although the High-Tech sector has been analysed numerous times, its definition is highly variable. One of the most convincing definitions is provided by Rogers and Larson as far back as 1984: “A high-tech industry is characterised by: (1) highly skilled employees, any of whom are scientists and engineers; (2) a fast rate of growth; (3) a high ratio of Research and Development (R&D) expenditure to sales; and (4) a worldwide market for its products. Not only is the technology very advanced, but it is also continuously changing, at a much faster rate of progress than other industries” (Rogers and Larsen 1984:29).

Many authors emphasise the importance of the systemic interplay between service and manufacturing functions. Wood (2005:430p), for example, warns us to tab into the “sector fallacy” separating service and manufacturing functions rather than recognising them as essentially inter-dependent and complementary to each other. The competitive advantage of firms never depends on a single input, but always on a combination of expertise along the various phases of the value chain. Not just technological, but also managerial, financial, logistical and marketing expertise is important to increase the competitive advantage of knowledge-intensive firms (Wood 2005). Furthermore, Wood (2005) argues that even global organisations are considering their futures more as service, rather than manufacturing corporations: “They see the main corporate challenges and future sources of value-added coming from service relationships and expertise needed to co-ordinate the complexity of international production, from initial design and innovation, through complex assembly to sustained marketing and sales" (Wood 2005:432). According to Sassen (2001b), it is exactly this geographic dispersal of manufacturing activities that creates a demand for expanded central management and planning and the necessary specialised services (Sassen 2001b).

2.2 The functional logic of business organisation

"Firms, not nations, compete in international markets. We must understand how firms create and sustain competitive advantage in order to explain what role the nation plays in the process" (Porter 1990:33). This is the statement with which Michael Porter (1990) starts his line of argument in his pioneering work about *'The Competitive Advantage of Nations'* (Porter 1990). The statement makes clear that firms and their strategic and organisational structures are the key players in economic and spatial development. According to Storper (1997), organisations – most importantly firms or networks of firms tied together into production systems – build an important level for spatial development processes (Storper 1997). Dicken (2007) argues that production networks are primarily coordinated through intra- and extra-organisational relations of enterprises that constitute the economic system of market economies (Dicken 2007). Within this system, firms require maximum flexibility in order to adapt rapidly to changing market conditions. They must constantly consider their benchmarks in order to maintain best practice. Often, they have to outsource routine activities and focus on core competencies in order to gain efficiencies and to remain ahead of competitors (Porter 1996). Increasing competition forces them to optimise the coordination between entrepreneurial tasks as well as the range of services and products that are provided (Picot et al. 2008). In order to explain these functional processes of business organisations, Dunning (2000a) distinguishes two broad paradigms: *Managerial related paradigms*, on the one hand, are process oriented. They focus particularly on the strategic behaviour of managers and how they harness and utilise scarce resources. *Organisational paradigms*, on the other hand, focus on a given set of capabilities and evaluate how institutional mechanisms and transaction costs can be optimised (Dunning 2000a). In the following chapter, the main features of these two paradigms are discussed in greater detail.

2.2.1 Strategic behaviour in the knowledge economy

Most corporations develop their location networks as part of their overall business strategy in order to optimise their added value and to compete successfully on global markets. But what exactly is strategy? Strategy may be further divided into corporate strategy and competitive strategy. The business historian Alfred Chandler (1962) has provided one of the most comprehensive definitions of *corporate strategy*: "[corporate strategy is] the determination of the basic long-term goals and objectives of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals. Decisions to expand the volume of activities, to set up distant plants and offices, to move into new economic functions or to become diversified along many lines of business involve the defining of new basic goals. New courses of action must be devised and resources allocated and reallocated in order to achieve these goals and to maintain and expand the firm's activities in the new areas in response to shifting demands, changing sources of supply, fluctuating economic conditions, new technological developments, and the actions of competitors" (Chandler 1962:13).

Competitive strategy, by contrast, emphasises the specificity of a firm in comparison to its competitors. Porter (1985), for example, defines competitive strategy as "the search for a favourable competitive position in an industry…. Competitive strategy aims to establish a profitable and sustainable position against the forces that determine industry competition" (Porter 1985:1). More recently, Porter (1996) argued that competitive strategy involves the creation of a unique position which shows clear differences from the rivals' activities. This means that firms have not only to decide what they should do, but also what they should *not* do. Furthermore, competitive strategy relates not only to single business activities, but also to the relations between these activities. In other words, competitive strategy is about "creating a fit among a company's activities" along the value chain (Porter 1996:75).

Three theories have particularly shaped the understanding of business strategies: the first is based on the resource-based view of the firm (Penrose 1995; Wernerfelt 1984); the second emerged from Porter's work on strategic management (Porter 1985, 1990); and the third arose from Prahalad and Hamel's notion of core competencies (Prahalad and Hamel 1990). In all these approaches, the performance of business corporations is based on the governance philosophy of "management by design", which describes the fact that the managers are the ones who decide on how knowledge should be coordinated in the organisation (Amin and Cohendet 2004:5). In the following sections, these approaches and their impacts on space are briefly summarised and put into the context of the knowledge economy.

The resource-based view on the firm

The fundamental argument of the resource-based view on the firm is that its competitive advantage lies primarily in the availability of physical and human resources. The inventors of the resource-based view on the firm – Wernerfelt (1984) and Penrose (1995) – found that resources not only provide capacities, but also force them to make specific choices. For example, they have to maintain a highly skilled workforce enabling them to realise process innovations; but these highly skilled workers also involve costs, because companies have to make an effort to retain these people in-house (Christopherson and Clark 2007). According to Wernerfelt (1984), a resource can be defined as both a strength and a weakness, such as brand names, in-house knowledge, technological knowledge, skilled personnel, efficient procedures etc. (Wernerfelt 1984:172). Penrose (1995) distinguishes physical and human resources. The former is made of perceptible things including equipment, land, natural resources etc. Some of them are completely exploited in the production process, others are sustainable, producing a financial return for a long period of time. Apart from physical resources, human resources – such as highly skilled labour, clerical, administrative, financial, legal, technical and managerial staff – are available. These human resources are particularly important in the context of the knowledge economy. They represent a substantial long-term investment for the company. If they leave the firm when they are the most productive and have reached the peak of their abilities, the company suffers a considerable loss of knowledge resources (Penrose 1995). Referring to these early theories, however, Gulati (2007) criticises that the focus of the scholars developing the resource-based perspective has remained largely on material resources that lie within a firm's boundaries. He argues that too little attention has been given to the *networks* in which firms are situated. Only recently, researchers have begun to explore the possibility that a firm's network may be critical in channelling resources to firms and shaping their business behaviour (Gulati 2007).

Generic strategies

Some of the most influential ideas on a firm's competitive strategy have been developed by Michael Porter (1985). He identifies three basic types of competitive strategies that a firm might choose to pursue (Porter 1985, 1990) (Figure 8).

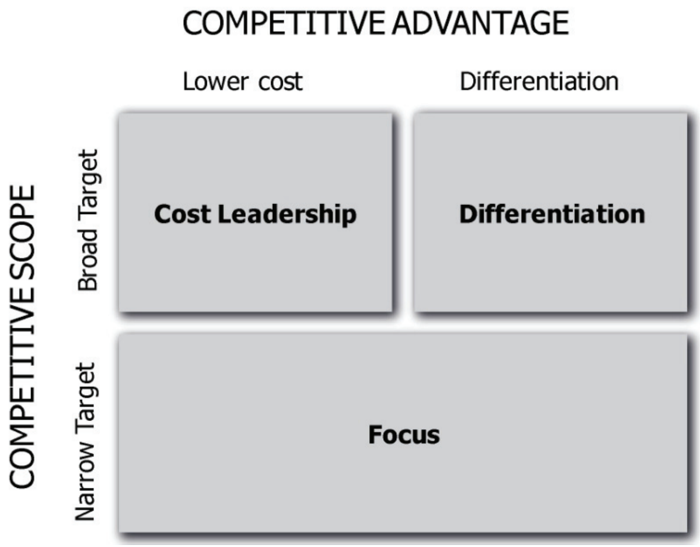


Figure 8: Generic strategies (Porter 1990:39)

One way is to be the lowest-cost producer of certain goods or services (*cost leadership*). In this case, firms try to take advantage of economies of scale by producing high volumes of standardised products. A second basic competitive strategy is to make some activities differ from that of competitors (*differentiation*). Firms may then charge a premium for its product which customers are prepared to pay because of the special qualities being offered. The third type of competitive strategy is the *focus strategy*, in which a specific segment of the market is targeted. This might be a particular type of customer, a particular geographic market area, or a particular element of the value chain. A focus strategy may be based on either of the two generic types of competitive strategy – cost or differentiation. With a cost focus, firms aim to be the lowest cost producer in a niche. With a differentiation focus, they create competitive advantage through differentiation within the niche (Porter 1990).

Based on this typology, Porter (1990) claims that the worst strategic error for firms would be to *be stuck in the middle*, which is to pursue all strategies at the same time. Pursuing all the strategies simultaneously means that a firm is not able to achieve any of them because of their inherent contradictions (Porter 1990). This popular view has been much criticised. Miller (1992), for example, questions the notion of being *stuck in the middle* arguing that there are many empirical examples of firms with hybrid competitive strategies that achieved considerable economic success. Furthermore, he argues that there is also a dynamic element in the strategic behaviour of firms, as many of them have entered the market as niche players and then gradually expanded to pursue a strategy of cost leadership (Miller 1992).

Core competencies
Taking strategic management as the main unit of analysis, Dunning (2000a) argues that contemporary organisational scholars – such as Prahalad et al. (1990), Bartlett and Ghoshal (2002) or Porter (2000b) – are paying increasing attention to the concept of core competences (Prahalad and Hamel 1990; Bartlett and Ghoshal 2002; Porter 2000b; Dunning 2000a). Porter (2000b) notes that advanced forms of strategy involve competing based on unique competitive positioning versus rivals. At the heart of this positioning are key strengths or core competencies (Porter 2000b). According to Prahalad and Hamel (1990), core competencies are difficult for competitors to imitate. Therefore, they provide potential access to a wide variety of markets. Core competences do not diminish with use; unlike physical assets, which are exhausted over time, they are enhanced as they are applied and shared. Therefore, Prahalad and Hamel (1990) suggest bringing together competence carriers from across the corporation on a regular basis to exchange ideas and experiences with the aim of building a strong feeling of community among themselves. In travelling regularly, talking and meeting frequently with peers, the carriers of specific competences tend to be encouraged to discover new opportunities and market niches (Prahalad and Hamel 1990). According to the core competency theory, knowledge-intensive firms should limit themselves to their strategic core. Jarillo (1988), for example, emphasises that goods and services which lie beyond these competencies may often be acquired far more cheaply from third parties – either directly from the market or through the creation of cooperative and strategic alliances with extra-firm partners (Jarillo 1988).

2.2.2 Organisational structure in the knowledge economy
As we have seen above, corporate and competitive strategies enable firms to meet their goals and to sustain a competitive advantage. The adoption of particular strategies has implications for the firm's organisational structure. This is the line of argument that Alfred Chandler (1962) introduced in his classic studies of the evolution of the American Corporate economy:

> *"As the adoption of a new strategy may add new types of personnel and facilities, and alter the business horizons of the men responsible for the enterprise, it can have a profound effect on the form of its organization. Structure can be defined as the design of organization through which the enterprise is administered. This design, whether formally or informally defined, has two aspects. It includes, first, the lines of authority and communication between the different administrative offices and officers and, second, the information and data that flow through these lines of communication and authority. Such lines and such data are essential to assure the effective coordination, appraisal, and planning so necessary in carrying out the basic goals and policies and in knitting together the total resources of the enterprise. These resources include financial capital; physical equipment such as plants, machinery, offices, warehouses and other marketing and purchasing facilities, sources of raw materials, research and engineering laboratories; and, most important of all, the technical, marketing and administrative skills of its personnel. The theories deduced from these several propositions is, then, that structure follows strategy and that the most complex type of structure is the result of the concatenation of several basic strategies" (Chandler 1962:13p).*

As the statement of Chandler (1962) shows, a basic task in organising production processes is to establish an efficient division of labour and an optimal integration of knowledge resources within the company. According to Bathelt and Glückler (2003), this involves the coordination of labour, raw materials, equipment etc. that are applied within and between different firms and locations. To solve this task, decisions have to be made in terms of which intermediate products will be produced in-house and which will be acquired from subcontractors and suppliers. Furthermore, firms have to decide which suppliers will be contacted and where they should be located (Bathelt and Glückler 2003). In order to reveal these aspects of the organisational structure of the knowledge economy, institutional theories, such as the transaction cost approach of Coase (1937) and Williamson (1975) in economics, as well as the embeddedness approach of Polanyi (1944) and Granovetter (1985) in social sciences, can be applied (Coase 1937; Williamson 1975; Polanyi 1944; Granovetter 1985). In the following, we shall deal with these theories in greater detail.

Transaction costs

According to Picot et al. (2008), the transaction cost theory was originally developed in order to explain the emergence of big corporations as centralised and hierarchically organised forms of production. Generally speaking, it analyses the rationale behind the organisation of production, especially whether a firm should organise specific activities in-house or buy from another firm. The transaction cost approach proved also to be a suitable instrument for analysing and evaluating the effectiveness and efficiency of the organisational structures of large corporations (Picot et al. 2008). More than half a century ago, Ronald Coase (1937) suggested that a firm would carry out a particular transaction up to the point at which the costs of organising an additional transaction within the firm are equal to the costs involved in carrying out the transaction in the market. Beyond this point, it makes more sense to organise the particular transaction outside the firm. Hence, the boundary of the firm is the point at which the internal transactions of the firm are replaced by the external transactions of the market (Coase 1937). Based on these considerations, Olivier Williamson (1975) introduced a new *institutional economics* perspective on economic transactions by developing a theory for determining the most efficient governance structure for firms (Williamson 1975). Since then, the transaction cost theory has been applied to a wide variety of organisational forms and institutions. Although its most extensive application was in the analysis of the boundary of the firm, the theory of transaction costs has also been used to explain the evolution of political institutions, legal rules and the implications of these for the economic performance of nations (North 1991, for example).

The transaction cost theory's fundamental unit of analysis is, of course, transaction costs. According to Picot et al. (2008), they can be understood – especially in the context of the knowledge economy – as information and communication costs to coordinate knowledge-intensive tasks that arise because of division of labour along the value chain (Picot et al. 2008). Dahlman (1979) distinguishes different kinds of transaction costs, such as *search and information costs* arising from imperfect information about the existence and location of trading opportunities, or about the quality of products available on the market, *bargaining and decision costs* representing resources spent in negotiating with economic agents to participate in trading at certain prices and conditions, and *policing and enforcement costs* representing resources spent in making sure that the other party sticks to the terms of the contract (Dahlman 1979:148). According to Williamson (1975), three main factors are particularly important in determining the amount of transaction costs (Williamson 1975).

- *Asset specificity:* Asset specificity refers to the application of assets, such as specific locations, specific machines, facilities and technologies, as well as specific employee skills. Williamson argues that such assets should be hierarchically integrated by means of long-term contractual relationships because they can be interpreted as strategically important core competencies that should be enhanced rather than organised externally to the firm (Williamson 1975).

- *Uncertainty:* Uncertainty refers to the limited competence, trustworthiness and reliability of economic agents. In an uncertain world, the fulfilment of a contract is complicated by frequent changes, implying numerous modifications of contracts and therefore leading to higher transaction costs. Williamson sees this as an important concern due to the existence of bounded rationality and opportunism. Expecting that individuals do not possess absolute rationality, Williamson assumes that economic agents will act opportunistically or will be "self-interest seeking with guile" (Williamson 1975:26).

- *Transaction frequency and atmosphere:* Transaction frequency simply refers to the number of transactions in a given time slot. In fact, Williamson's argument is one of amortisation of costs: the more frequent the transaction, the more viable is vertical integration. Transaction atmosphere, on the other hand, encompasses all of the organisation's social, legal and technological conditions including the partners' values, as well as the technical infrastructure that facilitates the interaction between the business partners (Williamson 1975).

These factors – together with their numerous combinations – are likely to have various impacts on transaction costs. Clearly, it is possible to unfurl a range of organisational forms between the pure market-based organisation and the pure hierarchical organisation. Hence, the seemingly easy task to choose between 'make' or 'buy' becomes an extremely difficult decision within a wide range of possible alternatives (Picot et al. 2008).

In Figure 9, Williamson (1991) illustrates how transaction costs of three different governance structures – hierarchy, hybrid and market – vary depending on the specificity of the goods and services that are produced.

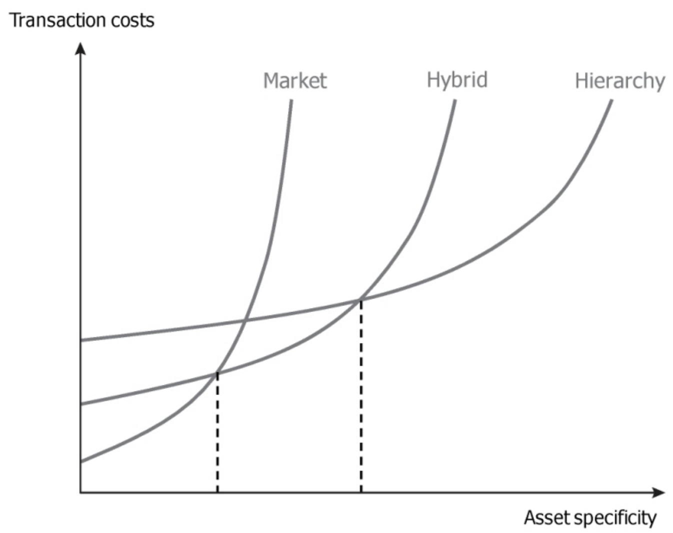


Figure 9: Transaction costs as a function of asset specificity (Williamson 1991:284)

Regardless of the degree of specificity, *hierarchies* – which mean intra-firm transactions – have the highest fixed transaction costs. The advantage of a hierarchical organisation is that a lot of incentives and control mechanisms are available that facilitate highly specific transactions leading to a relatively even increase of transaction costs with increasing specificity. Hence, the development of vertically integrated firms operating all over the world reflects that organisational proximity may overcome geographical and cultural distance (see also Section 3.1.3). *Market transactions*, in contrast, have the lowest fixed costs because they do not need long-term contractual relationships. The variable transaction costs of increasing specificity, however, are very high because the risk of opportunistic exploitation requires long negotiations regarding the contractual content. *Hybrid organisational forms* face a lesser threat of opportunistic exploitation since long-term relationships increase the potential for sanctioning opportunistic behaviour (Williamson 1991:284). Based on these considerations, transaction cost theory argues that those economic transactions that are highly specific, uncertain and frequent are more likely to take place within hierarchically organised firms. Those that are unspecific, certain and infrequent will more likely take place between firms, i.e. through market transactions (Williamson 1975).

Embeddedness

Transaction cost theory has been much criticised because of its assumption that all actors have universal behavioural principles, such as short-run maximising and opportunism (Storper 1992). Harrison (1992) criticises that economists since Adam Smith have argued that the behaviour of market participants is characterised by self-interest and perfect rationality. In this view, pure and perfect market competition is virtually untouched by sociological, cultural and political considerations. Many non-economists, however, find fault with this characterisation of economic behaviour (Harrison 1992). In this context, one well-known critique is Karl Polanyi's (1944) conception of embeddedness (Polanyi 1944). Due to the fact that Polanyi was dissatisfied with the neo-classical economics approach, which overemphasises market forces and rationality, he intended to stress that the economy is not only caught in economic networks, but also in non-economic institutions (Hess 2004). According to Polanyi, the production process in pre-capitalist economies was more integrated in a wide variety of social institutions than today, for example in the family, the neighbourhood or the community. The rise of capitalism led to a decoupling of the production and distribution process outside the economic sphere. Instead it led to an increase of independent market economies aiming to maximise financial profit without acknowledging that the actors of the economic system are simultaneously embedded in societal institutions (Jessop 2001).

Based on Polanyi's (1944) considerations, Mark Granovetter (1985) provided another well-known critique of neoclassical economics (Granovetter 1985). By focussing particularly on individual and collective agency, he presented a new access to the concept of embeddedness by stressing "the role of concrete personal relationships and structures (or "networks")… in generating trust and discouraging malfeasance" (Granovetter 1985:490). In his paper, Granovetter (1985) argues that while classical and neo-classical economists have an undersocialised – or disembedded – conception of human action, many institutional economists commit the opposite error of oversocialisation by bringing back social structure too excessively (see also Harrison 1992). Both under- and oversocialised views have in common a conception of atomised actors: "in the undersocialised account, atomisation results from narrow utilitarian pursuit of self-interest; in the oversocialised one, from the fact that behavioural patterns have been internalised and ongoing social relations thus have only peripheral effects on behaviour" (Granovetter 1985:485).

With respect to Williamson's transaction cost argument, Granovetter (1985) criticises the mixture of under- and oversocialised assumptions. On the one hand, he argues, Williamson would overplay the efficacy of hierarchical power within organisations. Market transactions, on the other hand, are an undersocialised conception neglecting the role of social relations among individuals in bringing order to economic life. Granovetter (1985) is convinced that there is both more order to interactions across the boundaries of independent firms, and more disorder within even hierarchical organisations governed by formal rules and contracts. In order to analyse these sources of order and disorder, he focuses on the embeddedness of economic activities: "The embeddedness approach to the problem of trust and order in economic life… threads its way between the oversocialized approach of generalised morality and the undersocialised one of impersonal, institutional arrangements by following and analysing concrete patterns of social relations" (Granovetter 1985:493). This means that firms must always be viewed within their socioeconomic contexts. They are closely interconnected with suppliers, customers, service providers and state authorities and therefore cannot be analysed as independent economic entities (Grabher 1993; Bathelt and Glückler 2003).

All in all, Hess (2004) appreciates Granovetter's approach because of its clear emphasis on relations and social structures being embedded in the wider socioeconomic context. Granovetter's paper was the starting point for a lively academic debate on this issue in economic sociology, economic geography as well as in organisation and business studies. However, the vast amount of papers in this field have also multiplied the number of meanings of embeddedness (Hess 2004). According to critics, embeddedness "is an increasingly popular but confusingly polyvalent concept" (Jessop 2001:223). In order to dispose of this confusing variety of meanings, Hess distils three major dimensions of embeddedness (Hess 2004:176f): (1) *Societal embeddedness:* the cultural, political, institutional and regulatory framework the actor is located in; (2) *Network embeddedness:* the structure of relationships among a set of individuals or organisations; and (3) *Territorial embeddedness:* the extent to which an actor is anchored in a particular territory or place (see Figure 10). In combination, Hess (2004) argues, these three dimensions are closely linked to each other and form the "space-time context of socio-economic activity" (Hess 2004:178).

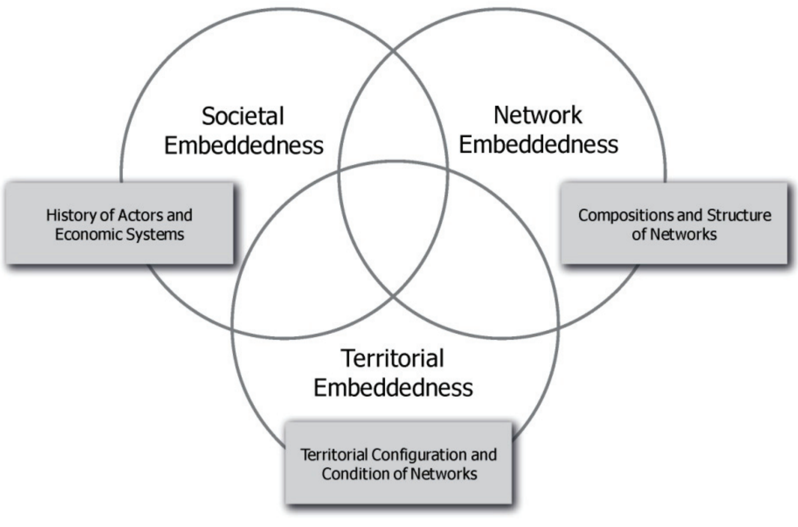


Figure 10: Categories of embeddedness (Hess 2004:178)

2.2.3 Intra-firm networks – the functional logic of TNCs

After having discussed the rationale behind a firm's intra-firm and extra-firm organisational structure, the next section focuses especially on intra-firm networks of transnational corporations (TNCs). According to Dicken (2007), more than any other institutions, TNCs have come to be seen as important shapers of the contemporary global economy.

What are transnational corporations (TNCs)?

Before looking at some basic aspects of the functional logic of TNCs, it is important to be clear as to what the term transnational corporation means. According to Yeung (2009), they are powerful firms which coordinate complex production networks spanning different spatial scales, for example: "Hewlett-Packard and Motorola in information and communication technology industries, Sony and Philips in consumer electronics, Toyota and General Motors in the automobile sector, ...Citigroup and HSBC in banking..." (Yeung 2009:330). Similarly, in Oxford Reference Online, Law and Martin (2009) define a transnational corporation as "an enterprise consisting of commercial entities in more than one state that are linked by ownership or otherwise. Transnational corporations operate in such a way that they exercise a uniform, cohesive, and common policy in order to further their economic interest" (Law and Martin 2009). In many national statistics, TNCs are defined in terms of ownership of overseas activities. According to Dicken (1992), however, ownership measures are problematic because they vary heavily from country to country, and they do not capture the increasingly complex ways in which firms are engaged in transnational operations through various kinds of networks (Dicken 1992). Therefore, Dicken (2007) adopts a much broader definition: "A transnational corporation is a firm that has the power to coordinate and control operations in more than one country, even if it does not own them" (Dicken 2007:106).

In this contribution, Dicken's (2007) broader definition is applied in order to capture the increasing diversity of network activities of knowledge-intensive firms. Many of these networks do not involve 100 per cent ownership; rather, they are characterised by various forms of collaboration between legally independent firms. Sometimes, TNCs are also referred to as multinational corporations (MNCs). In this study, the former term is preferred because it is more general. The term MNC suggests operations in a substantial number of countries; TNC, by contrast, simply implies the presence in at least two countries. In the empirical analysis of this study, the location patterns of multi-location, multi-branch enterprises are analysed regardless of whether the firm operates in many or just a few countries (see Section 6.1).

Organisational architectures of intra-firm networks

As the size, the organisational complexity and the geographical spread of TNCs increase, intra-firm networks between their geographically dispersed parts are becoming highly significant. On the one hand, a study by the OECD (2008) shows that the importance of TNCs is linked to their strengths in a range of knowledge-based assets that allow them to take advantage of profitable opportunities in foreign markets. They are able to set up subsidiaries and affiliates abroad, to co-ordinate production and distribution across many countries, and to shift their activities according to changing demand and cost conditions. As a consequence, cross-border trade between TNCs and their affiliates – often referred to as intra-firm trade – accounts for an increasing share of international trade in today's global economy (OECD 2008).

On the other hand, some barriers to the exchange of information and the diffusion of innovation have become less significant due to the fast development in ICTs (OECD 2008). Castells (1989), for example, notes that the functional linkages between the business headquarters and the decentralised business units became only possible because of ICT, which enabled the establishment of worldwide intra-firm information systems (Castells 1989). Similarly, Faulconbridge's empirical study (2007) about London's and New York's advertising and law clusters shows that both advertising and law firms hold close contacts with internal overseas offices, forming a kind of global learning network based on relational proximity and regular conversations with colleagues and peers worldwide (Faulconbridge 2007). In this context, the OECD (2008) study rightly notes that these trends tend to imply important changes in the governance of TNCs, with important implications for the role of subsidiaries in recognising and exploiting innovation potentials (OECD 2008). According to Dicken (2007), TNCs are faced with the dilemma to be globally efficient, geographically flexible and organisationally capable to coordinate their worldwide internal knowledge resources simultaneously (Dicken 2007:122).

In order to analyse these intra-firm patterns, organisational scholars such as Bartlett and Ghoshal (2002) focus on the organisational management as their main unit of analysis (Bartlett and Ghoshal 2002). According to Dunning (2000a), this results in a somewhat different, but very important, analytical perspective towards the rationale for the existence of hierarchical and market relations than that offered by Williamson (Williamson 1975, 1991). Williamson's transaction costs analysis tends to be concerned with the efficiency of *asset exploitation*. His focus is on the optimal mode of coordinating the use of existing resources and capabilities. Organisational scholars, on the other hand, focus on *asset augmentation* and the capabilities of the organisation to develop new market opportunities and innovations (Dunning 2000a).

Bartlett and Ghoshal's (2002) typology provides a useful perspective on the organisation of resources and capabilities in intra-firm networks (see Figure 11). They identify four different organisational models, each with distinctive structural, administrative, and management characteristics: a multinational, an international and a global organisational model, as well as a newly emerging integrated network model (Bartlett and Ghoshal 2002:65pp).

The *multinational organisation model* is designed by decentralised activities. The personal relations between the top management and the managers of the subsidiaries are a vehicle to control and coordinate the business processes within the company. These processes are completed by some simple financial control systems. National businesses are the building blocks of the company's worldwide operations. They are managed as independent entities and act as a kind of profit-centres.

In the *international organisation model*, much more formal coordination and control is exercised over the worldwide subsidiaries. Bartlett and Ghoshal describe this as "coordinated federation". In this model, the overseas operations are seen by the corporate management as extensions, which have to provide capabilities and resources for the home market. Thus, the headquarters use their formal power to control the information flow between the headquarters and the subsidiaries.

The *global organisation model* can be described as a "centralised hub". It originates from the earliest forms of corporate management, as they were adopted by pioneers like Henry Ford and John D. Rockefeller. The latter built tightly controlled manufacturing facilities all over the world to produce standardised products and to ship them internationally. Whereas the assets, resources and responsibilities are centralised within the headquarters, the subsidiaries have to sell the products without having influence on the existing plans and policies of the corporate enterprise. Thus, little freedom is given to overseas subsidiaries to design and make out new productive strategies.

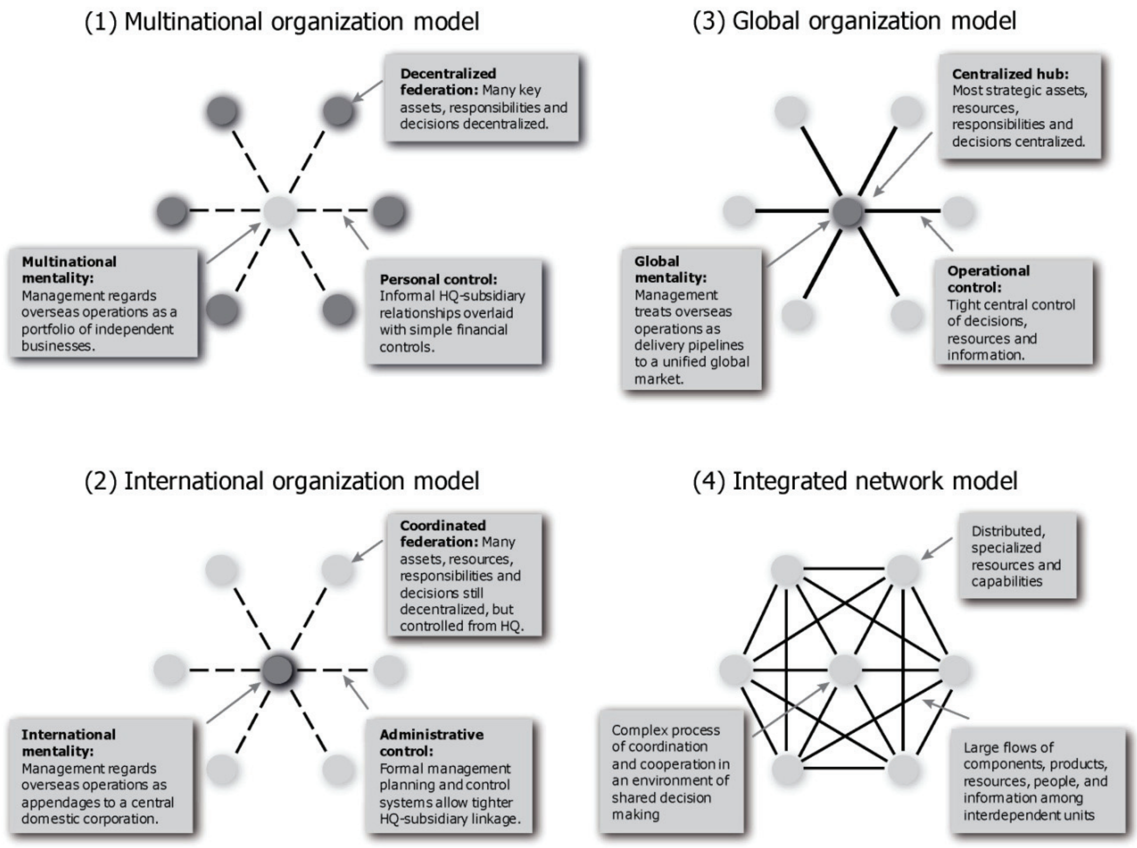


Figure 11: Organisational models (Bartlett and Ghoshal 2002)

In contrast to these organisational models, Bartlett and Ghoshal (2002) argue that we are now witnessing the emergence of an *integrated network model*, characterised by a high capacity to develop flexible coordination processes. Hence, TNCs are moving towards a common organisational architecture wherein specialised units are connected across borders in order to support the companies' endeavour to achieve their strategic objectives of efficiency, responsiveness and innovation. According to Bartlett and Ghoshal, the strength of this new organisational architecture is based on three fundamental characteristics (Bartlett and Ghoshal 2002:102p):

- *Dispersed assets:* The ability to understand the various market needs and technological trends is a crucial incentive for TNCs to source knowledge and innovation globally. By dispersing their activities worldwide, companies are not only able to capitalise factor cost differentials from low-cost labour and materials, they can also source scarce technological and managerial resources on an international scale.
- *Specialised operations:* If TNCs create specialised units free from operational restrictions, they are able to increase efficiency while at the same time maintaining a global market

coverage. For example, the dilemma between scale economies and flexible production can be defeated by using ICT and flexible manufacturing technologies.

- *Interdependent relationships:* Changes in the international competitive environment have developed such that traditional business structures are increasingly inadequate to organise global operations. Today, neither clear-cut dependency nor strong independency between business units is appropriate. On the one hand, extreme independent operators find themselves under challenge from those adopting a coordinated global approach with the ability to balance losses made in one market with substantial gains made in the other. On the other hand, those operators that are totally dependent on the parent company may well be not in a position to capitalise on local market opportunities and to beat off powerful national competitors.

The integrated network model introduced by Bartlett and Ghoshal (2002) is clear in its premise that in today's world of international competition, TNCs have to pursue a strategy of collaborative problem solving, resource sharing and implementation, i.e. they have to build on mutually interdependent relationships (Bartlett and Ghoshal 2002). Such capabilities apply both inside and outside the firm through a complex network of intra- and extra-firm relations. The functional logic of extra-firm networks will be explored further in the following chapter.

2.2.4 Extra-firm networks – functional logic along the value chain

In the previous section, the focus was on how firms organise and configure their internalised networks. But, of course, as Coe et al. (2010) rightly highlight, this is only a small part of the story of how the knowledge economy is organised. Intra-firm hierarchies of leading knowledge-intensive companies are only one set of connections among many (Coe et al. 2010). It is now widely admitted that the most advanced activities of knowledge-intensive firms are deeply inscribed into wide, external networks of suppliers, subcontractors and business clients, many of whom are small- and medium-sized enterprises (Storper 1992). During the 1970s, firms were gaining competitive advantage by using their internal proprietary assets to satisfy existing market needs. It is now apparent that since the new millennium, firms have turned more towards utilising their abilities to obtain knowledge-intensive assets from around the world. These assets are not only integrated into their own competitive portfolio, but also shared with those of other companies engaging in complementary value-added activities (Dunning 2000a). These extra-firm linkages are of increasing significance because firms have to rely not only on in-house knowledge, but also on resources external to the firm (Howells 2000).

In many cases, outsourcing strategies in respect of single activities are more efficient, leading to an increased quality of products and services. Many firms concentrate on their key competencies which are produced in-house, while activities that do not belong to the core business are outsourced to other companies. Even networks and strategic alliances between competitors open the opportunity for formal and informal information exchange within the same field of business (Porter 1990). According to Gomes-Casseres (1996), the overwhelming majority of strategic networks are between competitors reflecting a new form of business relationship: a "new rivalry... in the way collaboration and competition interact" (Gomes-Casseres 1996:2). Under these conditions, there is a high potential for developing new products and services needing both upstream and downstream inputs and costumers. Coe et al. (2010) argue that one important element of today's organisational dynamics is vertical specialisation along the value chain. According to Gereffi et al. (2005), this trend has been much further accelerated since the late 1990s, particularly in the electronics, automobile, finance and logistics sectors (Gereffi et al. 2005).

The value chain concept

According to Dicken and Lloyd (1990), business organisations can be understood as a bundle of different functions that enable the organisation to achieve its specific objectives (Dicken and Lloyd 1990). But what are these functions, and how do they relate to each other? A particularly useful framework for examining this question is Michael Porter's *value chain* concept (Figure 12). Porter (1985) argues that an important part of competitive advantage is based on the many discrete activities a firm performs along its value chain. The advantage of such a value chain perspective is that it disaggregates the firm into its strategically relevant activities and helps it to understand this differentiation concept. Thereby, a firm gains competitive advantage by performing these strategically important activities more cheaply or better than its competitors (Porter 1985).

According to Porter (1990), the firm's value chain consists of two major sets of activities (Porter 1990:41). *Primary activities*, on the one hand, are involved in the ongoing production, marketing, delivery and servicing of the firm's product. Five types of primary activities can be distinguished:

- *Inbound logistics:* activities that receive, store and distribute the inputs needed in the firm's production process. They involve such activities as handling materials, warehousing, controlling inventory and transportation.
- *Operations:* activities that transform these inputs into the firm's goods or services. Such activities vary according to the kind of production being performed. In a manufacturing firm, for example, they would include manufacturing processes, assembly, testing and packaging. In the service sector, they would involve the delivery of specific services.
- *Outbound logistics:* activities that collect, store and distribute the firm's products to its customers.
- *Marketing and sales:* activities that inform potential customers of the product's existence and make their purchase possible by advertising, sales representatives etc.
- *After-sales service:* activities that help to maintain or improve the value of the firm's product that is in use.

Support activities, on the other hand, provide purchased inputs, such as human resources or overall infrastructure, in order to support the primary activities. Porter (1990:41) identifies four types of support activities:

- *Firm infrastructure activities:* management activities in planning, financial control, accounting, legal affairs etc.
- *Human resource management activities:* recruiting, training, motivating and controlling the firm's labour force.
- *Technology development activities:* research and development, process and product design.
- *Procurement activities:* purchasing or acquiring the firm's inputs.

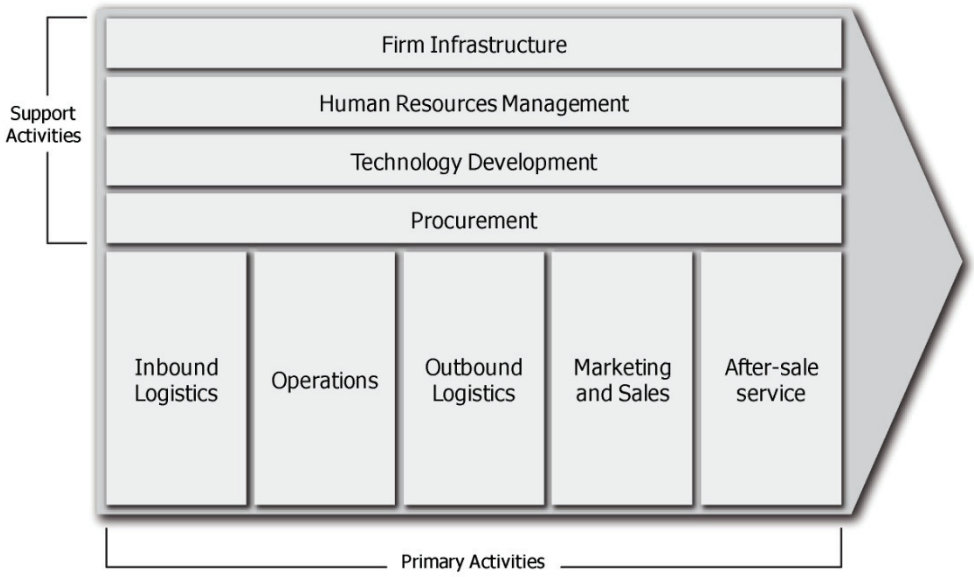


Figure 12: The value chain (Porter 1990:41)

Porter (1985) suggests that firms have to look at each activity in their value chain and assess whether they have a competitive advantage or not. If not, they should outsource this activity to a business partner who is better able to provide this competitive advantage (Porter 1985). According to Christopher (2005), this logic is now widely accepted and has led to a strong increase in outsourcing activities that can be observed in many industries worldwide (Christopher 2005). Furthermore, Porter (1990) notes that these outsourcing tendencies imply that a firm’s value chain is increasingly managed as a system, rather than as a collection of separate parts. Competitive advantage is determined by how well a company is able to manage the entire system, because value chain linkages not only connect activities inside a company, but also create interdependencies between a firm and its suppliers and customers along the value chain (Porter 1990).

Because of these increasing interdependencies, the management of value chain activities – supply chain management – becomes more and more important. According to Christopher (2005), the perhaps most challenging issues in a company’s strategy are in the area of supply chain management and logistics; not least because today’s “competition takes place between supply chains rather than between individual companies” (Christopher 2005:28). Similarly, Giannakis et al. (2004) argue that the performance of an organisation is highly influenced by the firm’s supply chain activities. As the competitive context of the economy continues to change, it has to be recognised that supply chain management can have a considerable impact. Hence, understanding and managing the value chain properly leads to commercial benefits and competitive advantage, because the whole can be greater than the sum of its parts (Giannakis et al. 2004). In this context, the governance of the value chain plays a crucial role.

Value chain governance

Gereffi et al. (2005) provide a theoretical framework to explain governance patterns along the value chain. Common to most efforts to illustrate organisational structures, e.g. transaction cost theory, Gereffi and his collaborators argue that extra-firm relations based on market relations, and intra-firm hierarchies based on vertically-integrated firms form the opposite ends of a continuum, with different forms of network governance being somewhere in-between. However, as Dicken (2007) argues, the division between internal and external transactions seriously oversimplifies the involvement of diverse management activities in today's knowledge economy. In fact, there is a wide variation of methods to co-ordinate business operations, composed of a mixture of intra-firm and extra-firm linkages (Dicken 2007). Based on this organisational spectrum, Gereffi et al. (2005) propose to distinguish five types of value-chain governance (see Figure 13): hierarchies, captive value chains, relational value chains, modular value chains and markets (Gereffi et al. 2005:83pp):

- *Hierarchy:* This governance form corresponds to the intra-firm discussion as previously mentioned. It is characterised by vertical integration and managerial control, flowing from managers to subordinates, or from headquarters to subsidiaries and affiliates. Hierarchical governance is driven by the need to exchange tacit knowledge between value chain activities as well as the need to manage complex webs of inputs and outputs and to control resources, especially intellectual property. Hence, when product specifications cannot be codified and competent suppliers cannot be found, firms are forced to develop and manufacture their products in-house.
- *Captive value chains:* Captive value chains are characterised by a lead firm that dominates and controls – although it does not own – all the major components in the network. They occur when the ability to codify and the complexity of product specifications are high, but supplier capabilities are relatively low. In this case, lead firms aim to lock-in suppliers in order to exclude competitors from reaping the benefits of their effort. Captive suppliers are frequently confined to a narrow range of tasks totally dependent on the lead firm for complementary activities, such as design, logistics or component purchasing. As a consequence, they face significant switching costs, i.e. they are held captive in the value chain of the lead firm.
- *Relational value chains:* Relational linkages have more symmetrical power relations than captive value chains. They are characterised by relational structures between independent firms that are based upon a high degree of trust. Relational value chains are of increasing importance in the knowledge economy. They can be expected when product specifications cannot be codified, transactions are complex and supplier capabilities are high. These highly skilled suppliers provide a strong incentive for lead firms to outsource in order to gain access to complementary competencies. The exchange of complex tacit information is most often accomplished by frequent face-to-face interaction making the cost of switching to new partners relatively high. The mutual dependence that then arises might be regulated through reputation as well as social and spatial proximity.
- *Modular value chains:* The development of modular value chains depends largely on the fact that some value chains have breakpoints, where tacit knowledge can be integrated into products or standards. This is possible when the architecture of a product is modular and technical standards simplify interactions. Because of this codification, complex information can be exchanged with little explicit coordination, and so the cost of switching to new partners remains relatively low. This leads to a situation in which lead firms concentrate primarily on product development, marketing and distribution, while suppliers concentrate on producing the products and selling them to a wide range of customers.

- *Markets:* Market governance can be expected when transactions are easy to codify, product specifications are relatively simple and suppliers have the capability to make the corresponding products with little cooperation with the buyers. Because the complexity of information exchange is relatively low, transactions can be governed with little explicit coordination. Hence, the costs of switching to new partners are low for both buyers and suppliers.

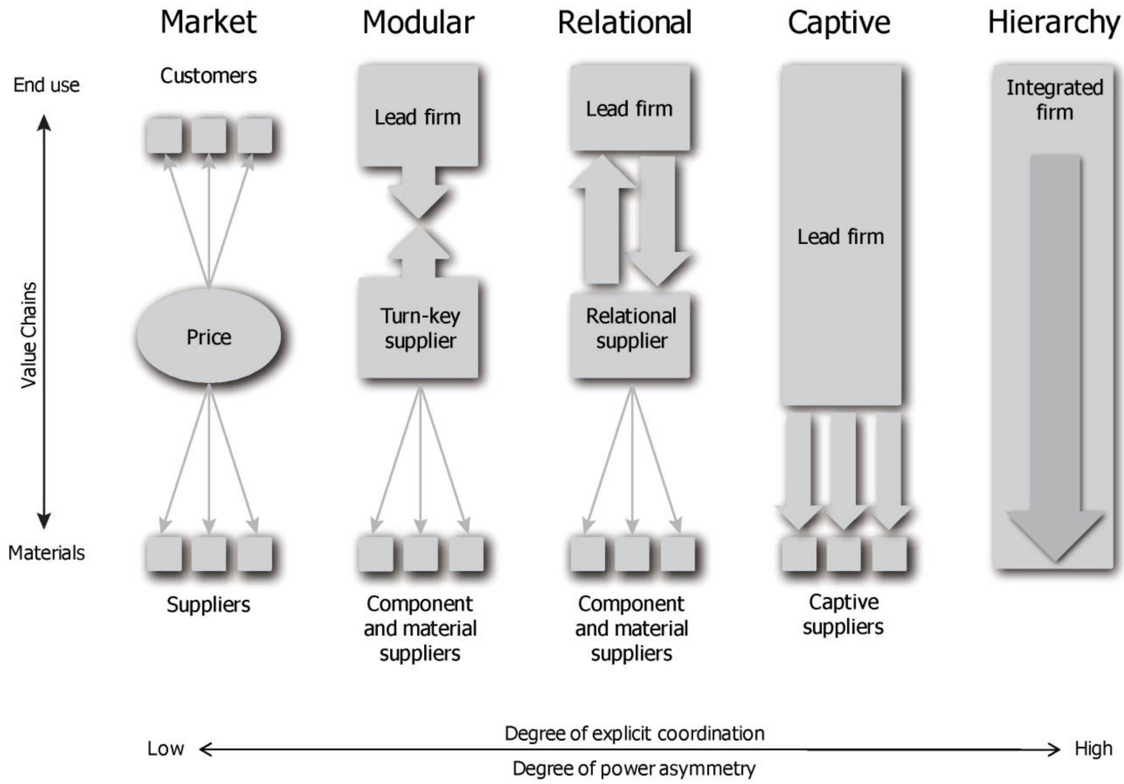


Figure 13: Governance types of value chains (Gereffi et al. 2005:89)

2.3 Conclusion: the functional logic of the knowledge economy

In this chapter, we have revealed some basic functional features of the knowledge economy. In the first part, the functional logic of knowledge creation has been discussed. Empirical evidence suggests that knowledge creation is clearly more than just an accumulation of information. It is an action-oriented combination of information that takes personal experiences and cognitive abilities into account. Knowledge is highly individual since every person creates his or her own cognitive structure. But, knowledge is also a context-specific and collective resource, as specialised activities in the production process require an increase of information exchange. The process of knowledge creation requires a dynamic interplay between tacit and explicit forms of knowledge as well as a strong interaction of people within organisations and between them. Knowledge can be differentiated into analytical, synthetic and symbolic types, which characterise the specific nature of knowledge on which innovation activities are based: analytical knowledge is based on deductive processes and formal models; synthetic knowledge is based on inductive processes and applied problem-solving; and symbolic knowledge is related to the aesthetic attributes of products (Asheim et al. 2007b).

Knowledge should not be mixed up with the concept of innovation. In a Schumpeterian sense, innovation is to create new products, new production methods, new services, new markets or new organisational structures, and – most importantly – to transform them into marketable results (Schumpeter 1943). Innovation emphasises the evolutionary character of knowledge creation. Evolutionary economics argues that knowledge accumulates at the firm level through learning by doing, using and interacting (Lundvall 1988). These learning patterns are embodied in individuals (skills) and in firms (routines), which develop cognitive capabilities over time. (Nelson and Winter 1982).

The functional logic of knowledge creation is highly significant in the context of the emerging knowledge economy. We have defined the knowledge economy as that part of the economy in which highly specialised knowledge and skills are strategically combined from different parts of the value chain in order to create innovations and to sustain competitive advantage. Important pillars of the knowledge economy are Advanced Producer Services (APS) and High-Tech industries. These are the drivers of today's global economy and the key shapers of spatial development in metropolitan regions. The interdependence of APS and High-Tech firms makes them highly intertwined partners in a complex production system.

In the second part of this chapter, the functional logic of business organisation has been identified as a nexus of intra-firm and extra-firm networks. We have seen that most corporations in the knowledge economy develop their location networks as part of their overall business strategy, whereby highly specific human resources and core competencies are flexibly combined in order to create differentiation and competitive advantage (Porter 1990; Prahalad and Hamel 1990). These strategies have implications for the firm's organisational structure. Theoretically, at one extreme, the whole firm's production network might be internalised within the organisational structure of a transnational corporation (TNC). At the other extreme, each function might be performed by separate firms. In this case, the links consist of a series of extra-firm transactions, organised either through the market or in collaboration with other firms. In addressing the relationship between the functional and the spatial logic of the knowledge economy, one has to recognise that its organisational structure is based on a complex and overlapping relational network, built by intra-firm and extra-firm linkages of knowledge-intensive enterprises.

These internal and external linkages are woven across physical space, not only connecting firms and parts of firms together, but also more or less dispersed cities and towns (Dicken 2007). In other words, the spatial logic of the knowledge economy reflects the way in which knowledge-intensive firms are managed and organised. Or, as Dicken (2000) puts it: "…the economies of places reflect the ways in which they are 'inserted' into the organisational spaces of TNCs either directly, as the geographical locus of particular functions, or indirectly through customer-supplier relationships with other (local) firms" (Dicken 2000:282p). In the following chapter, the interrelationships between the functional and the spatial logic of the knowledge economy will be discussed in greater detail.

3. The spatial logic of the knowledge economy

The functional logic of the knowledge economy has a significant impact on the spatial development in metropolitan areas. In Krätke's (2007) opinion, increasing activities of the knowledge economy leads to growing numbers of workplaces particularly in cities and metropolitan regions (Krätke 2007). Similarly, Castells (2000) demonstrates that knowledge-intensive advanced services have substantially increased their share of employment in most countries, and that they display the highest growth in employment and the highest investment rates in leading metropolitan areas of the world (Castells 2000). Additionally, a study of the Halle Institute for Economic Research about regional growth patterns in Germany observes that business services show a strong affinity to agglomerations with high economic growth and stock of human capital (Kubis 2008). Based on the *functional* discussion in the preceding chapter, the following section will now examine the *spatial* logic of the knowledge economy by analysing the spatial patterns of both knowledge creation and business organisation.

3.1 The spatial logic of knowledge creation

From the definition and description of knowledge outlined in Section 2.1, the next question is why geography is important to the understanding of knowledge and knowledge creation. According to Amin et al. (2004), the power of context – spatial and temporal – should be placed at the centre of any theorisation of knowledge formation (Amin and Cohendet 2004). Metcalfe et al. (1996) argue that conditions of knowledge accumulation are highly localised, mostly in a minority of urban regions (Metcalfe and Diliso 1996). In this context, Sassen (2010) uses the notion of "urban knowledge capital", which is created by diverse networks, information loops, and professionals coming from diverse parts of the world, together creating a particular type of knowledge capital (Sassen 2010:152). Malecki (2000) describes this aspect as the "local nature of knowledge", and highlights the necessity for accepting knowledge as a spatial factor of competition: "If knowledge is not found everywhere, then where it is located becomes a particularly significant issue" (Malecki 2000: 110).

3.1.1 Localised knowledge creation in the innovation process

Several authors underline the spatial dimension of knowledge creation. Howells (2000), for example, argues that the basis of localised knowledge creation lies in the specific characteristics of the innovation process that are highly sensitive to geographical distance and proximity. He identifies several ways in which localised knowledge creation influences the innovation process (Howells 2000:58p):

Localised patterns of communication: a key issue where geographical location influences the innovation process is in the field of communication. Undoubtedly, advances in ICT have helped to reduce the impact of distance but, nevertheless, the importance of face-to-face contacts in communication, and the tacit nature of much of this communication, still make geographical proximity a crucial factor in the innovation process (Howells 2000). Similarly, Gertler (2003) considers geographical proximity as an important factor because the exchange of tacit knowledge is highly context-specific and therefore difficult to pass on over long distances. Furthermore, he argues that creating new knowledge is increasingly based on direct face-to-face interaction between local economic stakeholders, such as firms, research units or public agencies (Gertler 2003). Von Hippel

(1994) terms this pattern of close, informal links which are difficult to reproduce over wider geographical spans as ‘local stickiness’ (von Hippel 1994).

Localised innovation search and scanning patterns: according to Howells (2000), geographical proximity also influences the nature of a firm’s search activities for technological inputs or possible collaborators. This is particularly true for smaller firms, which have much smaller spatial scanning fields than large, multi-location companies. Smaller firms can overcome this problem by locating in information-rich and contact-intensive agglomerations, where they can improve their chances of establishing effective business contacts (Howells 2000).

Localised innovation and learning patterns: moreover, innovation often occurs in response to specific local problems. Hence, ‘learning by doing’ (Arrow 1962), ‘learning by using’ (Rosenberg 1982), and ‘learning by interacting’ (Lundvall 1988) – sometimes referred to as the DUI mode of innovation (Jensen et al. 2007) – are increasingly acknowledged as key components in the innovation process. These learning patterns have increased the importance of spatial proximity and local relations in technological and industrial performance (Camagni 1991a).

Localised knowledge sharing: a further local characteristic of the innovation process concerns localised knowledge sharing. Knowledge sharing in firms not only occurs in a cultural or social sense, but also in a geographical sense. Because the acquisition and communication of tacit knowledge is strongly localised geographically, there is a tendency for localised knowledge pools to develop around specific activities. These knowledge pools are centred around complex and loosely structured personal contacts and informal information flows within and between knowledge-intensive firms (Howells 2000).

Localised patterns of innovation and capabilities and performance: lastly, geographical proximity can also reduce the risk and uncertainty of innovation, because it enriches the depth of particular knowledge resources. A high concentration of information flow produces lower risks and uncertainty in the development of innovation. These information flows are often supported by high levels of trust and reciprocity, thereby enabling regional economies to improve their innovative performance (Howells 2000).

All in all, the power and influence of geography still seems to shape information exchange and innovation activities to a considerable extent.

3.1.2 Spatial knowledge spillovers

The claim that geography still counts in terms of knowledge creation processes begs the question of how knowledge creation can be analysed empirically, and how it can be mapped in a geographical context. In this regard, the concept of *knowledge spillovers* becomes important.

Various definitions of knowledge spillovers exist. Griliches (1992), for example, defines them as “working on similar things and hence benefiting much from each other’s research” (Griliches 1992:36p). Similarly, Fischer (2001) argues that knowledge spillovers exist when knowledge that has been generated by one firm is also available to other firms without reimbursement, which means that knowledge becomes a semi-public good (Fischer 2001). Hence, because knowledge is difficult to keep secret, or patents do not ensure complete legal protection from imitators, the creation of new knowledge by one firm yields positive external effects on other firms working in the same field of business (Karlsson and Manduchi 2001).

In the last decade, there has been a growing number of studies which have tried to analyse the spatial patterns and the significance of knowledge spillovers (Gallié 2009; Capello 2009; Audretsch and Keilbach 2008; Breschi and Lissoni 2009). Cooke et al. (2007) emphasise that a number of authors have demonstrated through econometric models that knowledge spillovers are closely related to spatial proximity. For example, that greater geographical distances cause a decay of knowledge spillovers as shown by Anselin et al. (1997) for the US and by Bottazzi et al. (2003) for Europe (Anselin et al. 1997; Bottazzi and Peri 2003). Duranton and Overman (2005) conducted a distance-based test of knowledge spillovers for the UK and found that localisation economies take place mostly at distances of under 50 km (Duranton and Overman 2005). Often, it is argued that this area would cover most of a firm's labour market (Limtanakool et al. 2006) and the entrepreneurs' daily contacts (Sweeney 1987).

There are a number of ways in which knowledge spillover studies can be grouped together. According to Howells, four approaches can be distinguished (Howells 2002:875p):

(1) An early focus of spillover studies examined linkages associated with *patent activities and citation patterns*. Jaffe (1989), for example, analysed corporate patent activities and found that they were strongly influenced by the spending of universities on research, particularly in areas such as drugs, medical technology, electronics, optics and nuclear technology (Jaffe 1989). Similarly, Jaffe et al. (1993) found considerable spatial proximity effects with respect to patent citations, arguing that local knowledge spillovers might result from various mechanisms such as labour mobility or informal contacts (Jaffe et al. 1993). Almeida et al. (1997) used patent citations for a study of the semiconductor industry in the US, showing that there are distinct localisation effects in terms of citation patterns, especially for smaller firms that are tied into regional knowledge networks to a greater extent than larger firms (Almeida and Kogut 1997). A similar approach is used by Matthiessen et al. (2002). They analysed co-authorship and citation patterns – as recorded in the *Science Citation Index (SCI)* – in order to reveal knowledge spillovers between urban regions worldwide. They found that economic and political connections, language and distance play important roles in the pattern of research networks. Even for the major research centres, national links dominate over international links (Matthiessen et al. 2002, 2006). They also revealed a much more nationally centred pattern of co-authorship within Germany than initially expected (Matthiessen et al. 2010).

(2) A second approach to measure spatial knowledge spillovers is to map the *movements of people* carrying their knowledge with them. Zucker and Darby (1996), for example, focused on star scientists, defined as highly productive researchers who made a major scientific breakthrough in biotechnology. This work demonstrates that localised intellectual capital is a key to the development of the biotech industry and that knowledge generates externalities that tend to be geographically bounded within the region where these scientists reside (Zucker and Darby 1996). Equally, in their study about the US semiconductor industry, Almeida et al. (1997) mapped the inter-firm mobility of star patent-holders and concluded that the transfer of ideas is highly related to their mobility between firms (Almeida and Kogut 1997). In a qualitative study, using a series of in-depth interviews with 'superdutch' architectural firms, Kloosterman (2008) explored the spatial dimension of knowledge spillovers in Rotterdam and Amsterdam. He found that knowledge spillovers occur, particularly among the highly mobile labour pool consisting of young workers and trainees, many of them coming from outside the Netherlands (Kloosterman 2008).

(3) A third stream of spillover studies suggested by Howells (2002) is based on the assumption that *knowledge can be embodied in goods*. In this approach, knowledge flows are mapped using trading patterns. There are a series of empirical studies which assume that trade is the prime mechanism by which spillovers are mediated from one firm to another (Feldman 2000). Both Park (1995) as well as Coe and Helpman (1995) found evidence that international R&D spillovers are mediated by trading patterns between firms (Park 1995; Coe and Helpman 1995). Additionally, by comparing international and intra-national trading patterns based on firm-level data, Branstetter (1996, 1998) identified that knowledge spillovers occur primarily on the national scale, indicating that the national innovation system still plays an important role in terms of information exchange and knowledge creation (Branstetter 1996, 1998).

(4) A final group of knowledge spillover studies simply analyses the *locations of knowledge-intensive industries* and assess how concentrated they are in space. This approach is based on the assumption that such industries are concentrated – at least in part – because of the existence of knowledge spillovers. Audretsch and Feldman (1996), for example, found that knowledge-intensive sectors – as measured by industry R&D, academic research and skilled labour – tend to be more spatially concentrated than other industries, so that they can benefit more from knowledge spillovers (Audretsch and Feldman 1996).

All in all, even though many studies provide convincing arguments for the existence of knowledge spillovers, the extensive literature on this issue has also left many questions unanswered. Meusburger (2009:32), for example, argues that the metaphor of knowledge spillovers is misleading as it suggests that explicit knowledge "disseminates like a liquid as soon as it is not kept secret anymore". This assumption may be correct for low-grade knowledge or knowledge embedded in goods, but it is certainly wrong for knowledge requiring a highly specific expertise and longstanding experiences (Meusburger 2009). Similarly, Lambooy (2010) criticises that the knowledge spillover approach is limited, since it does not explain the actual transfer of information. This, he argues, would require looking more closely into the relationship between the spatial context of social networks, social capital and information flows (Lambooy 2010). Howells (2002) implies that the focus of many of the knowledge spillover studies was on intended and explicit forms of spillovers. Although acknowledged as being part of the wider spillover process, unintended knowledge spillovers have been largely neglected in knowledge spillover studies. Furthermore, he notes that key issues of knowledge transfer have largely been neglected by spillover analyses; for example sectoral differences in spillover patterns, the role of knowledge intermediaries and intra-firm information exchange as well as the role of learning in the knowledge creation process. And finally, Howells (2002) claims that virtually all of the knowledge spillover studies fail to acknowledge the role of knowledge demand and consumption as well as the ability of firms to absorb knowledge assets (Howells 2002).

3.1.3 The role of proximity

Critics of the knowledge spillover studies lead us to the question of what role proximity plays in the knowledge creation process of firms. But what is proximity? What is its relation to geographical space? How close is close (Gertler 1995)? Howells (2002) underlines that there is a strong need to isolate analytically the effect of geographical proximity from other forms of proximity to determine whether geographical proximity really matters in the process of knowledge creation (Howells 2002).

In this respect, the French School of Proximity Dynamics – consisting of French speaking economists, sociologists and geographers – made a key contribution (Torre and Rallet 2005; Carrincazeaux et al. 2008). As they focussed on the knowledge economy, the French Proximity researchers emerged in the 1990s in the context of innovation studies in the field of economics. Their main ambition was to explain the effects of proximity, and to treat space as an endogenous variable in economic theory (Torre and Rallet 2005). The proximity group has always been linked to other research programmes in regional science, such as industrial districts, innovative milieus and regional innovation systems (see Section 3.3.2). However, in contrast to these approaches, geography is not the starting point on which the proximity group bases its theories; it focuses mainly on the dynamics of production and innovation processes, regarding geographical proximity as one dimension among others (Carrincazeaux et al. 2008). In the academic debate, the following proximity dimensions are most frequently discussed.

Time proximity: since the rapid progress of communication and transportation systems there has been a highly modified perception and use of geographical space. It has now become necessary to consider proximity not only as a geographical but also as a relational entity. Amin and Cohendet (2004) note that a well-developed and diversified infrastructure of global travel and communication systems are important determinants in supporting time proximity, for example: rapid and frequent trains and flights, logistics networks aimed at keeping both freight and people on the move, plus easy access to a multiplicity of interactive communication and media facilities. Executive travellers exemplify these new relational geographies quite well. Executive business travel has become routine in business transactions. According to Amin and Cohedent, "it covers aspects of 'being there' that are not easily achieved through remote interaction but, at the same time, it does not demand enduring face-to-face interaction and local embedding" (Amin and Cohendet 2004:105).

Organisational proximity: the notion of organisational proximity means the ability of an organisation to make its members interact with each other (Torre and Rallet 2005). According to Carrincazeaux et al. (2008), organisational proximity relates to "complementary resources held by players that could potentially participate in a common productive process, within the same organisation or within a set of interacting organisations" (Carrincazeaux et al. 2008:619). Hence, organisational proximity is an important issue for knowledge creation. It leads to the development of the same sets of beliefs and creates a sense of belonging, which facilitates the interaction and communication between economic actors whilst offering a powerful mechanism for long-distance coordination (Torre and Rallet 2005). Boschma (2005) argues that organisational proximity is needed to control uncertainty and opportunism in the knowledge creation process. However, too much organisational proximity may be detrimental to knowledge creation due to lock-in and a lack of flexibility (Boschma 2005).

Cognitive proximity: according to Boschma (2005), the notion of cognitive proximity means that people who share the same knowledge base may learn from each other more easily than people without similar expertise: "actors need cognitive proximity… to communicate, understand, absorb and process new information successfully. However, too much cognitive proximity may be [also] detrimental to interactive learning" (Boschma 2005:64). In other words, the optimal degree of cognitive proximity depends on two factors. On the one hand, some cognitive distance is needed to stimulate innovation through combining different ideas; otherwise, the combination of ideas generates no additional insights. On the other hand, cognitive proximity is needed to enable effective communication and information transfer; otherwise, communication is not possible at all (Nooteboom 2000; Boschma and Immarino 2009).

Social proximity: the notion of social proximity indicates that economic relations are embedded in a social context. Boschma defines it as “socially embedded relations between agents at the micro-level” (Boschma 2005:66). In this context, embeddedness refers to the basic relationships as practised in communities of peers. These are based on trust, friendship and a common experience of affinity, which is argued to reduce the risk of opportunistic behaviour. Nevertheless, too little social distance in economic relations might also interfere with the knowledge creation process in firms because an overload of trust might lead to an underestimation of potential opportunism (Boschma 2005). An example of social proximity is the old boy networks in the American political and financial system. According to Johnson (2009), the US government is captured by the financial industry through a kind of belief system. Johnson intimates that this is shown by the obvious gaining of political power by the finance industry, as is revealed by the flow of personnel between Wall Street and Washington. He presents the example of Robert Rubin – a former Co-Chairman of Goldman Sachs – who served in Washington as Treasury Secretary under Clinton, and later became Chairman of the executive committee of Citigroup. A second example is Henry Paulson – former CEO of Goldman Sachs – who became Treasury Secretary under George W. Bush. These personal social relationships were multiplied many times over the last three presidential periods, albeit on a lower level. Thus, as Johnson argues, the ties of the old boy network between Wall Street and the White House have been strengthened, which finally led to the financial crisis of 2008 (Johnson 2009).

Institutional proximity: in contrast to social proximity, which focuses on micro-processes, Boschma (2005) associates institutional proximity with the institutional framework at the macro-level, which provides stable conditions for the creation of new knowledge and innovation. Again, Boschma (2005) argues that too much institutional proximity might be problematic for knowledge creation because of the risk of institutional lock-in and lethargy. On the other hand, however, too little institutional proximity might also be difficult due to a lack of social cohesion and common values (Boschma 2005).

Geographical proximity: geographical proximity can be defined as “kilometric distance that separates two units (individuals, organisations, towns) in geographical space” (Torre and Rallet 2005:49). An extensive body of literature – e.g. many knowledge spillover studies – claims that firms that are spatially concentrated benefit from knowledge externalities. The main argument can easily be summarised by the following equation: tacit knowledge = face-to-face transmission = need for geographical proximity = constraint of co-localisation (Torre and Rallet 2005). Undoubtedly, geographical proximity of one person to another encourages the exchange of tacit knowledge. As distance is extended, the opportunity to exchange tacit knowledge is reduced and positive externalities tend to decline. Geographical separation may even hinder the use and spread of codified knowledge because its understanding still requires tacit knowledge to be useful (Boschma 2005). Hence, geographical proximity enables regular personal communication, joint problem-solving, thereby stimulating information spillovers and knowledge creation. Maskell (2001), for instance, states that co-location of similar activities may ensure that successful ideas by other firms do not remain unnoticed, but are absorbed almost without cost (Maskell 2001). Another recent example is the empirical study of Pinto (2009) in which he analysed the innovation profiles of 175 regions in the European Union. His findings provide evidence that geographical proximity still has a relevant impact on innovation processes (Pinto 2009).

However, the role of geographical proximity should not be overestimated. One reason for this lies in the complementary nature of the different proximity dimensions. Boschma (2005), for example, argues that you cannot lay too much importance on geographical proximity as there are also other dimensions to be taken into account with regard to proximity. Geographical proximity may play a complementary role in the creation and the deepening of social, organisational, institutional and cognitive proximity. Hence, "geographical proximity per se is neither a necessary nor a sufficient condition for learning to take place" (Boschma 2005:61). This comes quite close to what Howells (2002) calls a more "indirect and subtle" impact of geographical proximity (Howells 2002:874).

Moreover, geographical proximity can also be reached temporarily by travelling and participating in meetings and workshops. Weterings and Boschma (2009), for example, underline that the need for regular face-to-face contacts for knowledge creation does not automatically mean that firms have to be located close to one another. In many cases, face-to-face contacts can be arranged on a temporary basis (Weterings and Boschma 2009). Similarly, Torre and Rallet (2005) argue that the search for permanent geographical proximity is no longer the main locational business strategy. The possibility of temporary proximity tends to qualify one of the most widespread theses in regional studies saying that firms have a strong tendency to locate near one another, because they need frequent face-to-face interactions (Torre and Rallet 2005).

And lastly, it has to be acknowledged that knowledge creation does not occur at one particular spatial level, but instead operates across different spatial scales at the same time. Empirical studies show that local as well as non-local relationships are important sources for knowledge creation (Simmie 2004; Holl and Rama 2009). Simmie (2003) for example shows that knowledge-intensive firms combine a strong local knowledge capital base with high levels of connectivity to similar regions in the international economy. In this way they are able to combine both explicit and tacit knowledge originating from multiple regional, national and international sources (Simmie 2003). Similarly, Bathelt et al. (2004) argue that local relations create more benefits when they are supported by international relations, which are able to provide variety by bringing new inputs and ideas into the region (Bathelt et al. 2004). As a consequence, Boschma (2005) suggests that instead of selecting one geographical scale *a priori*, empirical analysis should take a multi-level perspective in order to shed light on how the various dimensions of proximity operate across different spatial scales (Boschma 2005).

In conclusion, it seems that there is a strong awareness that different dimensions of proximity are critical to the competitive advantage of firms and regions. Much literature has been produced emphasising the numerous advantages of being near to each other in a geographical sense. At the same time, however, it has been remarked that there are also many other dimensions of proximity that have to be considered in order to understand the knowledge creation process (Boschma 2005). For the purpose of this thesis, two broad types of proximity will be distinguished: (1) *geographical proximity* based on the co-location of firms in the same area; and (2) *relational proximity* based on physical infrastructure, accessibility and the organisational ability of firms to facilitate interactions, as well as more subtle conditions such as cognitive, social and institutional environments.

3.2 The spatial logic of business organisation

The functional logic of the knowledge economy has not only significant impacts on processes of localised knowledge creation but also on the spatial configuration of business organisation. New forms of knowledge creation generate new forms of the spatial organisation of knowledge processes (Schamp 2003). In the following section, some basic spatial patterns of business organisation will be revealed in greater detail.

3.2.1 Competitive strategies and space

Various authors stress the importance of location for the competitive advantage of firms. Managing space and time is an essential strategic problem for multi-branch multi-location enterprises (Schoenberger 2000). Beugelsdijk (2007) indicates that if researchers want to analyse how space affects a firm's performance, they have to include strategy and structure at the firm level (Beugelsdijk 2007). According to Porter (1998) there exists a tight relationship between location and competitive strategy at the firm level: "the enduring competitive advantages in a global economy are often heavily local, arising from concentrations of highly specialised skills and knowledge, institutions, rivals, related businesses and sophisticated customers. Geographic, cultural and institutional proximity leads to special access, closer relationships, better information, powerful incentives and other advantages in productivity and innovation that are difficult to tap from a distance" (Porter 1998:90). Hence, choosing the right location is becoming an increasingly important part of a company's strategy. In many cases, location decisions in knowledge-intensive firms include focussing on core competences, using new channels for the distribution of goods and services, acquiring new customer groups, applying new communication and logistics solutions, as well as locating new sources of human capital (Ernst & Young 2005). The outcome of this location decision-making process has a direct impact on the locational structure of the firm and the spatial organisation of its physical and non-physical resources.

According to Dicken (2007), international firms doing business in many different socioeconomic environments have to make many strategic decisions and answer a number of fundamental questions, for example: which business functions should be organised in-house and which have to be outsourced to other companies? Where should the firm's internal subsidiaries and external suppliers be located? How should control being exercised over all the geographically dispersed activities – both intra-firm and extra-firm? All these questions lead to the fact that firms have very different incentives to engage in transnational or even multinational activities. Dicken classifies them into two broad categories (Dicken 2007:110p):

The first category is *market orientation*. Most multi-branch multi-location firms – whether High-Tech or APS – locate in particular geographical markets because they want to serve them with their products or services produced in the home country. Often, however, these products are slightly modified in order to take particular local tastes and requirements into account. Hence, for many firms, the development of intra-firm networks across national boundaries is an important strategy to break into new markets (Dicken 2007). Stam (2007) emphasises two main reasons why firms engage in transnational activities: firstly, because they are increasingly exposed to strong competition within their home region; and secondly, because the economic growth of the home region is too slow (Stam 2007).

The second motivation for firms to engage in transnational operations is *asset orientation*. Normally, the firms' assets to produce and sell their products and services are not evenly allocated across space, most obviously in industries dealing with natural resources, where firms have to be located as close as possible to their raw material because of considerable transportation costs. But also location-specific factors such as access to knowledge and access to a highly skilled labour force is very important, especially in the context of the knowledge economy. The strong tendency for knowledge and technological innovation to concentrate in specific spaces creates a strong incentive for firms to locate their operations in such knowledge-rich locations (Dicken 2007).

3.2.2 Locational adjustment

By including the time dimension in the analysis of spatial strategies of firms, it soon becomes apparent that these strategies change over time. The challenge thereby is to choose a location that optimally fits with the present and the future requirements of the company. Stam (2007) for example shows that especially during the development stage of new enterprises the embeddedness in social networks is an important obstacle to the firms' geographical expansion. In well-established companies, on the other hand, other factors – such as sunk costs – are much more important for a firm's locational behaviour, whereas social networks and local embeddedness lose weight (Stam 2007). Often, such strategic changes are associated with corporate growth. They are reflected in the establishment of new facilities or – in the course of economic crises – the concentration of resources and the closure of branch offices. Picot et al. (2008) argue that "when economic advantage can be realised through a change in location, for example, through closer market proximity, through the exploitation of cost advantages, through an increase in employees' quality of life, and through transport and supply advantages", the business location becomes an important competitive advantage for firms (Picot et al. 2008:9).

Taking the time dimension into account, Chapman and Walker (1987:121) developed a useful model of locational adjustment comprising a hypothetical enterprise producing four products and operating at four separate locations. They distinguish four types of locational adjustment (see Figure 14): Intensification, specialisation, concentration and rationalisation:

- *Intensification* at branch level results either in job losses or in a growing output without an increase in employment. As these changes remain internal to the individual business locations, the position of these locations within the corporate system remains unchanged in both geographical and functional terms.
- *Specialisation*, in contrast, alters the functional role of a location by concentrating different product lines at specific sites; the geography of the corporate system, however, remains unchanged.
- *Concentration* involves the closure of certain locations, but it does not necessarily lead to a reduction in the overall capacity of the corporation since the losses resulting from the shutdown in one location may be more than offset by new investments in one or more of the remaining branches.
- *Rationalisation* leads to fundamental changes in the geography of the enterprise. Existing branches are abandoned and replaced, sometimes at an entirely new site. In this case, rationalisation involves a reduction in both the overall output and the employment of the enterprise.

Chapman and Walker (1987) argue that these various strategies are neither mutually exclusive nor exhaustive. In fact, an enterprise may re-organise its activities by a combination of all four strategies; or it expands or reduces its activities without changing the total number of locations. Hence, Figure 14 must be regarded as a rather general indication of the range of options available to a multi-branch multi-location firm in adjusting its corporate system to cope with the constantly changing economic conditions (Chapman and Walker 1987).

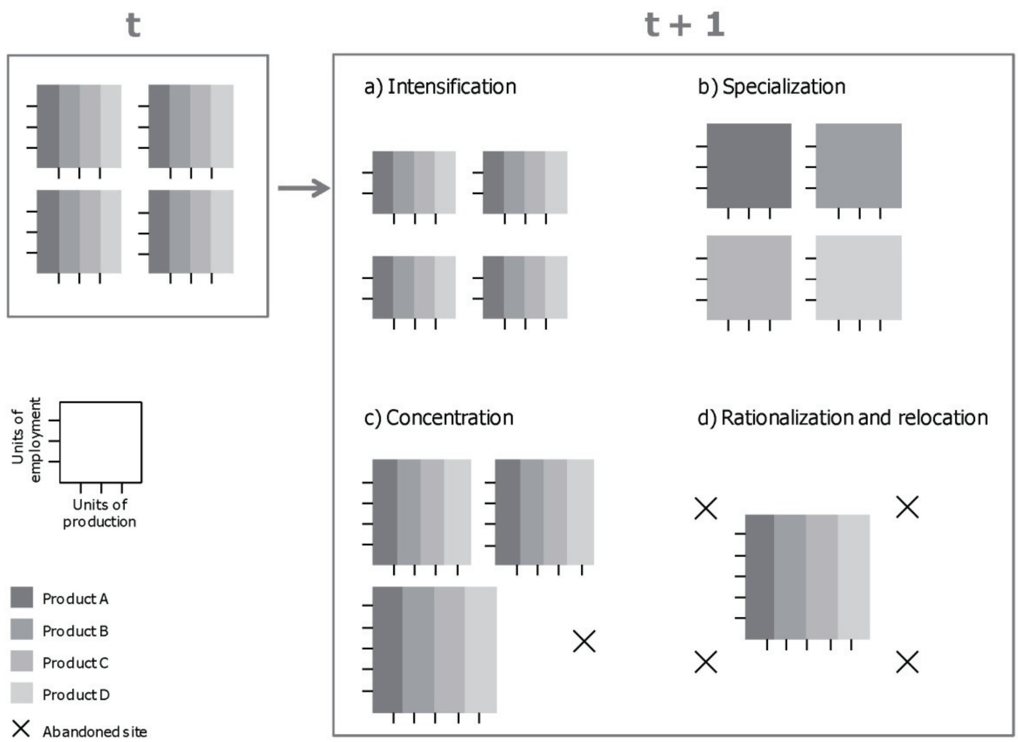


Figure 14: Possible forms of locational adjustment (Chapman and Walker 1987:121)

3.2.3 Business functions in space

It is interesting to know how TNCs organise their activities in space and where they locate their productive assets and subsidiaries. According to Dicken (2000), TNCs use their internal location network as part of their competitive strategy. Because they are defined as multi-branch multi-location firms operating across national boundaries, they are able to influence spatial development by their locational decision-making (Dicken 2000). Similarly, Massey (1985) argues that TNCs prefer to obtain their productive inputs – e.g. manpower, capital, raw materials etc. – from the most appropriate locations. Therefore they allocate their operations to those places where the local knowledge resources and the industrial culture are most suitable (Massey 1985).

According to Dicken (2007), different parts of the value chain have different requirements in terms of locational qualities. They therefore tend to develop rather distinct spatial patterns. Some elements of the value chain are spatially dispersed, whereas others are spatially concentrated and co-located with other parts of the value chain. Castells (1989) argues that the differentiation of the value chain within knowledge-intensive companies leads to a rather distinct spatial pattern of business functions and knowledge requirements: “Higher-level functions tend to be concentrated in certain privileged locations, attracting to these areas the upper tier of the labour force, while assembly functions, employing unskilled labour, are scattered over more and varied locations” (Castells 1989:77). In the following, the spatial patterns of six major business functions will be discussed more deeply (see also Dicken 2007).

Control and coordination: Control and coordination functions tend to be concentrated at corporate and regional headquarters. Corporate headquarters are responsible for all major strategic investment decisions that shape the intra-firm network of the whole enterprise (Yeung et al. 2001). According to Dicken (2007), corporate headquarters are "handlers, processors and transmitters of information to and from other parts of the enterprise" (Dicken 2007:141). Castells (1989) notes that although the dominance of metropolitan centres has decreased in comparison to the suburbs, corporate headquarters continue to be located within the CBDs. Nevertheless, secondary offices of major corporations as well as some headquarters, being unable to pay the prices of land and office space in the highly priced city centres, are increasingly shifting their locations to the suburbs (Castells 1989). Yeung et al. (2001) argue that TNCs are also willing to locate their operations according to the preferences of the corporation's key members. Top executives or key researchers, for example, may choose to reside in world cities with high-quality living conditions to manage the corporate business activities from there (Yeung et al. 2001).

In contrast to corporate headquarters, regional headquarters take over an intermediate level in the structure of TNCs. They are responsible for integrating the firm's activities within a region as well as coordinating and controlling the activities of regional subsidiaries such as manufacturing units or sales offices. By doing this, regional headquarters act as intermediaries between the corporate headquarters and its affiliates within a particular region (Dicken 2007). In other words, they act as a kind of "strategic mid-way house to implement global strategies at a regional level" (Yeung et al. 2001:165). They can be interpreted as "strategic windows" and "windows of influence" for firms operating on a global scale (Kriger and Rich 1987:45). According to Yeung et al. (2001), TNCs increasingly pursue a regional strategy in which they operate and manage their subsidiaries to capture economies of regionalisation. They are thereby able to sustain their competitive advantage and be highly flexible and responsive to local market conditions (Yeung et al. 2001).

Research and development: According to Dicken (2007), research and development (R&D) is characterised by complex series of activities ranging from applied scientific and marketing research to product development and design. Each of these activities has specific locational requirements such as access to universities and research institutions or access to highly qualified scientists, engineers and technicians. Many firms concentrate their research departments in one or a few large locations in order to gain economies of scale; or they locate R&D close to the corporate headquarters or customers in order to facilitate communication and the sharing of ideas as well as to benefit from closeness to customer needs, tastes and preferences. The need for a highly skilled labour force as well as proximity to universities and research institutions often confines R&D facilities to large metropolitan regions. These places mostly offer a strategic location on the global transport and communication network, high-quality financial and business services, a particular range of labour market skills as well as many social and cultural amenities (Dicken 2007).

Processing and production: The locational requirements of processing and production units vary considerably from one industry to another. However, as Dicken (2007) argues, during the past decades, a new organisational form of production has become more prominent: TNCs increasingly spread their production units globally as part of a worldwide *intra-firm sourcing* strategy. Specialised parts of the firm's value chain are located in different parts of the world resulting in a highly complex web of physical and non-physical flows. TNCs are thus developing into "global scanners" making considerable efforts to identify potential locations for subsidiaries all over the globe (Dicken 2007:152). Having the possibility to increase or decrease the capacity of operations within their corporate network, TNCs steadily evaluate and compare the performance of their corporate units with rivals and potential alternative locations. This provides not only a high degree of flexibility in terms of access to localised knowledge resources, but also decreases the risk of an over-reliance on a single location. However, the disadvantage of this dense network of production units is that an interruption in the supply chain can significantly affect the other units of the value chain system, even if they are located in a very different part of the world (Dicken 2007).

Financing: Financial services are important intermediaries in the operations of TNCs. At first sight, financial services appear to be especially foot-loose as they are not based on locations with specific raw materials. However, major financial services continue to be strongly concentrated in space; in fact, they are more concentrated than many other kinds of economic activities. Nevertheless, there are also clear variations regarding the particular business functions involved: higher-order financial functions are heavily concentrated in the major global financial centres of the world, such as New York, London and Tokyo (Sassen 2001b). Front-office functions, in contrast, have to be close to customers, leading to spatially dispersed branch networks of retail banks and other financial services supplying final demand (Dicken 2007).

Marketing: The main goal of marketing is to open up new markets for companies in order to sell their products or services by detecting and influencing the consumers' tastes and needs. Marketing operations are often concentrated at corporate headquarters. Increasingly, however, they are also placed in regional headquarters to better adapt marketing decisions to local conditions and the consumers' requirements. In order to facilitate cooperation with product design and development units, marketing functions are sometimes also located close to R&D facilities (Dicken 2007).

Sales and distribution: Sales and distribution units tend to be rather small and very widely dispersed because they need to be as close as possible to the firms' regional markets. They have to be sensitive to local conditions in order to feed back the relevant information into the corporate structure of the company and to tailor the products of the firm to the specific tastes of the local market (Dicken 2007). Because of the increasing need to coordinate geographically dispersed operations as efficiently as possible, third and fourth party logistics services are becoming more and more important. The emergence of these highly sophisticated logistics companies is the result of a tightening global competition in terms of efficient production processes. Some of them originate from transportation companies in the field of rail, road, shipping or airlines; others arise from wholesalers or are fully new logistics organisations (Coe et al. 2008a).

In the empirical part of this study, similar business functions are used to analyse localised systems of value chains. By means of a web survey that combines relational data on firm locations with the degree and importance of working interrelationships along individual firms' chain of value, some light has been shed on the value-added process of APS and High-Tech companies. In order to relate these relationships to a stylised value chain, the responding firms had to localise their business activities along the individual value chain elements of 'research & development', 'processing', 'financing', 'marketing', 'sales & distribution' and 'customers' (see Section 6.2).

3.2.4 Clusters and competition

For a long time, thinking about competition and business strategy has been dominated by the question – What happens *inside* companies (Porter 2000b). The *spatial* logic of economic activities has not been adequately considered. However, as Coe et al. (2010) underline, various studies in economic geography and regional science provided undisputed evidence that many innovation and production systems have strong implications on spatial development processes in metropolitan regions (Gereffi et al. 2005; Vind and Fold 2010). Today, management literature shows a growing awareness that buyer-supplier relationships and many other activities along the value chain have much to do with the locations at which the companies are based (Porter 2001). In *The Competitive Advantage of Nations* (1990), Michael Porter puts forward a microeconomically-based theory of local competitiveness within the context of a global economy. This theory gives geographical clusters a prominent role (Porter 1990).

According to Porter (2000a), clusters are "geographical concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries and associated institutions (e.g. universities, standards agencies, trade associations) in a particular field that compete but also co-operate. Clusters, or critical masses of unusual competitive success in particular business areas, are striking features of virtually every national, regional, state and even metropolitan economy, especially in more advanced nations" (Porter 2000a:15). This definition highlights that clusters are subject to strong national or regional competition, which – according to Porter – drives product and process innovation. This is an important feature that distinguishes the cluster concept from other territorial innovation models (TIMs), which focus more deeply on the social and cultural characteristics of space economies rather than on competitive environments (see Section 3.3.2).

Originally, Porter (1998) argued that there is a broad range of geographical scales of competitiveness. He noted that "a cluster's boundaries are defined by the linkages and complementarities across industries and institutions that are most important to competition" (Porter 1998). This implies that clusters exist on different spatial scales, ranging from a single city to a nation, a continent or even the whole world economy. Furthermore, Porter (1998) argues that the boundaries of a cluster are in a continuous state of flux because new industries are emerging and declining again and again (Porter 1998). Recently, however, Porter has become more clear that the intensity and the quality of interactions within clusters are particularly facilitated when firms are concentrated on a regional scale (Porter 2003, 2001).

According to Porter, clusters affect competition and the competitive advantage of firms in three main ways (Porter 2000b, 1998). First of all, clusters increase the *firms' productivity*. If firms are part of a cluster, they are able to source inputs more efficiently. They can lower the search and transaction costs in recruiting new personnel thanks to existing pools of specialised and experienced employees. They have access to highly specialised information, which can easily be transferred because personal contacts and friendships within the cluster facilitate the development of trust and encourage the flow of information, which results in the fact that the cluster as a whole is greater than the sum of its parts. Firms that are part of a cluster also have better access to investments made by the government or other public institutions, for example in the form of public spending for specialised infrastructure or for educational programmes. And finally, clusters enhance a company's productivity because local rivalry is highly motivating. Clusters make it easier to measure and compare the performances between firms because they share the same local business environment and conduct similar activities (Porter 2000b, 1998).

In addition to enhancing productivity, clusters are important for the firms' *ability to innovate*. Companies within a cluster are better able to perceive the needs of sophisticated buyers – which are also part of the cluster – than isolated rivals can. Furthermore, geographically concentrated clusters enable more flexibility to integrate new ideas and to capitalise innovations quickly. Competitive pressure within the cluster provides better incentives to develop innovations and increase productivity. Business executives continuously compete against each other in order to gain competitive advantages and to develop a unique position within the cluster (Porter 2000b, 1998).

Finally, Porter notes that clusters stimulate the *formation of new businesses*. Rather than establishing themselves in isolated locations, new companies often arise within already existing clusters. Clusters enable entrepreneurs to perceive market opportunities more easily, because there are more occasions to recognise potential gaps in existing products or services. Furthermore, since clusters often provide a wide range of assets to start new businesses – such as skilled workers or important intermediates – they significantly decrease the market barriers. If a new business has successfully established itself, they offer not only many opportunities for networking, but also a significant market for selling its products and hiring suitable staff. All these factors reduce the risk of entering the market – or of leaving it, if the business should fail (Porter 1998).

In order to understand the link between clusters, competition and company strategy, Porter's (1990) diamond framework provides a useful way of modelling the microeconomic environment of a cluster. This framework argues that a cluster's competitiveness is causally determined by four mutually reinforcing attributes (Porter 1990:71pp): factor conditions; demand conditions; related and supporting industries; firm strategy, structure and rivalry (see Figure 15).

Factor conditions are the cluster's endowment in the factors of production which are needed to compete successfully in a given industry. Porter (1990) emphasises two types of factor conditions. Firstly, there are *advanced factors* represented in up-to-date communication infrastructure, highly skilled personnel as well as research institutions in sophisticated scientific disciplines. Since these factors demand large investments in both human and physical capital, they are difficult to tap from a distance. Secondly, there are *specialised factors*, such as highly skilled personnel in very specific economic sectors, infrastructures with specific features or knowledge resources in particular technological fields. These factors define the cluster's unique position within the global economy and therefore provide a sustainable fundament for the competitive advantage of a regional economy (Porter 1990).

Demand conditions concern the situation of *home demand* for products or services provided by particular industries. According to Porter (1990), three broad attributes of home demand are particularly significant: the composition, the size, and the internationalisation. Porter argues that the first of these demand conditions – the composition and the quality of home demand – is the most important, because it is the main shaper of how firms perceive, interpret and respond to the buyers' needs. In other words: "the quality of home demand is more important than the quantity of home demand in determining competitive advantage" (Porter 1990:86).

Related and supporting industries refer to internationally competitive suppliers and related industries that are located in the cluster. The presence of such industries creates a competitive advantage from close networking between high-level suppliers and the industry itself. Related industries support firms in identifying new methods and technological opportunities as well as gaining easy access to information, which is related to the suppliers' activities and innovations (Porter 1990). At the same time, they are an important source of new market players and thereby guarantee a dynamic competitive environment within the cluster. Hence, clusters promote not only cooperation but also competition: "Rivals compete intensely to win and retain customers (…). Yet there is also cooperation, much of it vertical, involving companies in related industries and local institutions.

Competition can coexist with cooperation because they occur on different dimensions and among different players" (Porter 1998:79).

Firm strategy, structure and rivalry, finally, concerns the conditions in which the cluster's firms are organised and managed as well as the specific characteristics of the rivalry within the domestic market. According to Porter (1990), some of the most important of these conditions are the attitudes of the workers toward authority and management, the norms of interpersonal interaction as well as professional standards. Furthermore, Porter (1990) stresses the importance of intense rivalry between domestic firms, arguing that this creates strong pressures on firms to innovate efficiently and to become high-level suppliers of goods and services on a global scale: "Vigorous local competition not only sharpens advantages at home but pressures domestic firms to sell abroad in order to grow (…). Toughened by domestic rivalry, the stronger domestic firms are equipped to succeed abroad. It is rare that a company can meet tough foreign rivals when it has faced no significant competition at home" (Porter 1990:119).

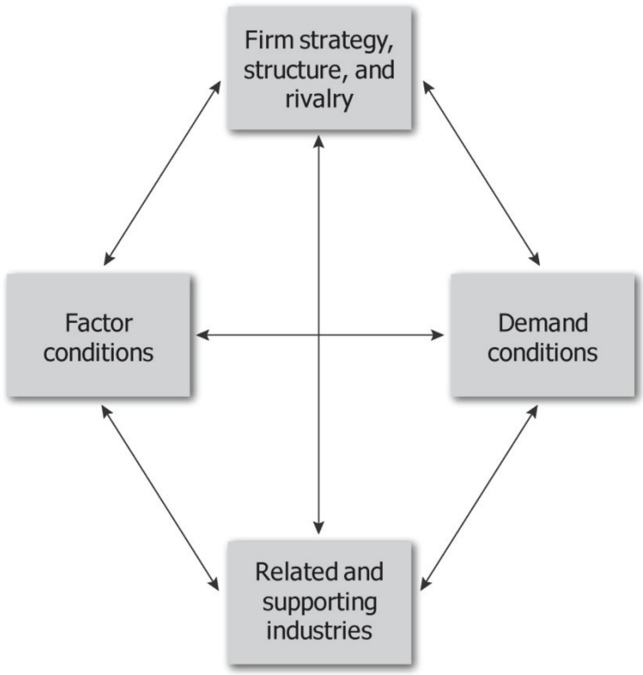


Figure 15: Clusters and competitive advantage: the Porter 'diamond' (Porter 1990:72)

All in all, Porter's cluster concept has attracted much attention. On the one hand, many local governments and regional development agencies have tried to improve their competitive position by applying Porter's advice. On the other hand, however, the Cluster concept has also attracted considerable criticism. For example: Martin and Sunley (2003) criticise the highly reductionist approach compressing immense complexity into a simple diamond model (Martin and Sunley 2003). Moulaert and Sekia (2003) argue that Porter's model – by focussing particularly on markets and competition – puts too little emphasis on networking and social interaction as factors of success for regional innovation and production systems (Moulaert and Sekia 2003). Bathelt and Glückler (2002) complain that the cluster concept does not provide an *a priori* way of identifying the geographical scale or the boundaries of a cluster. The cluster's geography seems to depend on functional linkages ranging from single cities to regional, national or even non-spatial networks at the same time (Bathelt and Glückler 2002). And finally, Simmie (2004) notes that Porter underestimates the continuing significance of urbanisation economies, i.e. the advantage arising from locating in large and diversified metropolitan agglomerations (see Section 3.3) (Simmie 2004).

Nevertheless, an important heritage of Porter's cluster concept clearly is that it analyses the spatial patterns of the knowledge economy by putting the activities of the firm – its strategic decisions and organisational structures – at the centre of the argument. In this context, it is interesting to note that several recent management and organisation academics have started to use the cluster concept in their analysis of a firm's competitiveness (Bell 2005; Pouder and St. John 1996; Tallman et al. 2004). Given the firm-level orientation of these academics, their work clearly complements the insights of economic geography by specifically addressing the functional logic of business organisation and the relationships between a firm's innovativeness and regional development (Beugelsdijk 2007).

3.3 Agglomeration economies

In the last decades, a vast amount of literature has been produced on agglomeration economies in economic geography and regional science. This boost was encouraged by the discussion on flexible specialisation (Piore and Sabel 1984), the re-emergence of industrial districts (Becattini 1989, 1992) and the focus on regions in globalisation (Storper 1997). According to Storper (1992) agglomeration economies appear to be a principal geographical process in which the trade-off between lock-in, flexibility and minimisation of transaction costs can be managed most effectively (Storper 1992). This generic process has been explained in various theories and concepts. The following section provides an overview of the most useful approaches for this thesis.

3.3.1 Traditional agglomeration models

Two opposing views about the expected long-term effects of economic activities on spatial development exist in regional science (Martin and Sunley 1998). The first has its roots in neoclassical economics, arguing that there are strong economic forces leading to the general convergence of income in space. Since spatial inequalities in economic performance boost a self-correcting development of prices, wages, capital and labour, regional disparities are unlikely to persist: capital will move to regions where labour is cheap, while labour tends to move to regions where capital is cheap. These interdependent processes continue until – in each region – wages for labour and returns to capital are equal (Terluin 2003).

The second view argues that – even in the long term – capitalist economies tend to create regional divergence rather than convergence. Since agglomeration economies stimulate the concentration of capital and labour in certain privileged regions at the expense of others, regional income tends to diverge. This argument has been advanced by Franoçis Perroux's (1950, 1955) growth pole theory and Gunnar Myrdal's (1957) cumulative causation theory. The basic idea of Perroux's growth pole theory – or pôles de croissance – is that leading economic sectors act as poles of economic growth, in which other industries and business activities are stimulated through multiplier effects (Perroux 1955, 1950). Although these growth poles refer primarily to economic sectors – not to locations – it can be argued that regions in which innovative industries are concentrated will grow faster because price effects and linkages along the value chain multiply economic growth (Harrison 1992). Similarly, Myrdal's cumulative causation theory assumes that once regional disparities are developed, a self-reinforcing process will maintain rather than erode the status of growing regions in comparison to lagging regions (Myrdal 1957). A recent school in this group of agglomeration models is also the *New Economic Geography (NEG)* approach, which analyses spatial concentrations of population and economic activity under conditions of increasing returns to scale and monopolistic competition (Fujita et al. 1999; Krugman 1998).

Marshall's industrial district

Agglomeration economies and the advantage of spatial externalities arising from co-location have been analysed since Alfred Marshall's identification of industrial districts (Harrison 1992; Markusen 1996; Asheim 2000). In several case studies on British regions, such as Lancashire or Sheffield, Marshall (1930) examined spatial externalities, agglomeration effects and localisation effects arising from small and highly interconnected local firms. In contrast to the traditional regional economic theories at this time, he attached more importance to agglomeration economies. Thereby, he focused particularly on socio-cultural factors, such as trust or industrial atmosphere, which tend to reduce transaction costs and promote the creation of incremental innovations within the regional industry (Asheim 2000). When using the term "industrial atmosphere", Marshall referred to specific conditions within industrial districts: "[in industrial districts], in which manufacturers have long been domiciled, a habit of responsibility, of carefulness and promptitude in handling expensive machinery and materials becomes the common property of all" (Marshall 1930:171).

Marshall argued that firms benefit from external economies and growing productivity as they concentrate in particular cities: "the economies arising from an increase in the scale of production of any kind of goods, … fell into two classes – those dependent on the general development of the industry and those dependent on the resources of the individual houses of business engaged in it and the efficiency of their management; that is, into *external* and *internal* economies" (Marshall 1930:266). External economies means the productivity of a single firm within a production system, which is often increased by "the concentration of many small business of a similar character in particular localities; or, as is commonly said, by the localisation of industry" (Marshall 1930:266). Since industrial districts provide large pools of skilled labour and enable an easy transfer of new ideas, firms benefit from external economies in the form of increasing returns to scale. This leads to an industrial culture, in which workers do not only move from one firm to another, they also live next-door to their employer, so that the whole district benefits from the fact that the "secrets of industry are in the air" (Marshall 1930).

Localisation and urbanisation economies

Marshall's concept was taken up by Edgar M. Hoover (1937), who grouped the sources of agglomeration advantages into internal returns of scale, localisation and urbanisation economies (Hoover 1937):

- *Internal returns of scale* are scale economies arising from expanding production *within* firms. Up to a certain point, many operations benefit from large-scale production by specialising in machinery and/or personnel. If the production is large enough, machines can be used for smaller tasks and workers can focus on specific jobs. For example, the general manager of a small company can be replaced by specialised managers in the fields of finance, production, marketing or human resources (Chapman and Walker 1987).

- *Localisation economies* – or what Glaeser et al. (1992) define as Marshall-Arrow-Romer (MAR) externalities – are *external* to the firm but *internal* to the regional industry (Glaeser et al. 1992). They arise as a particular industry concentrates in a given location. This leads to the development of local expertise, specialised skills and specific advantages in the corresponding economic activity. The main argument of the localisation hypothesis is that actors in related industries are able to communicate at lower cost. As a consequence, information spills over more easily from one firm to another (Graf 2006).
- *Urbanisation economies*, by contrast, arise from the diversity and the more general characteristics of a city: for instance the multiplicity of specialised business services, infrastructure and cultural and leisure functions, which may be used by any firm in the city rather than only by a single economic sector. As business activities grow in a particular area, the density and the quality of business services increase, the number of potential suppliers and buyers grows, and the variety of the workforce expands. These advantages relate to all economic sectors, not just to one. Hence, urbanisation economies promote economic diversity and density much more than localisation economies do (Chapman and Walker 1987).

Sometimes, urbanisation economies are referred to Jacobs' externalities. Jacobs (1969) argues that cities are the main source of innovation because they are the locations of very diverse knowledge pools. The exchange of complementary information between diversified firms leads to more innovation and economic growth (Jacobs 1969). According to Audretsch (1998) a large number of firms facilitates the entry of new firms, which then are specialising in niche markets and providing complementary inputs and services for the firms in the localised production system (Audretsch 1998). Similarly, Sassen (2001b) argues that urbanisation economies are crucial for APS firms: "…such specialised firms benefit from and need to locate close to other firms who produce key inputs or whose proximity makes possible joint production of certain service offerings. The accounting firm can service its clients at a distance but the nature of its service depends on proximity to other specialists, from lawyers to programmers. Major corporate transactions today typically require simultaneous participation of several specialised firms providing legal, accounting, financial, public relations, management consulting, and other such services" (Sassen 2001b:11p).

Since Alfred Marshall's concept of industrial districts, regional economists have generally agreed that agglomeration economies arising from the concentration of firms in particular places confer economic advantages. However, the debate on the appropriate content for the notion of agglomeration economies is far from finished. According to Moulaert and Sekia (2003) various explanations exist today between Weber's original formulation addressing minimum transport costs, Marshall's external economies and Hoover's explanation in terms of localisation and urbanisation economies (Moulaert and Sekia 2003). Hence, there is still much debate regarding the question which type of agglomeration – urbanisation economies or localisation economies – is providing the best business condition for the firms in the knowledge economy.

Some studies support the concept of urbanisation economies arguing that regional innovativeness is primarily based on economic diversity (Feldman and Audretsch 1999). A frequently cited study in this context is Glaeser et al. (1992), which uses data on employment in U.S. cities between 1956 and 1987 to show that urban diversity – not regional specialisation – is the main driver boosting employment growth in U.S. cities. This is a clear indication for the existence of urbanisation economies, supporting the model of Jacob's externalities (Glaeser et al. 1992). Similarly, Simmie (2004) argues that urbanisation economies – measured in terms of the size of an agglomeration – are more significant, because they provide a variety of inputs and facilitate contacts on a pick-and-mix basis, which is particularly important during the development phase of an innovation. Thus, the main incentive for innovative firms to cluster in large metropolitan areas like London and Paris is precisely because they are the home of a large number of firms, talents, intermediate services, research institutions and other facilities (Simmie 2004).

Other studies argue along the line of localisation economies. For US and Brazilian cities, for example, Henderson (1986) finds that localisation economies raise factor productivity, whereas urban diseconomies – such as congestion or environmental pollution – exert negative effects on a city's productivity growth (Henderson 1986). Boix and Trullén (2007) show that localisation economies are particularly relevant for manufacturing, while urbanisation economies primarily affect knowledge-intensive services (Boix and Trullén 2007). According to Tichy (2001) a trade-off in terms of short-run versus long-run advantages tends to exist (Tichy 2001): in the short term, specialised agglomerations are better able to benefit from localisation economies and specialised information exchange. In the long term, however, there is the risk of lock-in, as Grabher (1993) and others have demonstrated in several empirical studies (Grabher 1993). This finding is also supported by Henderson (2003) who shows that specialised High-Tech industries have a strong impact on knowledge spillovers in the short term, whereas diversification tends to subsist far longer (Henderson 2003).

Overall, Duranton and Puga (2000) argue that there seems to be a need for both large and diversified cities and smaller and more specialised ones. Some of them are better at creating new ideas, products and services, which requires a variety of knowledge inputs. Others, however, focus on standardised production in a more specialised context (Duranton and Puga 2000). Hence, urban systems in general seem to have an "innate tendency to create this type of imbalance" (Duranton and Puga 2000:553). Boschma and his collaborators analyse many of these specialisation-diversification dilemmas with the evolutionary economic geography concept of related variety (Boschma and Iammarino 2009; Boschma and Frenken 2009).

Product cycles and production systems

Drawing on the work of Schumpeter (see Section 2.2.1), Raymond Vernon developed his highly influential *product life cycle theory* (Vernon 1966). The main argument of the product cycle model is that the volume of sales of particular products follows a systematic development path: initial development, growth, maturity, decline and obsolescence (see Figure 16). At the time of introducing a new product, the total volume of sales tends to be low since customers neither know the product itself, nor its quality and reliability. If the new product is successfully established on the market, it enters a phase of considerable growth, in which both the number of competing firms in the industry and the overall demand for the product strongly increase. In the maturity phase, the market becomes slowly saturated so that the growth of demand decreases again. As a consequence, the competitive conditions tighten so much that the weaker competitors get knocked out of the competition. At the end of the product cycle, demand will exhaust and the product will finally become obsolescent (Dicken and Lloyd 1990).

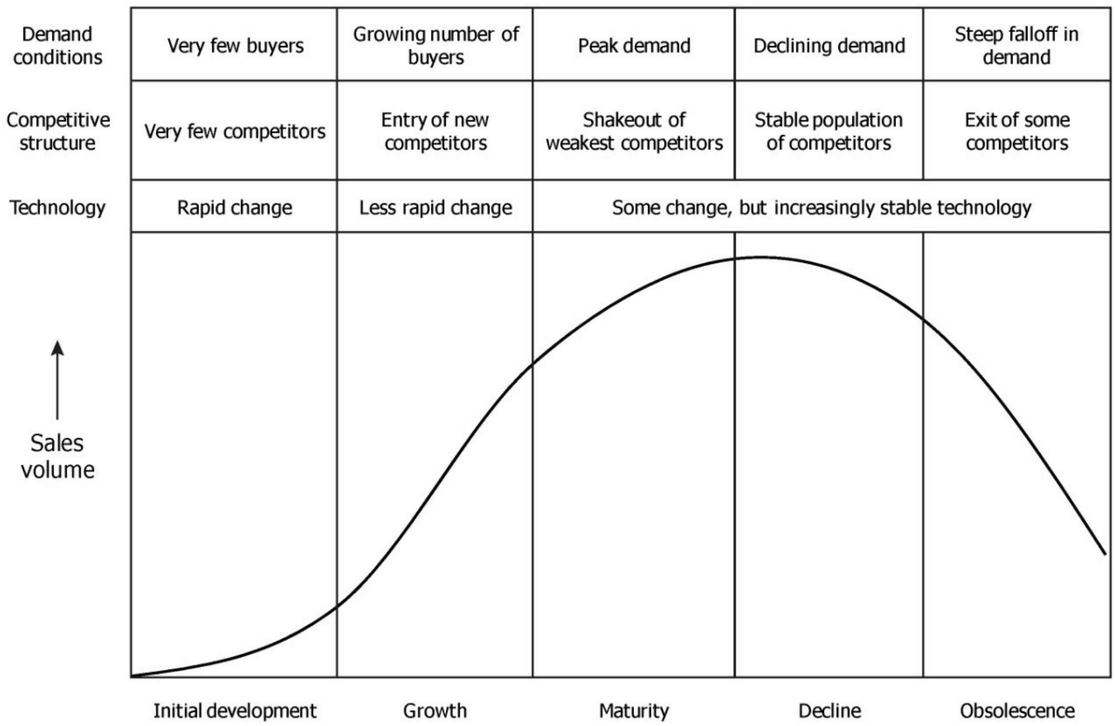


Figure 16: The product life cycle (Dicken and Lloyd 1990:286)

From a geographical point of view, the product life cycle concept is highly significant, since the different stages of the product life cycle tend to be associated with different types of location. For example, innovative companies being in the first phase of their life cycle are most likely to be found in large metropolitan areas. These regions provide sufficient external economies in terms of density, diversity and communication opportunities, which are critical to launch new products or services (Simmie 2005).

All in all, the product life cycle model makes an important contribution in emphasising changing market conditions and evolutionary processes in regional development. Thereby, one point seems to be clear: in today's knowledge economy, the average length of a product cycle is getting shorter and shorter, which puts increasing pressure on firms to innovate and continuously to develop new products and/or services (Dicken and Lloyd 1990).

3.3.2 Territorial innovation models (TIMs)

Based on these early agglomeration theories, a second wave of agglomeration models – under the rubric of *territorial innovation models (TIMs)* – was developed from the 1980s onwards to explain why local space is still important for newly-developing forms of production (Moulaert and Sekia 2003). The starting point of these theories was Michel J. Piore's and Charles F. Sable's concept of *flexible specialisation*, which identified the breakdown and de-verticalisation of large firms as a key characteristic in modern economies (Piore and Sabel 1984).

Flexible specialisation

The economic restructuring of the 1980s induced a number of reorganisation strategies in business firms. In the face of international competition and changing customer demands, this process is driven by the need for firms to be both more specialised and more flexible in the ways in which they organise their production (Simmie 2005).

In their book *The Second Industrial Divide*, Piore and Sabel (1984) describe the development from the Fordist mass production in large companies to the post-Fordist mode of customised production in small and medium-sized enterprises as a fundamental divide in the history of capitalism (Piore and Sabel 1984). The basic principle of the Fordist mass-production model was to increase efficiency and economies of scale by using assembly-lines in the production process of standardised goods. In the last decades, however, the mass-production system became too rigid and expensive for the characteristics of the emerging knowledge economy. Demand became increasingly difficult to predict and markets became much more diversified, so that the standardised mass-production lost its main advantage. In order to meet the new market conditions, firms changed their production philosophy in favour of flexible specialisation, which describes an innovation-led and consumer-focused form of work organisation based on manual production. Thereby, economies of scale are realised by putting together the capabilities of different local firms producing highly specialised products or services for the regional economy (Castells 2000).

As the notion of flexible specialisation implies, it describes two general trends in the structure of economic production systems. The first one describes an increasing degree of *specialisation* in the production process, leading to the fragmentation of business activities along the value chain into a number of individual operations. More and more, knowledge-intensive companies tend to focus their skills on core businesses, whereas more routine and standardised activities are outsourced to other firms. This results in an increasing number of management buyouts and a growing sale of subsidiaries (Dicken and Lloyd 1990). The second trend describes increasing *flexibility*. Smaller production units are changing the way production processes are organised and enable increasing product variety. According to Asheim (2002) this flexibility is exploited in two ways: *internally* through the use of ICT and functional flexibility in the production process and *externally* through outsourcing of specific activities to local – and increasingly also to global – production systems (Asheim 2002).

Specialisation and flexibility are stimulating *division of labour*. According to Picot et al. (2008) focussing on a single task enables a firm to develop unique knowledge resources and capabilities in order to work more efficiently. This principle of creating and using specialised skills in order to increase productivity has already been emphasised by Adam Smith (1776). He argued that division of labour leads to a more productive use of resources and therefore satisfy a larger number of needs (Smith 1776). However, as Picot et al. (2008) argue, partial tasks that are carried out along the value chain through division of labour must also be reunited in a coordinated way in order to complete the entire assignment. This results in a variety of exchange relationships that have to be initiated and negotiated (Picot et al. 2008). At this point, geography comes into play.

The flexible specialisation thesis inspired several new concepts in economic geography dealing with innovation, knowledge and regional development. At least four traditions can be distinguished. First, the *new industrial district* model, stressing the importance of cooperation and partnership in the innovation process; secondly, the French model of the *milieu innovateur*, emphasising the role of endogenous institutional potential to generate innovative firms; thirdly, the *regional innovation system* model, a translation of the institutional coordination principles found in sectoral and national innovation systems toward the regional and local level of development; and fourthly, the *new industrial spaces* model stemming from the Californian School of economic geography. Although these conceptual models are based on different research traditions, they all argue that information exchange and knowledge creation take place at the regional level. In contrast to the traditional agglomeration models, these concepts take grater account of qualitative externalities based on regional institutions, cultures and learning processes (Moulaert and Sekia 2003). In the following sections, the main features of these concepts are presented as put forward by their protagonists.

The new industrial district

The theory of the new industrial district – first identified by Giacomo Becattini in the so-called Third Italy – focuses on the innovation processes in and between small and medium-sized enterprises (SMEs) that belong to the same industry and local space (Moulaert and Sekia 2003). The Florentine research team around Giacomo Becattini elaborated systematically the ideas of the Marshallian industrial district. In doing so, they analysed the effects of both economic externalities and socio-cultural characteristics on the competitiveness of North-Italian regions. This research was the starting point of a rich literature emphasising the importance of social ties and institutional networks as well as the embeddedness of industrial production into local contexts (Becattini 1991; Pyke et al. 1990; Brusco 1982).

Commonly, the new industrial district is defined as a localised production system, based on a strong local division of labour between small and specialised firms, which are integrated in the value chain of an industrial sector (Moulaert and Sekia 2003). Becattini (1990) defines the district as "a socio-territorial entity which is characterised by the active presence of both a community of people and a population of firms in one naturally and historically bounded area. In the district, unlike in other environments, (…) community and firms tend to merge" (Becattini 1990:38). This definition proves to be more complex and socially rooted than for example the cluster concept of Porter (1990) who defines a cluster merely as a geographic concentration of interconnected companies and institutions in a particular field (Porter 1990). Chiarvesio et al. (2010) for example underline that the new industrial district is not only a network of firms, but also a complex social system, in which "purely self-interested behaviour is almost always substituted by the aim of general community benefits" (Chiarvesio et al. 2010:335). Hence, as Harrison (1992) argues, the new industrial district concept is clearly more than just old wine in new bottles: "…Becattini's analysis of what makes the Italian district 'tick' begins with Marshallian externality. But it then proceeds beyond the manipulation of cost curves, into something more qualitative" (Harrison 1992:475).

Empirical research highlights that the organisational and spatial configuration of industrial districts are continuously changing. Chiarvesio et al. (2010) for example shows that we are now witnessing a profound transformation in the structure of Italian industrial districts, in which leading firms are enlarging the boundaries of their supply base and investing in global networks in order to sustain competitive advantage (Chiarvesio et al. 2010). Other authors highlight that networks in industrial districts also connect large firms and their suppliers, which enables the introduction of flexible specialisation by subcontracting. As a consequence, the manufacturing depth of large companies is reduced and a smooth diffusion of innovation throughout the whole regional economy is facilitated (Grabher 1991).

The analytical precision regarding the variety of industrial districts has progressed markedly since the pioneering contribution of Markusen in 1996 about 'sticky places in slippery space'. In her paper, she rejects the Italian industrial district as the one and only dominant paradigmatic solution. Rather, she identifies five types of industrial districts, with quite different firm configurations and governance structures (Markusen 1996:297pp). The first is the typical *Marshallian* industrial district. It is characterised by small firms, localised investment links, labour market loyalty, flexible work regimes and substantial intra-district trade among buyers and suppliers. The second is the *Italian* variant. It adds some basic features to the original Marshallian approach, such as a high degree of cooperation among competitors, high proportions of design-intensive work as well as strong trade associations and local governments, which regulate and promote the core industries of the region. The third type of industrial district can be called *hub-and-spoke*. It occurs in regions where a number of international key firms act as hubs to the regional economy, with suppliers and related industries clustered around them. The fourth type is a *satellite platform* – an agglomeration of subsidiaries of externally based multi-branch, multi-location firms. This type of industrial district is often promoted by provincial governments as a way to stimulate regional development and economic growth. And finally, there are *state-anchored* industrial districts, which emerge around one or more public-sector institutions such as military bases, defence plants, universities etc. In the majority of cases, these institutions act as the most important anchor tenants within the industrial district (Markusen 1996).

The concept of the new industrial district has been criticised for several reasons. According to Storper (1995) the most important criticism is that the new industrial district model does not explain why some regional production systems are economically more successful than others, even though both of them are flexible and specialised. Storper (1995) argues that proponents of the industrial district concept "correctly understood that the flexible specialisation model was only interesting to the extent that such production systems were technologically dynamic and not highly territorially mobile; but the words flexibility and specialisation do not necessary correspond to these characteristics" (Storper 1995:195). A second problem concerns the scale of analysis. Markusen (1999) criticises that since the industrial district research is confined within the borders of the district, ties to other firms and organisations outside the region are often eliminated from the analysis, which leads to the highly misleading impression that a region's economic dynamism would be solely endogenously driven (Markusen 1999). In a similar vein, Hadjimichalis (2006) argues that the industrial district approach fails to take into account the wider national or even global system of price relations, within which the small firms actually operate. He is particularly troubled by the explanation of the Third Italy's success on the basis of internal factors only, while the rest of Italy and the world are reduced to simple consumers of their fashion products (Hadjimichalis 2006). Furthermore, some observers scrutinise the long term stability of industrial districts, arguing that they might be fragmented for example through the take-over of the most successful SMEs by TNCs (Harrison 1994b, 1994a). Storper (1995), for example, argues that in many industrial districts SMEs are just niche producers, while TNCs would actually occupy the central terrain of the corresponding sectors (Storper 1995). Finally, there is also a problem in generalising the new industrial districts concept. According to Storper (1995) only few production systems really exist that are dominated by small firms, particularly as in the case of the Third Italy. Precisely because there are deep historical roots to the Italian districts, it is highly questionable if "similar forms of industrial skill and co-ordination could be built *de novo*" – for example in regions with more Anglo-American competitive norms (Storper 1995:194).

The innovative Milieu

In the approach of the innovative milieu developed by the GREMI (Groupe de Recherche Européen sur les Milieux Innovateurs) firms are seen as part of a milieu with a high capacity to create innovative products and services (Bramanti and Maggioni 1997; Maillat et al. 1993; Aydalot and

Keeble 1988; Bramanti and Ratti 1997). These milieus are characterised by networks of synergy among regional stakeholders who are engaged in collective learning processes. The latter are based on the mobility of workers and the face-to-face relations between local suppliers and purchasers (Simmie 2005).

In its final version, the innovative milieu is described by the following crucial formula: local milieu + innovation network = innovative milieu (Maillat et al. 1993). This formula makes clear that the innovative milieu is characterised by two overlapping building blocks: the local milieu and the innovative network (see Figure 17). The *local milieu* comprises a network of informal and social relationships, in which actors and organisations have autonomy in their strategic decision making. It constitutes an emotional entity both internal and external to the milieu. The borders of a local milieu are defined in functional terms such as homogeneity in behavioural routines or technological cultures (Camagni 1991b).

The *innovation network*, on the other hand, is defined as "an evolution mode of the organisation of the innovation process, neither proceeding from market mechanisms nor structured according to a rigid hierarchical form, which allows the continuous development of collective learning processes which rest on new combinations of synergetic types of know-how brought about by the different partners" (Maillat et al. 1993, cited in: Bramanti and Ratti 1997:29). This conception makes clear that the GREMI researchers underline not only the importance of links within, but also with the world outside the milieu: "The concepts of *milieu innovateur* and innovation networks bring to our attention an essential aspect of the territorial dynamics of the new techno-industrial system, the modes of articulation among forms of coherence internal to the local milieu (endogenous capacity) and external elements which at the same time feed and overwhelm such an internal coherence ('the global') in a perspective of dynamic adjustment" (Bramanti and Ratti 1997:29).

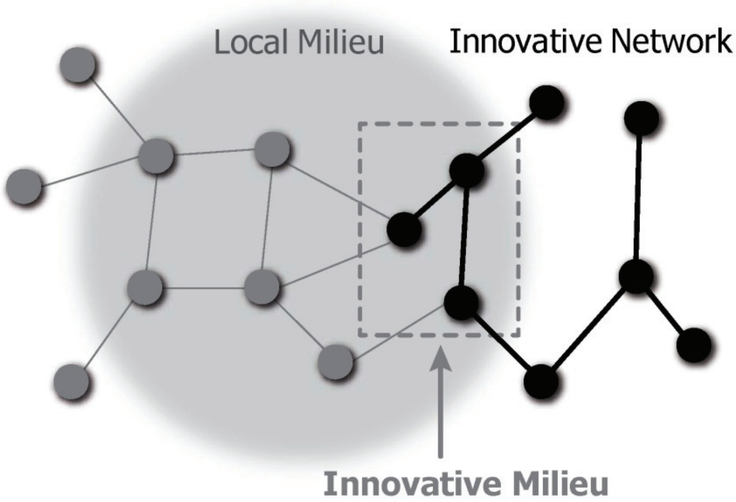


Figure 17: The innovative milieu (Fromhold-Eisebith 1995:36)

Taking these considerations into account, the innovative milieu can be defined as "a localised set of players who will develop, through interaction within the milieu and between the milieu and its surrounding environment, collective knowledge leading to ever more effective ways of mastering technologies and collectively managing resources" (Corpataux and Crevoisier 2007). Hence, the innovative milieu can be seen as "a *multi-dimensional reality* which links a collective of players to the dynamic realisation of productive systems, integrating at the same time both the territorial dimension and the techno-industrial paradigms behind the structural changes of the productive apparatus" (Quévit and Van Doren 1997:345). According to Simmie (2005) this is a critical extension to the traditional industrial districts approach, which focuses more strongly on the supply-side of local firm networks (Simmie 2005).

The opponents of the GREMI approach raise similar concerns as in the case of the Italian industrial district. According to Storper, the most important critique concerns the circularity in the argument: "innovation occurs because of a milieu, and a milieu is what exists in regions where there is innovation" (Storper 1995:203). Similarly, Simmie (2005) criticises the ambiguity in the GREMI's argument about what comes first: is an innovative milieu the outcome of a spatial concentration of innovative firms? Or, are innovative firms arising from the specific characteristics of an innovative milieu? Hence, despite its merits in terms of the emphasis on the interplay between local milieus and non-local innovative networks, the GREMI approach remains fuzzy in both the explanation of why innovative milieus emerge and how they promote innovations, where they are already in place (Simmie 2005; Simmie et al. 2002).

The spatial innovation system

The multi-faceted character of agglomeration economies has also been discussed quite openly in evolutionary economics (see Section 2.1.1), especially in the literature on innovation systems (Edquist and Johnson 1997). According to Graf (2006) the innovation systems approach is based on the idea that firms are not able to innovate in isolation. Rather, they are embedded in a system of actors and institutions, in which the diffusion of information is facilitated by the continuous exchange of experiences. This leads to an accumulation of knowledge within the system and – if economically useful – to the creation of innovative products and services. Hence, an innovation system can be defined as "a network of actors who interact in the process of the generation, diffusion, and utilisation of new, economically useful knowledge under a distinct institutional framework" (Graf 2006:16). The various interactions within these networks lead to strong synergy effects, based on feedback mechanisms between university researchers, product developers, intermediary organisations and end-users (Hessels and Lente van 2008). From a system theory perspective, these synergy effects can be defined as "the tendency to unify the power of two or more elements and the perception that the whole is greater than the sum of the parts that constitute it" (Giannakis et al. 2004:4). Or – in the context of innovation studies – it can be argued that "when the process of innovation is regarded as the outcome of a complex interaction, it is obvious that the whole system might be more than a sum of its parts" (Lundvall 1988:361).

The nature of the innovation process has also been analysed from a spatial perspective. In the last 20 years, the literature on spatial innovation systems has shifted from the national (Edquist 1997; Nelson 1993; Lundvall 1988, 1992) to the regional (Asheim and Isaksen 1997; Cooke et al. 1998) and local dimension (Muscio 2006; Carrincazeaux et al. 2008).

National innovation systems: Much of the early work on innovation systems was conducted at the national level, responding mainly to the question whether globalisation processes hollow out the nations capacity to influence their own technological development (Cooke et al. 2007; OECD 1999). In an early study, Freeman (1987b) defines a national innovation system as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman 1987b:1). Similarly, Metcalfe (1995) defines it as the "set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provide the framework within which governments form and implement policies to influence the innovation process" (Metcalfe 1995, cited in: OECD 1999:24). In contrast to these two definitions, Lundvall (1992) applies a much broader definition, including "all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring – the production system, the marketing system and the system of finance present themselves as subsystems in which learning takes place" (Lundvall 1992:12). Obviously, the national scale of the innovation system approach is only one among several possibilities. However – as Edquist argues – there are still many reasons why the nation state is important to understand the functioning of innovation processes (Edquist 1997). For example, many case studies identify huge differences between national innovation systems in terms of institutional environment, investment in R&D, economic performance and the like (Nelson 1993). Furthermore, many public policies that influence the innovation activities of firms – e.g. economic policy, industrial policy, innovation policy – are still defined and implemented at the national level. In other words, the specific composition of social, cultural, political, legal, educational and economic institutions within the nation state is the main factor which defines the nature of the national innovation system (Lundvall 1992; Nelson 1992).

Regional innovation system: As Asheim et al. (2005) note, the concept of regional innovation systems first appeared in the early 1990s (Cooke 1992), a few years after Freeman's first use of the innovation system concept in his analysis of Japan's economy (Freeman 1987b) and approximately at the same time as the idea of the national innovation system was becoming more widespread, thanks to the books by Lundvall and Nelson (Lundvall 1992; Nelson 1993; Asheim et al. 2005). In other words, the regional innovation system approach can be seen as a lower-scale variant of the national innovation system concept (Moulaert and Sekia 2003). However, the idea of regional innovation systems is not only based on its national counterpart, it is also inspired by the traditional agglomeration models (Perroux 1955; Myrdal 1957; Hoover 1937) as well as by the flexible specialisation thesis (Piore and Sabel 1984) and the new industrial district concept (Becattini 1989). Based on these theories, Cooke et al. (2007) define a regional innovation system as "a set of institutions, both public and private, which produces pervasive and systemic effects that encourage firms within the region to adopt common norms, expectations, values, attitudes and practices, where a culture of innovation is nurtured and knowledge transfer processes are enhanced" (Cooke et al. 2007:115). Thereby, the interplay between universities, research institutions, technology transfer agencies etc. – but also the presence of venture capital firms and business angles – stimulate the production, diffusion and application of knowledge on a regional scale (Cooke et al. 2007). In contrast to the national innovation system approach, it is the region which plays the central role in the coordination of economic processes, especially with respect to innovation (Cooke et al. 1998; Pinto 2009). Regional authorities for example can shape local learning and innovation processes by providing R&D- and educational infrastructure as well as supporting academic spin-offs in order to enhance human and social capital (Cooke et al. 2000). Thereby, regions are emerging as "laboratories of knowledge creation and innovation and the breeding ground for local policy networks" (Cooke et al. 2007:113). Building on empirical research in several European regions, Cooke et al. (2000:104) propose a model of a regional innovation system that describes a distinction between two knowledge subsystems originally made by Erkko Autio (Autio 1998) (see Figure 18). The first subsystem applies and exploits knowledge commercially. It occurs mainly in the form of firm relationships, transactions along the value chain, agreements among competitors, or shared industrial interests. The second subsystem concerns knowledge creation and diffusion and includes technology and workforce mediating organisations as well as public research and educational institutions. According to Cooke et al. (2000) this distinction is especially useful for innovation systems that operate within a multi-level governance framework, where shared initiatives are formulated and implemented across sectors as well as regional and national bodies (Cooke et al. 2000).

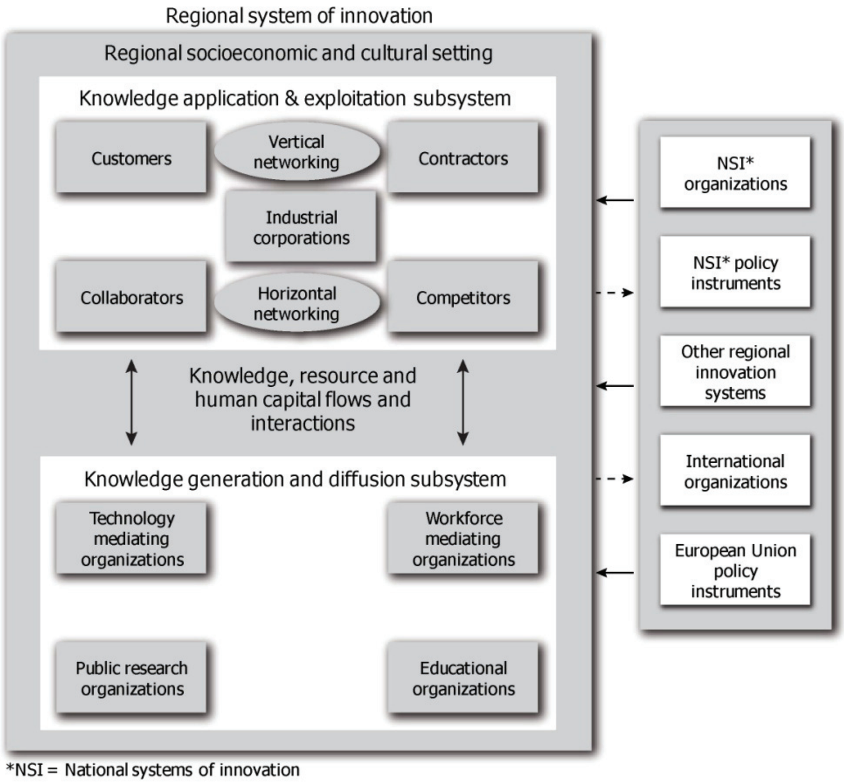


Figure 18: Regional innovation system (Cooke et al. 2000:104)

Local innovation systems: In recent years, it has been argued increasingly that innovation processes are concentrated even at the local level, in so called local innovation systems. According to Muscio (2006) local innovation systems develop an independent learning and innovation pattern, by-passing the region as a space of action. In the case of Lombardy, for example, he argues that it is more adequate to use the notion of local innovation systems, because the linkages among firms and institutions concentrate particularly at sub-regional levels, which are characterised by specific social and cultural contexts. Accordingly, many policies at the local level are designed to promote technological cooperation and to enforce knowledge transfer in innovative networks in order to stimulate learning processes within the local innovation system (Muscio 2006).

Even though there are considerable differences between national, regional and local innovation systems, Edquist (1997:17pp) identifies a number of common characteristics: (1) All versions of the innovation system approach place innovation in a Schumpeterian sense and learning processes of various kinds at the centre of the analysis. (2) All versions can be characterised as holistic in the sense that they have the ambition to encompass a wide array of determinants that are important for innovation. (3) In all innovation system concepts, the historical dimension is stressed in order to understand the innovation process and its path dependency. (4) In all versions, the differences between the various innovation systems are stressed and focused upon, which makes the concept highly relevant for comparative case studies. (5) All versions emphasise the interdependence and non-linearity of the innovation process. (6) All versions of the innovation system approach use the concept of innovation in its broad definition, including organisational, managerial, social and technical innovation. (7) And finally, one of the most important common characteristics of all innovation system approaches is their emphasis on the role of institutions as crucial elements for the innovation process (Edquist 1997).

However, like the other territorial innovation models, the innovation system approach is associated with various kinds of conceptual flaws. According to Edquist (1997) one of the most important critics concerns its various definitions: “none of the major authors provide a sharp guide to what exactly should be included in a (national) system of innovation” (Edquist 1997:29). Furthermore, the concept of *institutions* – an important building block of the innovation system approach – remains fuzzy and inconsistent. On the one hand, it refers to specific political institutions such as educational systems or industrial policies. On the other hand, it also includes normative connotations such as industrial cultures, norms, values, attitudes etc. Hence, the innovation system approach cannot be seen as a coherent formal theory. At most, it provides a collection of various concepts that are useful to analyse innovation processes in different spatial and institutional contexts (Edquist 1997).

New industrial spaces

Another influential approach inspired by the flexible specialisation thesis is the concept of *new industrial spaces* launched by the Californian School of external economies. Starting in the 1980s, these researchers were elaborating a new reflection on the types of relations between division of labour, transaction costs and agglomeration, combining insights from different literatures such as industrial districts, flexible specialisation, transaction economies and others (Storper and Scott 1988; Scott 1985). In the line of the flexible specialisation thesis, they argue that “it now seems that a new, hegemonic model of industrialisation, urbanisation and regional development has been making its historical appearance in the US and Western Europe (…). Because of the tendency to externalisation of the transactional structures of production, selected sets of producers with especially dense interlinkages have a tendency to agglomerate locally (…). Accordingly, the turn towards flexibility has been marked by a decisive re-agglomeration of production and the resurgence of the phenomenon of the industrial district…” (Storper and Scott 1988:21pp). A much cited study confirming this new phenomenon is Storper and Christopherson’s (1987) study of the motion picture industry in the US. In this study, they conclude that flexible specialisation leads to a new configuration in industrial production, through new forms of horizontal integration, a further strengthening of external economies and strong agglomeration tendencies (Storper and Christopherson 1987).

The Californian School identifies *flexible production systems* as important driving forces for industrial localisation and regional development. Flexible production systems can be defined as “forms of production characterised by a well developed ability both to shift promptly from one process and/or product configuration to another and to adjust quantities of output rapidly up or down in the short run without any strongly deleterious effects on levels of efficiency” (Storper and Scott 1988:24).

Thereby, the efficiency of the flexible production system is related to agglomeration economies and decreasing transaction costs associated with extra-firm linkages: “This locational strategy enables them to reduce the spatially-dependent costs of external transactions. In flexible production systems, the tendency to agglomeration is reinforced not only by externalisation but also by intensified re-transacting, just-in-time processing, idiosyncratic and variable forms of inter-unit transacting, and the proliferation of many small-scale linkages with high unit costs” (Storper and Scott 1988:26).

An important assumption behind this process is that certain market conditions – e.g. changing technological trajectories – give rise to economic *uncertainty*. This uncertainty is managed by reinforcing division of labour in order to minimise the risk of overcapacity and lock-in as well as to maximise the benefits of specialisation. This disintegration of labour, however, raises the transaction costs of input-output relations. Because these transaction costs are more frequent, less predictable and more complex than intra-firm transactions, they rise with geographical distance. Hence, the spatial concentration of economic activity can be seen as the outcome of minimising transaction costs and – at the same time – maximising external economies because of the advantage of flexibility, risk minimisation and functional specialisation (Storper 1995).

According to Storper (1995), the Californian School’s main merit is that it unifies the theory of industrial localisation with that of regional development. Compared with other approaches, it sensitised the scientific debate for the importance and the complexity of geographical input-output relations (Storper 1995). The major limitation, however, lies in the fact that the many complex socio-economic relations within flexible production systems are reduced to the simple dynamic of transaction costs (Bramanti and Ratti 1997). Storper (1995) for example criticises that the localisation of input-output relations – or traded interdependencies – is inadequate to explain the link between flexible production and the increasing importance of regional economies. In some industries, agglomerations tend to be technologically successful without having dense local input-output linkages and institutional coordination (Storper 1995).

From traded to untraded interdependences

Towards the end of the 1980s, the researchers around the Californian School became more sensitive to the dynamic dimension of agglomeration economies. By combining insights from institutional, agglomeration and evolutionary economics, Storper (1997), for example, argues that spatial proximity in agglomerations reduces not only transaction costs between firms but also facilitates the capabilities for organisational and technological learning. Thereby, not only *traded interdependences* – i.e. localised input-output relations in the form of user-producer relations – but also *untraded interdependences* – i.e. labour markets, regional conventions, norms and values etc. – play an important role in the process of economic and organisational co-ordination. In order to explain the basic rationale behind the resurgence of regional economies, he developed the concept of the “holy trinity” (Storper 1997:49), consisting of technology, organisation and territory as the three main pillars of economic geography (see Figure 19). The importance of *technology* is based on the dynamics in technological change, in which both tacit and codified forms of knowledge influence the development path of industries and regions. *Organisation*, on the other hand, looks at how firms are integrated in internal and external business activities, what kind of traded and untraded interdependences exist and which role specific institutions and conventions play within the organisational structure of the firms’ business networks. The *territory*, finally, builds the seedbed, on which the interplay between organisations and technologies is articulated. In this, not only regional input-output linkages are of importance, but also learning processes based on untraded interdependences, regionally specific conventions, norms and cultures, which define regional worlds of production and innovation (Storper 1997).

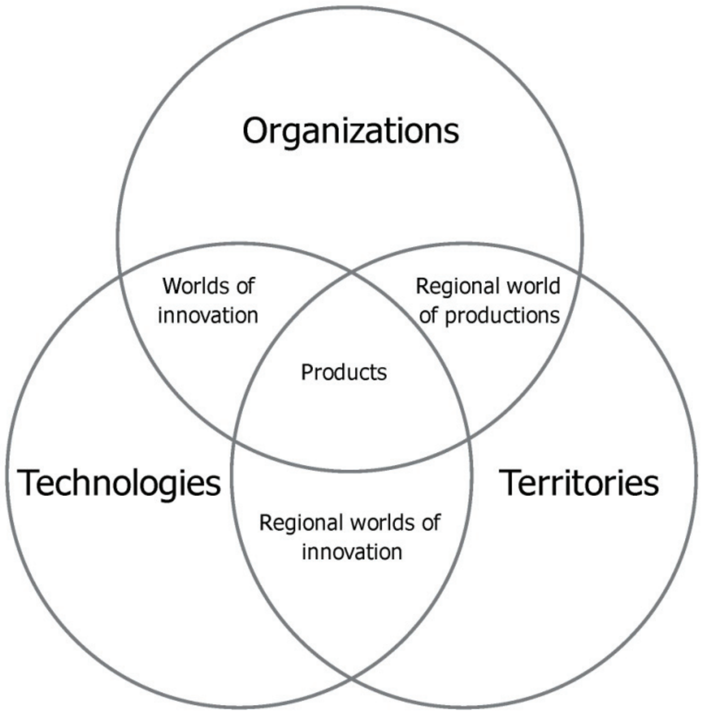


Figure 19: Storper's holy trinity of regional economics (Storper 1997:49)

Critics on territorial innovation models

TIMs are often criticised for their lack of clarity and their vague and fuzzy formulations. Markusen (1999) for example criticises that these fuzzy conceptualisations make it difficult for decision-makers to apply them to real-world problems. Furthermore, she argues that the fuzziness of the concepts themselves stems from the lack of empirical evidence that goes beyond case study examples and anecdotes. For example, only very few contributions really reveal the different shades of flexible specialisation. In some cases, it is the production process that is seen as increasingly specialised and flexible, in others, the notion applies to firms, workers or even to regions. Therefore, Markusen (1999) appeals to the academic world to make their results more accessible and informative to policymakers and planners: "we must ensure that we are working with powerful, plainly stated theories which can be operationalised and which offer clear guidance for those with the responsibility to shape the future of cities and regions" (Markusen 1999:881).

Another critique has been put forward by Beugelsdijk (2007). He argues that the claim 'the region matters' is all too often deduced from the aggregate empirical observation of geographically concentrated innovation activities. This leads many authors to reach a wrong conclusion – known as ecological fallacy – in which macro phenomena, which are representations of micro activities, are re-generalised to the micro level. For example: "The empirical finding that a firm's linkages with local partners are important… does not automatically imply that the region is a necessary condition for a firm's increased performance" (Beugelsdijk 2007). Furthermore, Beugelsdijk (2007) criticises the over-socialised view of many TIMs, in which regions are treated as actors, while firm-specific characteristics are neglected. This leads to a regional bias as well as an overestimation of the region's importance for the value creation process in firms (Beugelsdijk 2007).

Finally, several authors level the criticism that TIMs are too inward looking, pitting internally coherent agglomeration economies against the world of global networks characterised by fierce economic competition. Yeung (2009) for example states that many proponents of the TIM literature tend to see agglomeration economies and institutional structures as both necessary and sufficient conditions to account for economic development, whereas the processes connecting different knowledge centres in the global economy have largely been neglected (Yeung 2009). Similarly, Lagendijk (2006) argues that TIMs would underestimate the way territories are constituted by a wide variety of global practices that become – to some extent – locally embedded (Lagendijk 2006). And finally, Amin (2004) notes that too much is read into what is done and achieved locally, while too little is made of the wide variety of connectivities that reach beyond the local or regional borders (Amin 2004).

In order to reveal these extra-regional connectivities, it is necessary to include global network economies in any conceptualisation of spatial development. Before moving on to this issue, Figure 20 provides an overview of the theoretical roots and building blocks of the agglomeration models discussed in this chapter and the sections before.

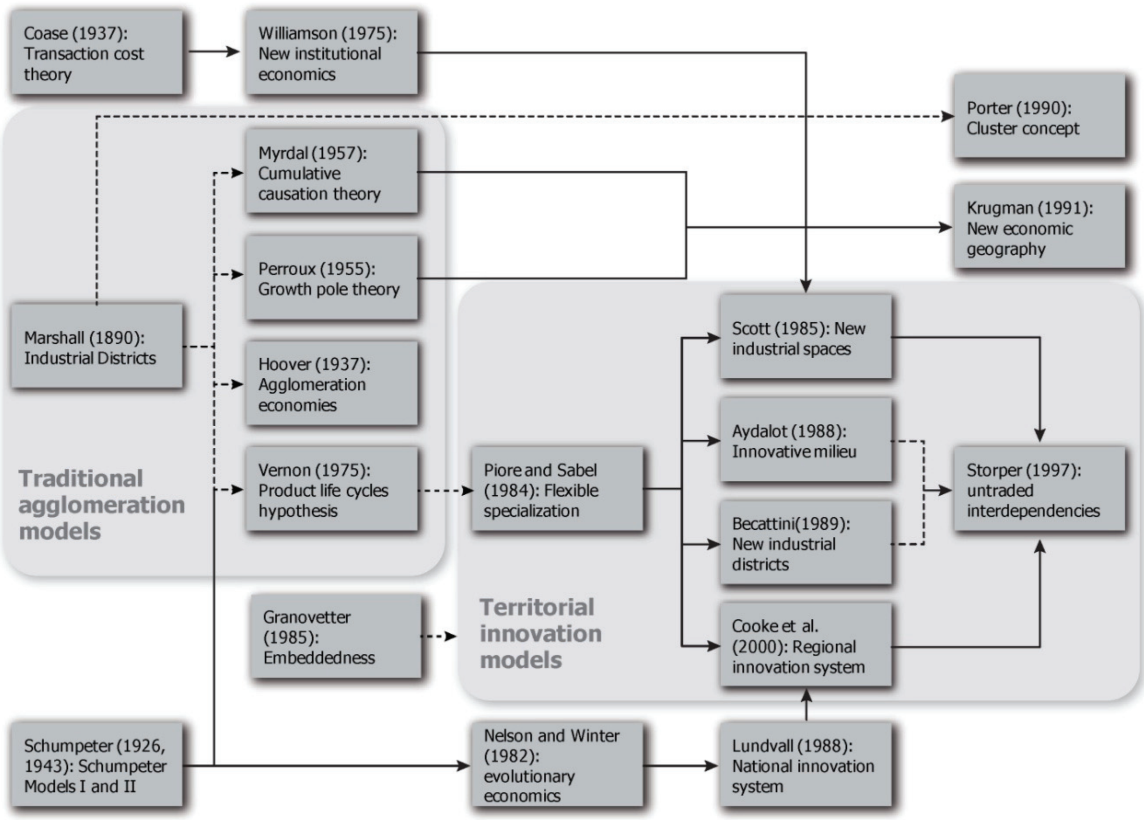


Figure 20: Theoretical roots and building blocks of agglomeration economies (Author's illustration)

3.4 Global network economies

Most observations on how external economies influence spatial development have focused on agglomeration economies. Many of these investigations, however, have failed to consider the contribution of global network economies in knowledge creation. As Bathelt et al. (2004) argue, there is only a limited number of studies providing satisfying empirical evidence that local interactions are at least as important as non-local linkages. Many empirical studies – even on archetypical regional production systems – have shown that intra-regional transactions are by no means dominant over extra-regional relations. Local interactions are increasingly questioned as the dominant form of knowledge creation and learning (Simmie 2003; Cabus and Vanhaverbeke 2006; Bathelt et al. 2004). Simmie (2003) for example observes that most innovative firms operate *from,* rather than *within* localities (Simmie 2003). On the other hand, Cabus and Vanhaverbeke (2006) argue that global network economies need to be acknowledged as complementary to agglomeration economies (Cabus and Vanhaverbeke 2006). In the following section, some of the most important approaches relating to global network economies will be discussed. Generally, it is possible to differentiate between two streams of theoretical thinking: *world city network models* and *value chain models*.

3.3.1 World city network models

For many years, researchers have been interested in identifying and describing the characteristics of the greatest cities in the world. Peter Hall (1966) for example begins his seminal contribution on *'The world cities'* by stressing that "there are certain great cities, in which a quite disproportionate part of the world's most important business is conducted. In 1915 the pioneer thinker and writer on city and regional planning, Patrick Geddes, christened them 'the world cities'" (Hall 1966:7). This statement and reference to Geddes is widely quoted as the starting point of the research on global and world cities (Smith 2003). In this, Hall (1966) defines world cities in terms of their multiple roles: "In the first place, they are usually the major centres of political power. They are the seats of the most powerful national governments and sometimes of international authorities too… Round these gather a host of institutions, whose main business is with government: the big professional organisations, the trades unions, the employers' federations, the headquarters of major industrial concerns (…). These cities are the national centres not merely of government, but also of trade. Characteristically they are great ports, which distribute imported goods to all parts of their countries, and in return receive goods for export to the other nations of the world… The world cities are the sites of the great international airports… Traditionally, the world cities are the leading banking and finance centres of the countries in which they stand. Here are housed the central banks, the headquarters of the trading banks, the offices of the big insurances organisations and a whole series of specialised financial and insurance agencies" (Hall 1966:7). Hall's (1966) book was the starting point of a remarkable research agenda analysing the internal attributes of several key cities such as London, Paris, Moscow, New York and Tokyo, but also important city-regions such as the Randstad-Holland and Rhine-Ruhr have been analysed. In his studies, Hall covered a wide variety of topics from culture, politics, trade and communications infrastructure through to finance, technology and universities (Hall 1966). Within this range of topics, however, he highlighted the critical role of the economic function to world cities. By doing this, he actually pre-announced most later writings on the subject (Taylor 2004b).

Drawing on the insights of Peter Hall's work, the current round of world city research is more closely related to the emergence of the knowledge economy that is accommodated by ICT and in which APS play a prominent role. The most influential concepts in today's world city research are John Friedmann's (1986) *world city hypothesis*, Saskia Sassen's (1991) *global cities*, Manuel Castells' (2000) *space of flows*, and Peter Taylor's (2004b) *world city network* (Friedmann 1986; Sassen 1991; Castells 2000; Taylor 2004b). Each of these concepts has been widely recognised as a seminal contribution to the development of world cities literature. In turn, we are going to refine these concepts.

The world city hypothesis

The world city concept goes back to the paper written by Friedmann and Wolff in 1982. The more influential contribution, however, has proved to be Friedmann's (1986) statement of *'The World City Hypothesis'* (Friedmann and Wolff 1982; Friedmann 1986). In this paper, Friedmann (1986) describes the rise of a transnational urban network referring to a major geographical transformation of the capitalist world economy whose production systems are increasingly internationalised. This reconfiguration results in a new international division of labour whose main agents are TNCs with complex spatial and organisational structures. Friedmann (1986) argues that it is the presence of these transnational enterprises that makes world cities into geographical places of great economic power. According to Yeung et al. (2001), TNCs in world cities benefit particularly from the good strategic location within the global transport and communication network, high-quality external services such as financial and business services, a particular range of labour market skills as well as from a wide variety of social and cultural amenities (Yeung et al. 2001).

Friedmann (1986) explains the world city concept in terms of seven theses that "link urbanisation processes to global economic forces" (Friedmann 1986:69). For our purpose, the first three of these theses are the most important, because they provide the foundation for our concept of global network economies (see also Taylor 2004b:22p).

The first thesis describes the *functional* dimension of world cities: "The form and extent of a city's integration with the world economy, and the functions assigned to the city in the new spatial division of labour, will be decisive for any structural changes occurring within it" (Friedmann 1986:70). Thereby, Friedmann (1986) emphasises three main city functions: headquarter functions, financial functions, and articulation functions. The most important cities – such as New York or London – carry out all these functions simultaneously. Because world cities are integrated with the world economy by these functions, structural change within them can be seen as resulting from "an urban adaption to changes that are externally induced" (Friedmann 1986:70). This is a fundamental insight into the interpretation of regions as unbounded, relational spaces.

The second thesis describes the *hierarchical* dimension of world cities: "Key cities throughout the world are used by global capital as 'basing points' in the spatial organisation and articulation of production and markets. The resulting linkages make it possible to arrange world cities into a complex spatial hierarchy" (Friedmann 1986:71). This hierarchy is formed by taking into account a number of city characteristics: major financial centres, headquarters of TNCs, international institutions, rapid growth of business services sectors, important manufacturing centres, major transportation nodes and population size. From this information, Friedmann (1986) identifies primary and secondary world cities. The geographical arrangement of these cities reveals core and semi-periphery cities as well as three continental subsystems: Asia, North America and Western Europe.

The third thesis describes the *structural and dynamic* dimensions of world cities: "The global control functions of world cities are directly reflected in the structure and dynamics of their production sectors and employment" (Friedmann 1986:73). This thesis underlines that the dynamism of world cities results particularly from the growth of high-level business services employing a large number of professionals. Here, major importance is attached to corporate headquarters, international finance, global transport and communication as well as advertising, accounting, insurance and legal services. In terms of occupation patterns, this often results in a dichotomised labour force with highly specialised professionals on one side, and a vast number of low-skilled workers on the other (Friedmann 1986).

According to Friedmann (1986) the territorial basis of a world city is more than just the CBD. Friedmann and Wolff (1982) argue that over the next generation, world cities can potentially grow to an unprecedented size with ten million people or more. In this sense, world cities can no longer be considered as cities in the traditional sense; rather they are developing into urbanised regions or large-scale "urban fields" (Friedmann and Wolff 1982:323). This implies that world cities are, in fact, more often polycentric urban regions rather than central cities, containing a number of historically distinct cities that are located in more or less close proximity. These complex regions are knitted together through high-speed transport infrastructures and linked to the global economy through a system of international transport terminals and telecommunication facilities capable of servicing the entire region (Friedmann and Wolff 1982).

Global cities

The global city concept can be traced back to the publication of Saskia Sassen's *The Global City* in 1991 (Sassen 1991). Much of Sassen's research has been related to the emergence of a globally networked knowledge economy in which APS firms play a predominant role (see also Section 2.1.2). Sassen (1994) defines global cities as "strategic sites in the global economy because of their concentration of command functions and high-level producer-service firms oriented to world markets" (Sassen 1994:154). In this sense, her key indicator of global city status is whether a city has the capability to service and manage the global operations of firms and markets.

The starting point of Sassen's argument is that the combination of spatial dispersal and global integration of economic activity has created a new strategic role for central corporate business functions such as managing, coordinating and financing the global networks of TNCs. A major driving force behind this process is the digitisation of the global economy: the more globalised and digitised the operations of firms, the more their central management and coordination functions become strategic. Both Sassen (2001b) and Castells (1989) argue that it is precisely because of this digitisation that worldwide dispersal of operations and system integration can be achieved simultaneously (Castells 1989; Sassen 2001b). Nevertheless, the central corporate functions in today's global economy have become so complex that the headquarters of large global firms increasingly outsource them to highly specialised APS firms. According to Sassen, these firms are subject to strong agglomeration economies, in which the mix of firms, talents and specialised expertise makes cities into informational production sites: "Global cities are, in this regard, production sites for the leading information industries of our time" (Sassen 2001b:xx). However, these APS firms are also developing extensive global network economies. In the 1980s and 1990s, many of them followed their global clients to become important TNCs in their own right. Through their transnational spatial strategies, APS firms create world-wide office networks covering major cities in most or all world regions, and it is this very multitude of connections between these service complexes that gives rise to the formation of "transnational urban systems" (Sassen 2001b:xxi).

In Sassen's (2001b) opinion, these transnational urban systems result in a new geography of centrality cutting across existing core-periphery patterns in the world economy. One implication of this is that the city centres – or the CBDs – might become increasingly disconnected from their broader hinterlands or even their national economies. The reason for this disconnecting process lies in the locational strategies of APS firms that are increasingly located right within the city centres of economic regions, which connect these places directly with other city centres in the world. As Derudder (2006) notes, this form of centrality is fundamentally different to Freedmann's world city concept: "Sassen's focus on centrality leads her to conceptualising 'global cities' as focal points that operate separately from their hinterlands. Friedmann's focus on the relative concentration of power, in contrast, implies that a 'world city' may consist of multiple cities and their hinterlands that may themselves be subject to urbanisation processes" (Derudder 2006:2034). In this respect, it becomes clear that Sassen opts "for an analytic strategy that emphasises core dynamics rather than the unit of the city as a container – the latter being one that requires territorial boundary specification" (Sassen 2001a:80).

However, it has to be stressed that Sassen not only discovers the city centre as new type of centrality. Given the various impacts of ICT on economic activities, she identifies at least three additional "territorial correlates for the space of centrality, of which the downtown traditional business centre is but one" (Sassen 2010:156). Firstly, the space of centrality can also extend into older social geographies – such as the suburbs or the wider metropolitan area – in the form of a grid of nodes of intense business activity. This regional grid of nodes represents a renewal of the region as a functional entity, which is likely to be embedded in conventional forms of infrastructure, for example rapid rail and road connections to airports. Secondly, Sassen identifies a formation of a trans-territorial centre based on intense economic transactions in the network of global cities, taking place partly in digital space and partly through traditional transport and travel. The most powerful of these new geographies of centrality at the global level connects the major international financial and business centres such as New York, London, Frankfurt, Zurich etc. And finally, she argues that a new form of centrality is also constituted in an electronically generated space. According to Sassen (2001b) it becomes increasingly evident that even the highly complex network of virtual economic activity contains central points of coordination and centralisation (Sassen 2001b).

By characterising global cities as highly concentrated command points in the organisation of the world economy, to a certain extent Sassen follows Friedmann's world city hypothesis. According to Sassen, however, the main difference between the world city concept and the global city model concerns the level of generality and historical specificity (Sassen 2001b). Sassen puts a new emphasis on the *production* of financial and service products. In her view, global cities are more than simply command centres; they are the first global service centres in urban history: "They are sites for (1) the production of specialised services needed by complex organisations for running a spatially dispersed network of factories, offices, and service outlets; and (2) the production of financial innovations and the making of markets, both central to the internationalisation and expansion of the financial industry" (Sassen 2001b:5). Whereas Friedmann's world city concept is characterised by a certain kind of timelessness, the global city model marks a specific socio-spatial historical phase (Sassen 2001b:349). In this regard, it could be argued that most of today's major world cities are also global cities, but there may well be some global cities today that are not world cities in the sense of Friedmann's initial concept. For example: "the fact that Miami has developed global city functions beginning in the late 1980s does not make it a world city in that older sense of the term" (Sassen 2001a:xix).

Space of flows

Another heuristic framework about global network economies is provided by Manuel Castells' highly influential concept of a *space of flows* (Castells 2000). The main point of Castells' argument is that technological networks have given rise to a shift from a *world* economy to a *global* economy: "A global economy is a historically new reality, distinct from a world economy. A world economy, that is an economy in which capital accumulation proceeds throughout the world, has existed in the West at least since the sixteenth century, as Fernand Braudel and Immanuel Wallerstein have taught us. A global economy is something different: it is an economy with the capacity to work as a unit in real time on a planetary scale. While the capitalist mode of production is characterised by its relentless expansion, always trying to overcome limits of time and space, it is only in the late twentieth century that the world economy was able to become truly global on the basis of the new infrastructure provided by information and communication technologies. This globality concerns the core processes and elements of the economic system" (Castells 1996:92p).

According to Castells, a consequence of this emerging global economy is a new spatial logic that is determined by the pre-eminence of the space of flows over the space of places (Castells 2000). By the space of flows Castells (2000) refers to the system of exchange of information, capital and power that structures the basic processes of societies, economies and states between different localities, regardless of localisation: "…our society is constructed around flows: flows of capital, flows of information, flows of technology, flows of organisational interaction, flows of images, sounds, and symbols. Flows are not just one element of the social organisation: they are the expression of processes *dominating* our economic, political, and symbolic life (…). Thus, I propose the idea that there is a new spatial form characteristic of social practices that dominate and shape the network society: the space of flows" (Castells 2000:442, italic in original). In other words, the dominant form of space in the network society is no longer the space of places, it is a new space of flows, in which places do not disappear but they become defined by their position within the space of flows (Castells 2000).

But what are the real driving forces of the space of flows and how are they actually defining the space of places? The clearest expression of what is meant by the space of flows is provided by Castells (1989) in his earlier work *'The Informational City: Information, Technology, Economic Restructuring and the Urban-Regional Process'* (Castells 1989). Since then, key elements of Castells' spatial argument have remained more or less unchanged (Taylor 2004b; Sokol et al. 2008). The starting point of Castells' (1989) theorisation is that the emergence of ICTs has induced the transformation of the society toward an informational mode of development. Through this transformation process, the economy becomes increasingly informational, because "the production of surplus derives mainly from the generation of knowledge and from the processing of necessary information" (Castells 1989:136). Key players in this informational mode of development are large-scale organisations, such as TNCs. Particularly, it is a "nucleus of information-intensive industries whose organisation and spatial logic occupies the top of the functional and economic corporate hierarchy" (Castells 1989:144). These industries correspond highly with our definition of APS firms (see Section 5.2) including banking and finance, insurance, legal service, engineering, accounting, and other business services. Thanks to new ICTs, these knowledge-intensive industries have dramatically transformed their spatial organisation, resulting in a "complex, hierarchical, diversified organisational structure" characterised by a "variable geometry depending upon time, place, and realm of activity" (Castells 1989:168). However, this variable spatial structure is not an undifferentiated process. Rather, it follows a hierarchical and functional logic, in which higher-level functions tend to be concentrated in certain privileged locations, while assembly functions are scattered over more and varied locations. Castells (1989) argues that the more information-based an industry is, the clearer is the trend toward a hierarchical pattern of locations. These locations, however, are interconnected by the means of "communication flows" leading to the fact that the "space of organisations in the informational economy is increasingly a space of flows" (Castells 1989:169).

There is much critique of Castells' work. Most importantly, several authors criticise Castells' assertion that the forces of globalisation are replacing the space of places with the space of flows. Dicken (2007) for example argues that this idea is highly misleading because every firm and every economic activity is grounded in specific locations, not only in the form of the built environment, but also in the form of localised social networks and cultural practices (Dicken 2007). Furthermore, in an empirical study of emerging cities on the Arabian Peninsula, Thierstein and Schein (2008) show that the global visibility of urban space, which specifically addresses the needs of the knowledge economy, contributes significantly to the attractiveness of cities and city districts (Thierstein and Schein 2008). Hence, at least, the space of flows and the space of places have to be seen as two different sides of the same coin. In order to understand the spatial development of Mega-City Regions, one has to consider both global network economies of non-physical functional interlocking-networks in the knowledge economy – conceptualised as space of flows – as well as the physical side of localised urban nodes – considered as spaces of place.

A second critique describes Castells' approach as too modernist and too abstract. For Thrift (2002) for example the space of flows postulated by Castells needs to be conceptualised rather differently as "…a partial and contingent affair…, which is not abstract or abstracted but consists of social networks, often of a quite limited size even though they might span the globe" (Thrift 2002:41). Similarly, Smith (2003) argues that the only people who seem to live in Castells' world are transnational elites, making the argument out of touch with the real world: "…the argument made by Castells about networks is too abstract…, too impersonal… and too unpopulated…; but it is also too immodest…, too exaggerated…, too top-down…, too alien… and too cumbersome and certain... for actually getting at what makes networks work" (Smith 2003:32p).

World city network

While Castells (2000) offers a heuristic and theoretical framework as to why globalisation requires a networked conception of cities, Peter Taylor (2004b) provides with his *world city network* approach an empirical instrument for analysing inter-city relations in terms of the organisational structure of the global economy (Taylor 2004b). Thereby, he reveals the relationships between head offices and other branches located all over the world, building theoretically on Saskia Sassen's (2001b) identification of APS as crucial actors and outcomes of globalisation and localisation processes, and Manuel Castells' (2000) notion of a space of flows (Sassen 2001b; Castells 2000). However, even though Taylor refers to these highly influential concepts, he argues that many of them – even the classics such as Friedmann (1986) and Sassen (2001b) – concentrate simply on measuring data on world city *attributes*, while ignoring the critical importance of the *relations* within the world city system. Empirical explorations of world city patterns should not only concentrate on attributes *within* but also on relations *between* cities, which are primarily generated through the location strategies of APS firms (Taylor 1997). According to Derudder et al. (2007) the global patterns that arise through the aggregation of these network strategies are not only very diverse but also include intertwining hierarchical, functional and regional structures (Derudder et al. 2007). In other words, the performance of a city depends, among others, on the global connectivity of the city, which in turn depends on the global engagement and performance of TNCs located in the city (McCann and Acs 2009).

Drawing on these conceptual guidelines, the Globalization and World Cities Study Group (GaWC) has developed a methodology for studying the formation of the world city network based on the location strategies of APS firms. Thereby, the GaWC researchers conceptualise the world city network as an interlocking network with three conceptual levels: a *network level*, which constitutes the entire world city network; a *nodal level*, which considers the individual cities and towns; and a *sub-nodal level*, which refers to the knowledge-intensive firms providing advanced producer services. According to Derudder et al. (2003) it is the latter level at which the world city network formation actually happens. With this conceptualisation, GaWC follows Sassen's (2001b) understanding of global cities as international service centres where APS are concentrated for servicing their transnational corporate clients. Through their attempts to provide seamless services to their clients across the world, APS firms create global networks of offices in cities around the world, whereby each office network represents the locational strategy of a firm to provide its global service; for example, partners and junior lawyers in worldwide offices of an international law firm may work together to arrange a particularly complex contract for a major business client. According to Taylor et al. (2008) such use of geographical spread of professional expertise is quite common in advanced services for major business clients. Thus, providers of such services invariably have large office networks within and between cities (Taylor et al. 2008). Based on this conceptualisation, the world city network can be defined as "the aggregate of the many service firms pursuing a global location strategy", whereby APS firms "inter-lock world cities into a network of global service centres" (Derudder et al. 2003:878). The mathematical specification of this interlocking network model will be presented in Section 6.1.

3.4.2 Global value chain models

Another starting point for understanding the organisational structure of global network economies is contained in the notion of the value chain, a concept established many years ago in industrial economics and in business literature. It has been used most prominently by Michael Porter (1985, 1990) and received much attention in the management community (Porter 1985, 1990) (see Section 2.2.4). According to Henderson et al. (2002) its main value lies in the emphasis of the sequential structure of interconnected economic activities (Henderson et al. 2002). In its most basic form, a value chain is "…the process by which technology is combined with material and labour inputs, and then processed inputs are assembled, marketed, and distributed. A single firm may consist of only one link in this process, or it may be extensively vertically integrated…" (Kogut 1985:15). The key questions in this literature are which business activities and technological applications should be produced in-house, and which operations tend to be outsourced to other enterprises. From a geographical point of view, of course, it is also of interest to know where these various activities are located (Gereffi et al. 2005). The question of power relationships in networks also plays a role, however. Who exercises power and over whom is power exercised? Who loses power and who wins power at the expense of others? According to Allen (2010), world city network models – as discussed above – continue to explain power as a hierarchical phenomenon and zero-sum game rather than as networked and open-ended process in its outcomes. He argues that “much of what goes on in city networks has less to do with the power of some cities to dominate others and rather more to do with the power exercised to hold the networks together, to forge the connections and to bridge the gaps. ...it is more about the power to ‘run’ the networks, to exercise power with rather than over others, than it is about domination and control” (Allen 2010: 2896p). In other words, Allen (2010) understands power more as a process, rather than a stock of powerful resources. Global value chain models take a similar perspective in explaining how global industries are organised and governed in networks (Coe et al. 2008b). Consequently, three sets of terminology have become especially prominent.

Global Commodity Chain (GCC)

An early, but still very active body of research exists on *Global Commodity Chains (GCC)*, a term popularised by Gary Gereffi in a large number of publications since 1994. The GCC framework originates in the intellectual school of world-system theory. According to Dicken (2001), the most substantial collection of papers on GCCs – see Gereffi and Korzeniewicz (1994) – arose from a meeting of the American Sociological Association held in 1992, which aimed to bring a new focus to world-system theory (Dicken et al. 2001). For Gereffi and his collaborators, global commodity chains consist of “sets of interorganisational networks clustered around one commodity or product, linking households, enterprises, and states to one another within the world-economy. These networks are situationally specific, socially constructed, and locally integrated, underscoring the social embeddedness of economic organisation (…). The analysis of a commodity chain shows how production, distribution, and consumption are shaped by the social relations (including organisations) that characterise the sequential stages of input acquisition, manufacturing, distribution, marketing, and consumption” (Gereffi and Korzeniewicz 1994:2). By analysing the governance of global production and distribution, the GCC framework pays particular attention to the power of large retailers and globally-oriented branded merchandisers (Sturgeon et al. 2008).

Global Value Chain (GVC)

In the last decade, however, the strategies of TNCs have changed quite dramatically, outsourcing many activities and developing strategic alliances even with competitors (Gereffi et al. 2005). As a result, they have become less vertically integrated and more network-orientated (Wildemann 2003). As a consequence of these structural changes, researchers at the Institute of Development Studies in Sussex have developed a second approach: the *Global Value Chain (GVC)* framework. In contrast to the GCC framework, the GVC approach attempts to delineate the varying governance structures both within and between different sectors (Coe et al. 2008b:267). Thus, the value chain is understood as providing the full range of activities that firms and workers undertake to bring a product or a service from its conception to its end-use and even beyond (Gereffi et al. 2005). According to the proponents of the GVC approach, the chain metaphor is purposely simplistic: “It focuses us on the location of work and the linkages between tasks as a single product or service makes its way from conception to end use, not because this chain of activity occupies the whole of our interest, but because it provides a systematic and parsimonious way to begin the research process” (Sturgeon et al. 2008:299).

Global Production Networks (GPN)

A major weakness of the GVC approach lies in the fact that it conceptualises the production and distribution of products and services as linear and vertically integrated process. However, as

Sturgeon (2010) argues, such processes are better understood as intertwining networks of internal and external business relations: “A chain maps the vertical sequence of events leading to the delivery, consumption and maintenance of goods and services – recognising that various value chains often share common economic actors and are dynamic in that they are reused and reconfigured on an ongoing basis – while a network highlights the nature and extent of the inter-firm relationships that bind sets of firms into larger economic groupings” (Sturgeon 2001:10). Similarly, Dicken (2007) emphasises that economic processes are not linear, but circuitous and interdependent, because each activity along the value chain depends upon many different kinds of inputs. In fact, individual value chains themselves are involved in broader production networks of intra-firm and extra-firm relations, thereby forming multidimensional webs of economic activities (Dicken 2007). Henderson et al. (2002) also underline the importance of embeddedness, both territorially and within business networks: “the mode of territorial embeddedness... is an important factor for value creation, enhancement and capture” (Henderson et al. 2002:453).

This central insight motivated a number of researchers in Manchester to develop a further, more comprehensive approach: the *Global Production Network (GPN)* (Henderson et al. 2002). According to Coe et al. (2004), global production networks are defined as “the globally organised nexus of interconnected functions and operations by firms and non-firm institutions through which goods and services are produced and distributed” (Coe et al. 2004:471). They are *global*, because their interconnected nodes and links extend spatially across national boundaries and, thereby, integrate parts of various national and sub-national territories (Coe et al. 2008a). Furthermore, drawing upon insights from both the new regionalist as well as the GCC and GVC literatures, the GPN approach focuses on the “dynamic strategic coupling of global production networks and regional assets, an interface mediated by a range of institutional activities across different geographical and organisational scales” (Coe et al. 2004:469). In other words, only if regional assets match the strategic needs of the firms that are integrated in global production networks, do they become an advantage for regions to competing in the global economy. This requires appropriate institutional structures, which not only promote regional advantages, but also improve the region’s integration into global network economies (Coe et al. 2004). This conceptualisation makes clear that a region is not a tightly bounded space, but a “porous territorial formation whose… boundaries are straddled by a broad range of network connections” (Coe et al. 2004:469).

Although the GCC, GVC and the GPN frameworks provide a comprehensive tool to analyse worldwide production processes, some shortcomings have to be acknowledged. First, the study of the actual geographies of value chains remains relatively underdeveloped (Brown et al. 2010). Coe et al. (2004) even argue that the global commodity chain approach is still preoccupied with the nation-state as the main geographical scale of analysis (Coe et al. 2004). A second, more specific limitation in the value chain research is that the empirical scope of analysis has mainly been concerned with a small number of primary commodities and industrial sectors (Hassler 2003; Palpacuer and Parisotto 2003; Pilat et al. 2008; Rothenberg-Aalami 2004), thereby, paying little attention to APS enterprises. A third shortcoming – put forward by Jacobs et al. (2010) – is the fact that the value chain research has an underdeveloped set of tools for the operationalisation of the conceptual framework. There appears to be a strong preference for a qualitative, interview-based approach at the expense of quantitative research methods (Jacobs et al. 2010).

Even though there is little or no cross-referencing between the *world city network* and the *value chain literatures*, they display a remarkable conceptual overlap. They both depict fundamentally spatial models of flows (Brown et al. 2010), and take economic globalisation and the spatio-economic behaviour of firms as the holistic starting point of their analysis (Jacobs 2008). Besides these similarities, however, there are two major differences between them. The first concerns the information flow in business networks. Whereas the world city research focuses particularly on intra-firm networks of APS firms, the value chain models concentrate on extra-firm relations, global division of labour and the power that is wield within the supply chains of specific commodities or goods (Jacobs 2008). The second difference concerns the geographical scale of investigation. Whereas the world city network approach uses the city as its main spatial analytical entity, the value chain framework often remains preoccupied with the nation state as the geographical scale of analysis, which clearly reflects the world-system origins of the value chain concepts (Dicken et al. 2001) (see Figure 21).

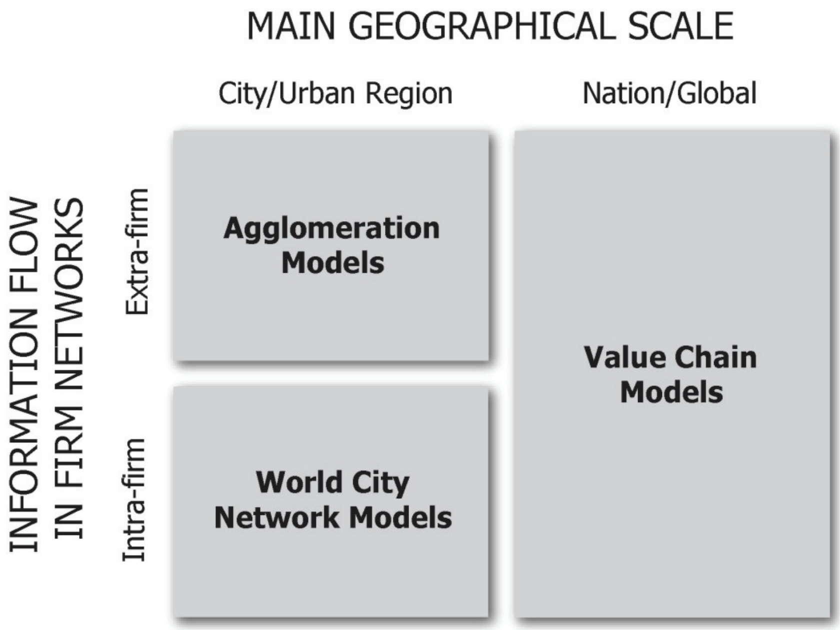


Figure 21: Agglomeration models, world city network models and value chain models (Author's illustration)

3.5 Conclusion: the spatial logic of the knowledge economy

In Chapter 3, we examined the spatial logic of the knowledge economy by analysing the spatial patterns of knowledge creation and business organisation, as well as their articulation in agglomeration economies and global network economies. In the first section, we have seen that the spatial patterns of knowledge creation lie in the specific characteristics of the innovation process. Geographical proximity influences the communication, scanning and learning patterns, as well as the sharing of localised knowledge and the innovation capabilities of knowledge-intensive firms (Howells 2000). Many authors emphasise the economic advantages of geographical proximity. However, in doing so, they also point out that there is a strong need to isolate analytically the effect of geographical proximity from other forms of proximity to determine whether geographical proximity really matters in the process of knowledge creation. Generally speaking, two broad types of proximity dimensions can be identified: (1) *geographical proximity* based on the co-location of firms in the same area; and (2) *relational proximity* based on physical infrastructure, accessibility and the organisational ability of firms to facilitate interactions, as well as more subtle conditions such as cognitive, social and institutional thickness.

In the second part of the chapter, we have identified competitive strategies of knowledge-intensive firms as important shapers of spatial development. Choosing the right location is becoming an important part of a company's strategy. Firms have different motivations to engage in transnational operations: on the one hand, *market orientation* pushes them to locate in foreign markets; on the other hand, *asset orientation* pulls them into regions, where knowledge recourses and highly skilled workers are located. Therefore, the challenge is to choose a location that is optimally in line with the present and the future requirements of the company (Dicken 2007). The outcome of this location decision-making process has a direct impact on the locational structure of the firm and the spatial organisation of its physical and non-physical assets. Different parts of the value chain have different needs in terms of location. Some business functions tend to be spatially dispersed; others are co-located with other parts of the value chain (Dicken 2007). The latter affects the competitive advantage of firms by increasing their productivity, driving the speed of innovation and stimulating the formation of new businesses (Porter 2000b).

In the third part, agglomeration economies have been highlighted as a generic geographical process, mapping the micro-economic logic of knowledge creation and business organisation. Early theories on agglomeration economies were strongly inspired by Alfred Marshall (1920), who argued that spatial concentration could confer external economies on firms as they concentrate in particular regions (Marshall 1920). Marshall's concept was taken up by Hoover (1937, 1948), who grouped the sources of agglomeration advantages into internal returns of scale, localisation and urbanisation economies. *Localisation economies*, on the one hand, reflect the tendency for firms in closely related industries to locate in the same place; *urbanisation economies*, on the other hand, arise from the diversity and the more general characteristics of a city (Hoover 1937). A few years later, Raymond Vernon developed his highly influential *product life cycle theory*, arguing that during the first innovative stage of a product's live cycle, firms are most likely to be found in large metropolitan agglomerations because of their dependence on external economies (Vernon 1966). Based on these early agglomeration theories, a second wave of agglomeration models was developed in the 1980s onwards to explain why local space is still important for newly-developing forms of production: *flexible specialisation* (Piore and Sabel 1984); *new industrial districts* (Becattini 1991); *innovative milieus* (Maillat et al. 1993); *regional innovation systems* (Cooke 1992); *new industrial spaces* (Storper and Scott 1988); and the concept of *untraded interdependences* (Storper 1995).

In the fourth part, we have demonstrated that global network economies need to be acknowledged as complementary to agglomeration economies. Five major world city network approaches have been identified. The first approach by Hall (1966) aims to identify the strategic domination of certain world cities in the world-system by analysing and ranking the locational preferences and roles of TNCs (Hall 1966). Then, building upon Hall (1966), a second approach focuses upon the decision-making corporate activities and power of TNCs in the context of the new international division of labour. This approach – which includes key works such as Friedmann and Wolff (1982) and Friedmann (1986) – has not only enriched the theoretical approach of world city studies, it has also been a major catalyst for the works in the 1990s. A third approach associates cities with their propensity to engage with the internationalisation and concentration of APS in the world economy. The key work here is undoubtedly Saskia Sassen's *The Global City* (Sassen 1991). Soon after, Castells' (1996) immensely influential concept of a space of flows contrasts the traditional space of places (Castells 1996). And finally, Peter Taylor's (2004b) *World City Network* approach analyses inter-city relations in terms of the organisational structure of the global economy, viewing world cities as global service centres connected into a single worldwide network of APS firms (Taylor 2004b).

Whereas these *world city network models* focus particularly on intra-firm networks of APS firms, *value chain models* concentrate particularly on extra-firm relations and the global division of labour, value and power within the supply chains of goods (Gereffi et al. 2005). The *Global Commodity Chain* framework pays particular attention to the powerful role that large retailers have come to play in the governance of global production and distribution (Sturgeon et al. 2008). The *Global Value Chain* approach attempts to delineate the varying governance structures both within and between different sectors (Coe et al. 2008b). And *Global Production Networks* can be defined as the globally organised nexus of interconnected functions and operations through which goods and services are produced, distributed and consumed (Coe et al. 2004).

At this point, it is important to emphasise that the distinction between agglomeration economies and global network economies is not intended to create a dichotomy between local and global economies. Indeed, the debate on this subject was initially polarised around a dualism between 'local' and 'global'. On the one hand, local knowledge, interpersonal ties, institutions and embeddedness have been stressed. On the other hand, the new possibilities of global travel, ICT, supply-chaining and organisational networking within TNCs, have been focused on. More recently, however, both sides have started to acknowledge that local and global ties contribute importantly to knowledge generation within and between firms on different spatial scales (Amin and Roberts 2008). Cabus and Vanhaverbeke (2006), for example, underline that jumping geographical scales becomes a major part of entrepreneurial strategies in order to maximise network economies (Cabus and Vanhaverbeke 2006). Various empirical studies indicate that trans-local relational learning networks are the key to understand the process of local and non-local learning (Faulconbridge 2007). Bathelt et al. (2004) point out that companies actively try to stimulate learning processes by building 'pipelines' to transmit information across agglomerations: "A well-developed system of pipelines connecting the local cluster to the rest of the world is beneficial for the cluster in two ways. First, each individual firm can benefit from establishing knowledge-enhancing relations to actors outside the local cluster. Even world-class clusters cannot be permanently self-sufficient in terms of state-of-the-art knowledge creation. New and valuable knowledge will always be created in other parts of the world and firms who can build pipelines to such sites of global excellence gain competitive advantage. Second, it seems reasonable to assume that the information that one cluster firm can acquire through its pipelines will spill over to other firms in the cluster through local buzz (…). This is why a firm will learn more if its neighbouring firms in the cluster are globally well connected rather than being more inward-looking and insular in their orientation" (Bathelt et al. 2004:45f). According to Sturgeon et al. (2008), such external pipelines have different dimensions: an *organisational* dimension reflecting intra-firm subsidiaries or extra-firm relations along the value chain; an *interpersonal* dimension embodied in the routine travel of managers or through the use of advanced ICT systems; and an *institutional* dimension in the form of communities that meet online or in conventional face-to-face meetings and conferences (Sturgeon et al. 2008:300).

All in all, it is important to acknowledge that the process of knowledge creation is embedded in a multi-scalar set of networks ranging from the global, through the national and the regional, to the local scale. In fact, knowledge-intensive firms have to make far more complex decisions regarding the geographical and organisational coordination of their activities than the simple global-local dichotomy suggests (Dicken 2007). Hence, the insights of both approaches – agglomeration economies and global network economies – need to be integrated more explicitly into the research agenda. What is needed is an analytical framework that can accommodate the full range of spatial scales at work (see Section 5.3).

4. The Mega-City Region model

Based on the theoretical discussion of above, the following chapter will elaborate on a new spatial form emerging in advanced economies: the functionally polycentric Mega-City Region. The discussion will be organised in three steps. First, the Mega-City Region model is presented by synthesising the main theoretical reasoning, which explains the inter-relationship between the functional and the spatial logic of the knowledge economy. Secondly, the main building blocks of polycentric Mega-City Regions are emphasised. And finally, there are three key hypotheses, which define the main focus of the empirical study in this thesis.

4.1 The Mega-City Region model

The Mega-City Region model hypothesises that the emergence of polycentric Mega-City Regions is the result of the inter-relationship between the functional and the spatial logic of the knowledge economy. On the *micro-scale*, there is the functional logic of knowledge-intensive enterprises, which manage their businesses in order to create new knowledge and to sustain competitive advantage; on the *meso-scale*, agglomeration economies are encouraging economic activities in metropolitan regions; and on the *macro-scale*, global network economies are connecting business activities located all over the world (see Figure 22 further below). The strategic coupling of these three conceptual scales might bridge what Morgan (2007) describes as the "debilitating binary division between territorial and relational geography" in regional studies (Morgan 2007:1248). Similarly, Rozenblat (2010) argues that agglomeration economies (meso-scale) create multiplier-effects, which strengthen the efficiency of inter-urban linkages (macro-scale) and therefore affect the centrality of cities in global business networks (Rozenblat 2010:2841). However, it is important to emphasise that these scales are not fixed; rather, they represent the extreme points of a continuum of complex mutual interactions.

Micro scale: The knowledge economy

A key driver behind the development of polycentric Mega-City Regions is the functional logic of the knowledge economy. Firms that are engaged in innovation processes need constantly to create new knowledge and to manage these knowledge resources in an appropriate organisational structure. These knowledge creating and managing processes lead to the fact that most corporations develop their location network as part of their overall business strategy in order to compete successfully on global markets.

Creating new knowledge: The creation of new knowledge lies at the centre of the knowledge economy (Cooke 2002). Considering the knowledge intensity of various economic sectors, it becomes clear that knowledge creation has become increasingly complex in recent years. Firms are using a large variety of knowledge sources and they are collaborating with many actors along the value chain. Knowledge creation requires both tacit and explicit knowledge since tacit insights are needed to interpret explicit knowledge meaningfully. Even though skills and experiences are highly individual, knowledge creation is a collective process, since specialised activities require an increase of information exchange and a strong interaction of people within organisations and between them. The purpose of creating new knowledge is to transfer it into innovation, which is to create new products, new production methods, new services, new markets or new organisational structures. The continuous development of innovations enables knowledge-intensive firms to benefit from temporary monopoly profits and to sustain competitive advantage.

Managing business organisations: The knowledge-creating process can be optimised through qualified knowledge management concepts. According to Picot and Scheuble (1999), an effective knowledge management system is a prerequisite for being competitive in knowledge based global economies. One of the most important aspects of knowledge management is the creation of intra-firm and extra-firm structures in order to improve the transfer of information within and between companies. Intra-firm structures, on the one hand, provide an internal framework in order to identify, communicate and transfer information between different business units. Central in this regard is the progress made in ICT and the development of standardised databases and workflow systems. Extra-firm structures, on the other hand, intend to integrate external knowledge sources in order to increase efficiency and performance (Picot and Scheuble 1999). Picot et al. (2008) argue that the specific design of intra-firm and extra-firm structures depends on whether tacit or codified knowledge is involved in the organisational design. Thereby, firms have to check whether face-to-face communication is preferable, whether knowledge of certain experts can be codified, and whether knowledge brokers – e.g. consulting firms – should be employed (Picot et al. 2008).

Strategic location decision: Based on the requirements for knowledge creation and business organisation, most corporations in the knowledge economy develop their location network as part of their overall business strategy. This strategy considers both where a firm's internal functions should be placed and where suppliers and customers should be located. In the context of the knowledge economy, location-specific factors such as access to information and access to a highly skilled labour force are becoming increasingly important. As we have seen above, the concentration of knowledge in specific places creates a strong incentive for firms to locate their internal operations in such locations all over the world. In doing so, they can split their activities into units and localise them in the most favourable places in terms of local knowledge resources and industrial culture. In these places, they can establish external networks to suppliers, subcontractors and business clients in order to source local skills and specialised expertise. These internal and external linkages are woven across physical space, not only connecting firms and parts of firms together, but also more or less dispersed cities and towns (Dicken 2007).

Meso scale: Agglomeration economies

The functional logic of the knowledge economy has significant impacts on agglomeration economies in metropolitan areas. Agglomeration economies are based on the fact that the 'whole' is greater than the sum of its parts. Generally speaking, they result from the clustering of knowledge-intensive firms in certain areas enabling them to benefit from geographical proximity, urbanisation and localisation economies as well as from traded and untraded interdependencies, which finally leads to the creation of local knowledge resources.

Local clustering: Organisations can facilitate their innovation process by co-locating with other firms and institutions. The competitive advantage of knowledge-intensive firms is often heavily local, arising from concentrations of highly specialised skills, institutions, rivals, related businesses, and sophisticated customers (Porter 1998). Especially higher-level functions – such as control and coordination functions, or research and development functions – tend to be concentrated in certain privileged locations. This local clustering of economic activity affects the competitive advantage of firms by increasing their productivity, driving the speed of innovation and stimulating the formation of new businesses (Porter 2000b).

Geographical proximity: The result of this local clustering process is geographical proximity, which enables regular personal communication and the exchange of tacit forms of information between the economic actors. Geographical proximity advances urbanisation and localisation economies (Hoover 1937): Urbanisation economies enable firms to share the costs of a variety of services. They encourage the establishment of a whole range of infrastructural, economic, social and cultural facilities, which cannot be provided in small locations, where customers and suppliers are spatially dispersed. Localisation economies, on the other hand, arise as a particular industry concentrates in a given location. This enables highly specialised firms to communicate at lower cost, and to benefit from infrastructure with specific properties. Urbanisation and localisation economies lead to the development of traded and untraded interdependencies (Storper 1995): Traded interdependencies are direct transactions between firms, e.g. input-output relations along the value chain. Untraded interdependencies, by contrast, are the less tangible benefits, based on regional labour markets, conventions, norms and values.

Local knowledge creation: Traded and untraded interdependencies play a decisive role in the creation of local knowledge resources. According to Howells (2000), the importance of face-to-face contacts in communication and the tacit quality of much of this communication still make geographical proximity a crucial factor in knowledge creation. This leads to the tendency for localised knowledge pools to develop around specific activities, which are characterised by personal contacts and informal information flows, both within and between firms of the knowledge economy. The spatial concentration of these information-flows influences the communication, scanning and learning patterns, as well as the sharing of localised knowledge and the innovation capabilities of knowledge-intensive firms (Howells 2000).

Macro scale: Global network economies

The functional logic of the knowledge economy not only has significant impacts on agglomeration economies, but also on global network economies. Global network economies are based on the advances achieved in information and communication technologies. They result from global sourcing strategies of knowledge-intensive firms, which establish global networks in order to benefit from relational proximity and global information exchange.

Global sourcing: Although there is strong evidence that knowledge is highly concentrated in a minority of city-regions, it is unlikely for a firm that all the knowledge required for innovation can be found within a single region. Companies spread their activities globally in order to source inputs and gain access to emerging markets (Porter 1998). According to the OECD (2008), international R&D-investments of TNCs have increased considerably. Many TNCs pursue a strategy of global technology sourcing. Thereby, networks of globally distributed R&D facilities are established so as to tap into local knowledge pools and to gain access to new technologies (OECD 2008). According to the modern evolutionary theory (Nelson and Winter 1982; Dosi et al. 1988), intra-firm networks of large TNCs provide important vehicles for transferring information and research findings all over the world (Henderson and Castells 1987; Thrift and Taylor 1982). High-Tech industries, for example, increasingly use global sourcing to improve existing expertise or even to create completely new technological assets by locating R&D facilities abroad (OECD 2008).

Relational proximity: Global sourcing leads to relational proximity between economic actors, with time proximity and organisational proximity being especially important (see Section 3.1.3). Time proximity is supported by a well-developed transport and communication infrastructure, such as fast and frequent trains and flights, plus easy access to interactive communication systems. This brings an enormous amount of potential suppliers and customers within the reach of knowledge-intensive firms, without demanding enduring co-location and local embedding (Amin and Cohendet 2004). Organisational proximity, on the other hand, is needed to control uncertainty and opportunism in the knowledge creation process (Boschma 2005). It creates a sense of belonging, facilitates interaction and provides a powerful instrument for long-distance coordination (Torre and Rallet 2005). The key idea of relational proximity is nicely described by Amin and Cohendet (2004): "The everyday possibility of striking and maintaining distant links, the everyday possibility of action at a distance, the everyday possibility of relational ties over space, the everyday possibility of mobility and circulation, the everyday organisation of distributed systems, make mockery of the idea that spatial proximity and 'being there' are one and the same" (Amin and Cohendet 2004:108).

Global information exchange: Relational proximity enables the establishment of global networks: world city networks and global value chains. These networks reflect the process of economic globalisation and the spatio-economic behaviour of knowledge-intensive firms. Whereas world city networks focus particularly on intra-firm networks of APS firms, global value chains concentrate on extra-firm links, global division of labour and the power relations within the supply chain of goods (Jacobs 2008; Lüthi et al. 2010b). The advantage of global information exchange is associated with the potential to use global knowledge to stimulate local interpretations. Access to external sources of information is a significant factor in the competitive advantage of the knowledge economy. In this sense, the process of knowledge creation must be understood as "an international system that encompasses both local and international knowledge spillovers and multilayered economic linkages extending over several different spatial scales" (Simmie 2004:1103).

The emergence of functionally polycentric Mega-City Regions

At the intersection of agglomeration economies and global network economies, a new form of urbanisation is emerging in advanced economies: the functionally polycentric Mega-City Region, characterised by "a pattern of extremely long-distance de-concentration stretching up to 150 kilometres from the centre, with local concentrations of employment surrounded by overlapping commuter fields" (Hall 2007:6). Based on the functional logic of the knowledge economy, I argue that polycentric Mega-City Regions are the outcome of a spatial up-scaling process of agglomeration economies and a spatial concentration of global network economies in a large-scale urban setting. In this sense, Mega-City Regions represent a re-scaling of the strategic locations of the knowledge economy.

Spatial up-scaling of agglomeration economies: The most distinctive attribute of polycentric Mega-City Regions is their vast scale. According to Hall (2004), in the last forty years, de-concentration has become extremely complex. The result is a highly polycentric metropolitan system, characterised by accelerated growth in and around smaller cities and towns in the wider metropolitan orbit of one or several big cities (Hall 2004). A number of factors make the spatial up-scaling of agglomeration economies highly relevant to the expansion of the urban landscape: e.g. the rapid decentralisation of economic activities; the increased mobility due to new transport technologies; the multiplicity of travel patterns; or the existence of complex cross-commuting (Davoudi 2003:981). Obviously, the up-scaling process of agglomeration economies is highly determined by the achievements realised in transportation and telecommunications technologies. Hall (2009), for example, emphasises that the costs of several modes of transport and communication have drastically declined and, in some cases, speed and reliability have significantly improved. New infrastructures in the form of high-speed trains stimulate the transformation of relations in time and space and further the dispersal of urban development (Hall 2009). Castells (2000) argues that new communication technologies make it possible to relocate operations – particularly back offices – in the borderland of Mega-City Regions: "The peripheries of major metropolitan areas are bustling with new office development, be it in Walnut Creek in San Francisco or Reading near London. And in some cases, new major service centres have sprung up on the edge of the historic city, Paris' La Défense being the most notorious and successful example" (Castells 2000:416). As a consequence, polycentric Mega-City Regions are increasingly enabled to achieve agglomeration economies of comparable magnitude to those of large mono-centric cities. Bound together through both physical links (motorways, high-speed rail lines, telecommunication infrastructure etc.) and non-physical links (intra-firm and extra-firm cooperation, email, telephone calls etc.) polycentric Mega-City Regions are emerging as large-scale metropolitan regions.

Spatial concentration of global network economies: The spatial concentration of global network economies is determined by the location behaviour of knowledge-intensive firms. In order to improve their added value, they need several local business conditions, such as proximity to international gateway infrastructures like airports and high-speed train nodes. Many international knowledge-intensive enterprises have already recognised the advantage of being located around airports or within the corridors between the airport and the city (Schaafsma 2008). Paradoxically, some Mega-City Regions function like hubs making long-distance access easier than local access to the core city's hinterland (Torre and Rallet 2005). Knowledge-intensive firms are also looking for high quality infrastructures such as universities with a good reputation or large settlements of leading global companies, as well as for the availability of specialised knowledge, the presence of competitors, business partners and customers as well as qualified manpower (Porter 1990). Moreover, as Castells (1989) notes, the availability of telecommunication facilities not only leads to a global dispersal of economic activities, it also actually triggers a process of intensifying concentration, because it allows TNCs to communicate easily from their headquarters with the affiliates located elsewhere. Castells (1989) argues that the impact of telecommunication infrastructure on the location of knowledge-intensive industries is to reinforce their centralisation in the higher nodal points of the knowledge economy: "it is only because of the existence of automated telecommunications and on-line equipment that offices located in a very few areas are able to extend their global reach without comparable diversification of location" (Castells 1989:149).

All in all, starting from the functional logic of the knowledge economy, the Mega-City Region model shows that local clustering and global sourcing can be compatible and mutually reinforcing business strategies, by which firms reap the benefits of local agglomerations and global-scale production. The interplay between the up-scaling process of agglomeration economies and the spatial concentration of network economies is strongly subject to increasing returns making polycentric Mega-City Regions into essential spatial nodes and engines of today's global economy. According to Hall and Pain (2006), this process of 'concentrated de-concentration' – or 'de-concentrated concentration' – generates a progressive redistribution of economic functions in space: in core cities, there is a continuing concentration of higher-order business functions, whereas in secondary cities, there is a growth of more routine functions, such as back-offices or High-Tech manufacturing (Hall and Pain 2006). However, all the cities and their functions are highly symbiotic and strongly interconnected. As a consequence, the entire Mega-City Region achieves major agglomeration economies through the concentration of economic activities in a complex system of centres and some degree of functional specialisation between them. According to Hall (2009), the more central core cities succeed in the global economy, the more they will tend to pass on the growth to other cities in their vicinity (Hall 2009). It is this two-fold process of simultaneous spatial concentration and decentralisation – both elements associated with the same dynamics of the knowledge economy – which explains the complexity of Mega-City Region development.

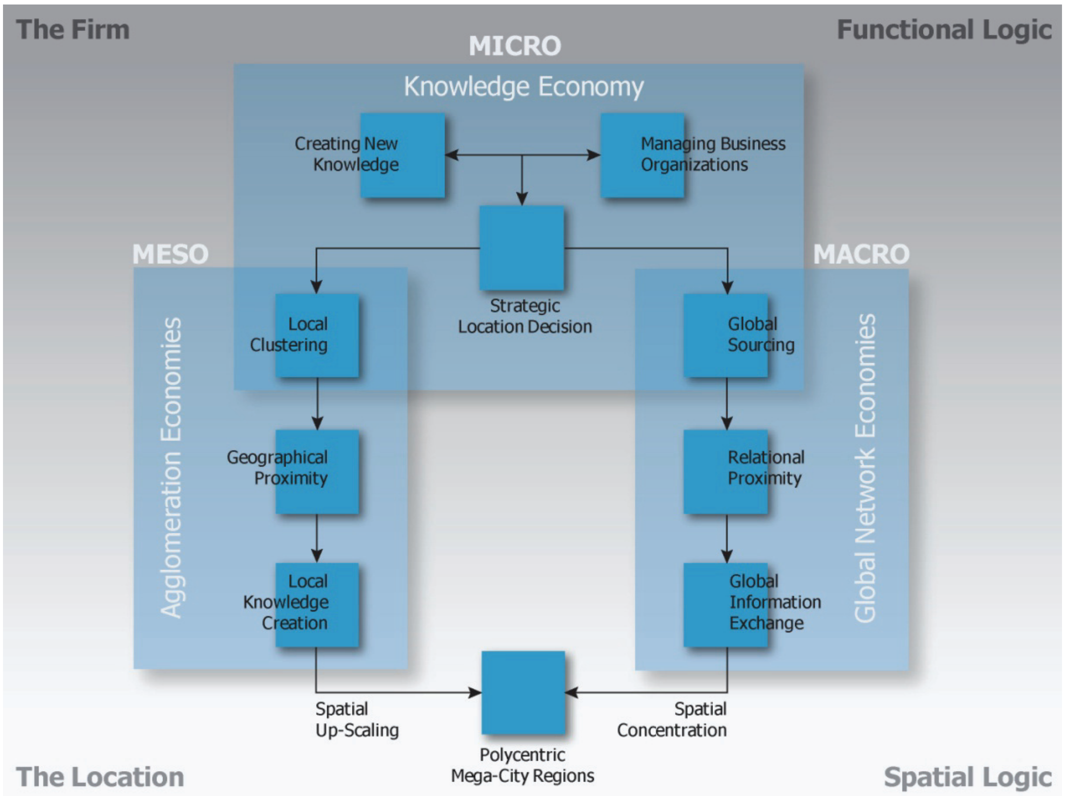


Figure 22: The Mega-City Region model (Author's illustration)

4.2 Building blocks of polycentric Mega-City Regions

The polycentric Mega-City Region is not a completely new concept. It first appeared in the classic work of Patrick Geddes: *Cities in Evolution* (Geddes 1915). Geddes argued that, especially in advanced European and North American regions, individual cities and towns tend to develop into large *conurbations*. In 1961, Jean Gottmann made similar observations in his pioneering study *'Megalopolis: The Urbanised Northeastern Seaboard of the United States'* (Gottmann 1961). A few years later, Peter Hall (1966) observed that next to the traditional "highly centralised giant city" there exists a "polycentric type of metropolis". This polycentric metropolis consists of "a number of smaller, specialised, closely-related centres" and should be understood as "a perfectly natural form, which has evolved over a period of history quite as long as the single metropolitan centre" (Hall 1966:9). The most recent rediscovery of the concept, however, has been in Eastern Asia, in areas like the Pearl River Delta and Yangtze River Delta regions in China, the Tokaido (Tokyo-Osaka) corridor in Japan, and Greater Jakarta (Hall 1999; Scott 2001).

Geddes' and Gottmann's detailed descriptions show that they analysed polycentric urban regions from a *morphological* perspective. The contemporary concept of polycentric Mega-City Regions, however, is neither defined in morphological terms, nor based on administrative units. Rather, it is defined in *functional* terms, based on Castells' concept of the space of flows: "The internal linkages of the area and the indispensable connections of the whole system to the global economy via multiple communication links are the real backbone of this new spatial unit. Flows define the spatial form and processes" (Castells 2000:439). Based on these functional considerations, we apply the definition proposed by Hall and Pain (2006) – who view polycentric Mega-City Regions as emerging through a "long process of very extended decentralisation from large central cities to adjacent smaller ones" (Hall and Pain 2006:3) or "outward diffusion from major cities to smaller cities within their spheres of influence" (Hall and Pain 2006:12). They define polycentric Mega-City Regions as:

> *"…a series of anything between ten and 50 cities and towns physically separated but functionally networked, clustered around one or more larger central cities, and drawing enormous economic strength from a new functional division of labour. These places exist both as separate entities, in which most residents work locally and most workers are local residents, and as parts of a wider functional urban region connected by dense flows of people and information carried along motorways, high-speed rail lines and telecommunications cables" (Hall and Pain 2006:3).*

The key point of this definition is that Mega-City Regions are not solely characterised by simple attributes, such as demographic size or physical settlement structures, but as socio-economic relational processes linking regions to other cities and towns on different geographical scales. In other words, Mega-City Regions are not only determined by what they contain, but especially by what their economic stakeholders *do* in the context of their day-to-day business practices (Pike 2007). Thus, Mega-City Regions are defined by their linkages among their constituent functional parts and without any predefined territorial boundaries. In this way, we are able to avoid an 'a priori' identification of Mega-City Regions and to start with firms and their functional logic driven by the knowledge economy. This definition emphasises three important characteristics of polycentric Mega-City Regions: *polycentricity*, *connectivity* and *critical size*. In turn, we shall deal with these concepts in greater detail.

Polycentricity

An essential feature of Mega-City Regions is that in different degrees they are polycentric (Pain and Hall 2008). According to Kloosterman and Musterd (2001), polycentricity has become an important feature of the urban landscape in advanced economies. Scott et al. (2001) state that "most metropolitan regions in the past were focused mainly on one or perhaps two clearly defined central cities, the city-regions of today are becoming increasingly polycentric or multiclustered agglomerations" (Scott et al. 2001:18). In a similar vein, Hall (2001) argues that contemporary global city-regions are characterised by an extremely complex and sophisticated internal geography that is "quintessentially polycentric" (Hall 2001:73).

However, the concept of polycentricity lacks a clear definition. The notion is used quite differently throughout academic literature: in regional science, it is used to analyse urban dynamism and spatial development processes; in planning, it is applied to design spatial strategies and urban development concepts; and in politics, the concept is adapted to promote normative territorial development policies (Davoudi 2007a). Often, polycentricity has been criticised as lacking in precision as well as being a normative rather than a scientific concept (Hague and Kirk 2003). Efforts to establish a unified definition have proved difficult, because the concept originates from two separate discourses: a political discourse based on strategic thinking, and a scientific discourse based on empirical observation. Today, it is generally accepted that polycentricity can be applied to describe analytical evidence *and* normative development goals. However, in order to guarantee clarity of argument, it is important to keep these two discourses strictly apart (Lambregts 2006).

The recent *political discourse* in Europe has taken its point of departure as the formation of the European Spatial Development Perspective (ESDP) (Faludi and Waterhout 2002). In this discourse, polycentricity is promoted as a key concept for EU spatial development policies, in order to develop economic potentials strong enough to counterbalance the European 'Pentagon' – the leading economic area bounded by the cities of London, Paris, Hamburg, Munich and Milan. Thereby, the concept of 'International Economic Integration Zones' has been developed in order to generate and exploit polycentric potentials (European Commission 1999:20). Hence, as Halbert (2008) argues, political polycentricity can be seen as "an evaluation of a regional system's ability to go with… its institutional fragmentation" (Halbert 2008:1150).

From an *analytical* point of view, two aspects are of particular relevance to polycentricity. First, there is *morphological* polycentricity, which refers to the distribution of urban areas in a given territory. Polycentricity then is associated with a fairly evenly sized distribution of urban centres in a given area (Hall and Pain 2006) and sometimes also with an equal spacing of these centres (ESPON 2004). Or as Halbert (2008) puts it: "…a region is … morphologically polycentric when no city is so big as to dominate others and … cities are as evenly spread over the territory as possible" (Halbert 2008:1149). Typically, morphologically polycentric regions are characterised by a flat functional urban hierarchy. One well-known way to identify this is through measuring the so called rank-size distribution. Thereby, morphological polycentricity means the ability of an urban structure "to follow a constant relation between the rank of the cities and their size" (Halbert 2008:1149).

On the other hand, there is *functional* polycentricity, which is based on the networks of flows between urban areas at different spatial scales. Following Castells' (2000) conceptualisation of a space of flows, functional polycentricity highlights the importance of exchanges between cities; not only within a specific regional system, but also beyond, potentially encompassing cities across the world. In this perspective, a polycentric Mega-City Region is made of a number of cities connected through high volumes of day-to-day information exchanges, which are also relatively well balanced in space (Halbert 2008). According to Burger and Meijers (2010), such an equal balance in the distribution of flows can be found particularly in an urban system, in which functional relations are not directed at one centre, but are reciprocal and criss-cross (Burger and Meijers 2010). The more multi-directional the flows are, the more polycentric is the functional urban system. In this sense, functional polycentricity extends the morphological approach by including patterns of interaction between different urban centres (ESPON 2004).

The complementary nature of morphological and functional polycentricity is summarised in Figure 23. Morphological aspects refer to the distribution of urban centres in a given territory, whereas functional aspects refer to networks of flows and co-operation between urban centres. Consequently, an area's morphological map may display a morphologically mono-centric pattern – i.e. one dominant city and a number of smaller centres – or a morphologically polycentric pattern – i.e. co-presence of a number of cities of more or less equal size. In a similar fashion, an area's functional map may display a functionally mono-centric pattern – i.e. relations are predominantly oriented towards one centre – or a functionally polycentric pattern – i.e. relations have no obvious orientation (ESPON 2004; Burger and Meijers 2010).

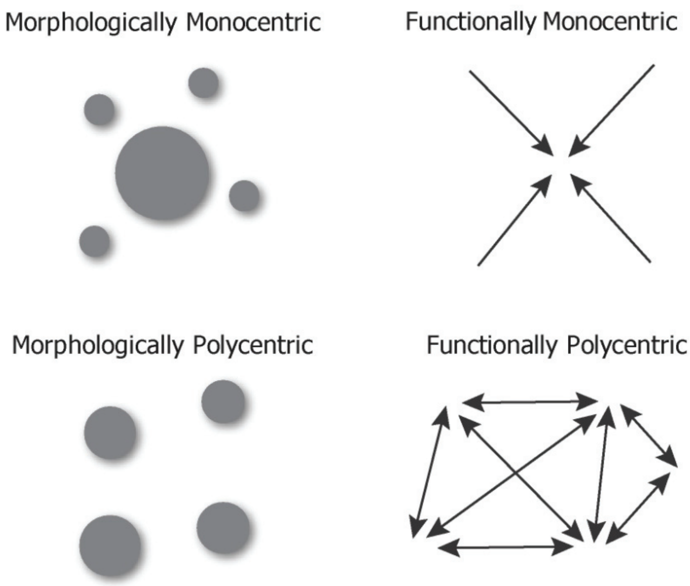


Figure 23: Two complementary aspects of polycentricity
(ESPON 2004; Burger and Meijers 2010)

Davoudi also points out the changing meaning of polycentricity at different spatial scales (Davoudi 2003, 2007a). At the *intra-urban scale*, the concept has been used to describe a shift from monocentric urban settings – captured in concentric zone models – towards urban structures with centres and sub-centres generating cross-cutting traffic in complex spatial patterns. For example: new retail centres located beyond the city centre; the diversified location of urban functions due to the splitting of 'front' and 'back' office needs; the diversification of household traffic due to two earner households and new transport needs caused by shopping and leisure (ESPON 2004; Davoudi 2007b).

At an *inter-urban* scale, polycentricity is described as an emerging urban form, in which economic activities are distributed over several cities of similar size without dominance of specific urban centres (Pain 2008:1163). Thereby, the focus is on polycentric urban regions (PURs). According to Kloosterman and Musterd (2001:628), PURs are assumed to have – at least – the following characteristics: (1) they consist of a number of historically distinct cities that are located in more or less close proximity – roughly within commuting distances; (2) they lack a clear leading city that dominates in political, economic, cultural and other aspects. Instead, they tend to consist of a small number of larger cities that do not differ that much in terms of size or overall economic importance, together with a greater number of smaller towns; (3) the member cities are not only spatially distinct, but also constitute independent political entities (Kloosterman and Musterd 2001). Alternatively, in the ESPON 111 project on the *'Potentials for polycentric development in Europe'*, a polycentric urban system is associated with a functional division of labour, economic and institutional integration, and varying degrees of political co-operation (ESPON 2004). These two examples show that different authors emphasise quite different aspects in their conceptualisation of inter-urban polycentricity. Whereas Kloosterman and Musterd (2001) focus on morphological, historical and administrative factors, the ESPON researchers emphasise particularly relational aspects of inter-urban polycentric development (Lambregts 2008b).

At the *inter-regional scale*, polycentricity refers to the expansion and spatial integration of metropolitan regions at a continental level – for example conceptualised as 'megapolitan regions' in the US context (Lang and Knox 2009). In Europe, these emerging urban corridors have been described as 'Golden Triangle', 'Blue Banana' or 'Pentagon' (Davoudi 2007a:68). The latter is characterised in the ESDP as the only major geographical zone of global economic integration in Europe, representing 40 per cent of the EU's population, 20 per cent of its territory and 50 per cent of its GDP (European Commission 1999:61). The Pentagon is regarded as the only economic area in Europe that is able to compete with the huge urban corridors in East Asia, which are "absorbing an increasing proportion of their countries' population and economic growth" (Choe 1998:159). However, recent studies provide evidence that the financial support for polycentric development at the European level tends to reinforce more monocentric urban patterns at the national level, mostly at the expense of peripheral and lagging regions (Davoudi 2007a; ESPON 2004). According to Davoudi (2007a), this is partly because only major urban centres have the critical mass, the infrastructure and the institutional capacity, which is needed to absorb and deploy the EU resources effectively (Davoudi 2007a:68).

All in all, the great variety of approaches to polycentricity shows that the concept is currently used in a very loose way. Indeed, it can be characterised as a rather fuzzy concept (Markusen 1999). As the ESPON (2004) report states, polycentricity has remained largely rhetorical, especially at the European level. Neither a method to measure polycentricity at different spatial scales is available, nor an instrument to assess the impacts of polycentric development in terms of competitiveness, cohesion and sustainability. Therefore, it makes little sense to determine the optimal level of polycentricity, which might be somewhere between total monocentricity and full spatial dispersal (ESPON 2004). According to Lambregts (2008b) it is the combined use of different definitions which makes the conceptualisation of polycentricity and its measurement so difficult. On the analytical side, morphological and functional definitions are mixed. Additionally, there is the normative side, which interprets polycentricity as a forward-looking political strategy to promote social, economic and spatial cohesion (Lambregts 2008b). This conceptual confusion has led many authors to call for further conceptual and empirical work (Kloosterman and Lambreghts 2001; Davoudi 2003; Parr 2004, 2005; ESPON 2004; Lambregts 2006; Meijers 2007; Hoyler et al. 2008b; Lambregts 2008a; Kloosterman and Musterd 2001; Lambregts 2008b).

Connectivity

A second essential characteristic of polycentric Mega-City Regions is their functional connectivity, enabling them to benefit from flows of information on different geographical scales. According to Hall (2001), information moves in two ways: physically inside people's heads, for example via direct face-to-face exchange; and non-physically in the form of e-mail and telecommunication, for example within branch office networks of knowledge-intensive firms. Physical connectivity may occur on a daily basis in the form of commuting, or less frequently in the form of face-to-face business meetings (Hall 2001).

Increasingly, commuting takes place not only within the city and its suburbia, but also at the scale of two or more cities within polycentric urban regions (Kloosterman and Musterd 2001). For Blumenfeld (1971), a reasonable travelling time from the outskirts to the centre had to be "no more than forty minutes" (Blumenfeld 1971:61p). For others, the broad rule for a convenient commuting distance is one hour (Geddes 1915; Bailey and Turok 2001; Camagni 2001). Whilst most commentators have used the latter as the maximum commuting distance, Batten (1995) has argued for the lower limit of half an hour (Batten 1995). More recently, studies undertaken under the ESPON program have used a measure of forty five minutes driving time as a proxy for identifying potential Functional Urban Areas (FUAs) across Europe (ESPON 2004). In all these examples, lines of equal time-distance to and from the city – i.e. time-isochrones – are used to define the extent of polycentric urban regions (Davoudi 2007b). However, the faster people can travel, the farther they commute within their time budget. According to Camagni (2001), the higher speed in travelling has not shortened commuting times. It only increased the travel distance: "commuting times show a remarkable stability through time in all territorial systems, leading many scholars to think about an anthropologic constant in the form of a fixed time-budget constraint, averaging one hour, for daily trips in all societies" (Camagni 2001:109). In the Netherlands, for example, the distance travelled a day per head for business reasons increased by 40 per cent between 1985 and 1998. Empirical evidence suggests that this increase is the result of a growing share of commuting between different urban regions (Kloosterman and Lambreghts 2001). In Switzerland, both travel time and distance have increased in the last 25 years. Between 1984 and 2005, commuting time has increased by 41 per cent, from about 70 to 98 minutes; and also commuting distance has increased from about 29 to 38 km (BFS and ARE 2007). All in all, as we have seen in the previous section, this will lead to an outward expansion of the boundaries of polycentric Mega-City Regions, which in turn requires an upward shift in the spatial scale of analysis. This trend is even intensified as one considers not only commuting from home to work, but also shopping and especially leisure mobility (Kloosterman and Musterd 2001).

Another basic feature for polycentric Mega-City Regions is international accessibility. According to van Winden et al. (2007), it is absolutely crucial for a city to have a good international, regional and multimodal accessibility in order to acquire, create, disseminate and use knowledge resources effectively (van Winden et al. 2007:532). Equally, Simmie (2002) argues that hub-airports are critical factors for cities as nodes in global knowledge networks, because they facilitate face-to-face contacts with international partners and enable cities to combine a rich local knowledge base with international knowledge resources in designing and specifying innovations (Simmie 2002). Frequent and direct flights to the major business centres in the world enable a city to "receive, accommodate, move around and send off the carriers of tacit knowledge disguised as travelling executives, project teams, specialists and the like" (Lambregts 2008a:1183). Hence, international accessibility is a crucial competitive asset for large cities and city-regions, whereas, for provincial cities, the lack of international connectivity can be a serious constraint in their economic competitiveness (van Winden et al. 2007).

However, traditional physical measures of functional regions – such as commuting catchment areas – are only partially relevant at the Mega-City Region level. Often, these areas are simply too big to make many daily trips possible. Another integrating force is non-physical business linkages. According to Hall (2001), these kinds of business connections are of particular importance for the strongly communicative corporations in the knowledge economy. Many of today's knowledge workers are no longer present in the office five days a week. Rather, they work directly at the customer's location, or they operate from their home office, which often is in a considerable distance from the company's office location. If internal face-to-face contact is needed, they travel through air or high-speed rail connections to the meeting place, which might be located in the traditional downtown area, at the airport, or even in another metropolitan centre (Hall 2001). This gives people the flexibility to live at greater distance to the workplace, either in remote urban quarters or in nearby agglomerations. This does not mean that direct face-to-face contacts are unimportant. This kind of direct physical communication, however, may be used for very specific types of information exchange, for example for building trust, strategic networking or acquiring important jobs (Lang and Knox 2009).

Although physical and non-physical connectivities have different impacts on the development of polycentric Mega-City Regions, they have to be accepted as complimentary processes. Evidence from France, for example, shows that telecommunication traffic and personal travel have advanced almost at the same rate over a long period of time (Hall 2004). This means that the more people use non-physical communication in their business activities, the more they need to meet each other face-to-face, and vice versa. As a result, non-physical connectivity, based on the World Wide Web and new communication tools, has become just another infrastructure, which supports the geographical concentration of economic activities and strengthens the contemporary functional urban hierarchy (Choi et al. 2006). For the internal geography of polycentric Mega-City Regions, the combination of physical and non-physical forms of connectivity implies a huge complexity and sophistication. Even though traditional meeting points in the city centre keep their importance, they tend to be supplemented by new kinds of nodes for face-to-face interaction, for example conference centres at airports or high-speed train stations (Hall 2001).

Critical size

A final important feature of polycentric Mega-City Regions is critical size. Many authors argue that – in comparison to large mono-centric cities – polycentric Mega-City Regions provide a better balance between economies and diseconomies of scale. By 'borrowing size' (Alonso 1973) from each other, the various centres of polycentric Mega-City Regions are assumed to create strong network externalities. Because of that, they are able to achieve a sufficient scale to sustain competitive advantage (Lambregts 2008b). Blotevogel (2002) argues that a minimum of 1.5 to 2 million inhabitants are required to guarantee a more or less complete range of metropolitan functions

(Blotevogel 2002). Sassen (2007) draws attention to the fact that in such regions multiple types of agglomeration economies – urbanisation and localisation economies – may co-exist, which provides a favourable range of different services for knowledge-intensive firms (Sassen 2007). According to van Winden et al. (2007), the sheer size of an urban configuration matters as an attraction factor for both companies and knowledge workers. For companies, it is easier to find specialised staff and suppliers, which are important sources of new ideas and creativity. For knowledge workers, on the other hand, large metropolitan regions guarantee a variety of different jobs and increase the probability of finding an adequate position. Furthermore, a large urban size ensures the availability of cultural and social amenities as well as specific infrastructures, such as international schools or hub-airports, connecting the city to the major business centres in the world (van Winden et al. 2007). All in all, for firms located in polycentric Mega-City Regions, the combination of agglomeration economies, generated on a large metropolitan scale, with network economies stretching over different spatial scales, provides the necessary critical mass in terms of knowledge resources to compete successfully in the global economy.

4.3 Mega-City Regions in Germany – three hypotheses

The purpose of this contribution is to elaborate to the question of how German cities are integrated into the world city network by the functional logic of the knowledge economy. Starting from the theoretical and conceptual considerations of above, I propose three interrelated hypotheses with respect to the German space economy, each of them representing another dimension of the Mega-City Region model: the first hypothesis relates to the *horizontal* dimension and elucidates the Mega-City Region's spatial expansion; the second hypothesis refers to the *vertical* dimension by reasoning the functional urban hierarchy within and between Mega-City Regions in the context of the knowledge economy; and the third hypothesis represents the *functional* dimension and explains the strategic behaviour of knowledge-intensive enterprises. As these hypotheses are stated, I shall follow with a short comment, in which they are explained or further questions are posed.

Hypothesis 1: A multiplicity of high-grade APS and High-Tech locations creates interlinkages between cities and towns at an extended regional scale, leading to a new spatial phenomenon in Germany: polycentric Mega-City Regions.

This hypothesis understands polycentric Mega-City Regions as spatial structures configured across increasingly extensive geographical scales. The increasing complexity of network economies leads to a kind of paradox associated with the emergence of polycentric Mega-City Regions. The inter-urban functional linkages are found to be extending and intensifying while, at the same time, global functions are clustering and centralising. Evidence from previous research suggests that these apparently contradictory processes are intersecting at the Mega-City Region level (Lüthi et al. 2010b; Hall and Pain 2006; Thierstein et al. 2006). While specialised global functions are concentrating in 'first cities', proximate regional centres are gaining complementary service functions across a wide geographical area. Cities that formerly were independent centres – each servicing their own hinterlands – have become mutually dependent. This process has led to a concentration of flows around the largest cities, forming what may be characterised as functional mergers of cities (Hall and Pain 2006). Because of the various requirements for competing in the world economy, it is not possible for a first city to act without the smaller agglomerations in its vicinity. Smaller cities fulfil an important role as complementary economic spaces within a system of localised value chains.

Interlocking networks of knowledge-intensive firms link these different agglomerations together, thus defining Mega-City Regions as physically separated but functionally networked socioeconomic spaces (Hall and Pain 2006; Thierstein et al. 2006). Furthermore, polycentric Mega-City Regions are developing into spatial systems of socioeconomic added value interconnecting different value chains of knowledge-intensive enterprises. Under these conditions, there is an elevated potential for the development of new products and services requiring upstream and downstream inputs and customers (Lüthi et al. 2010b).

Hypothesis 2: Global network economies create a steep functional urban hierarchy in the German space economy, in which only few agglomerations establish substantial international connectivity; in terms of national and regional connectivity, this functional urban hierarchy is less pronounced.

From the seminal work of Peter Hall (1966) about the characteristics of world cities to the pioneering work of Saskia Sassen (2001b) about the global city, the central aim of the world city research tradition has long been to evaluate the economic power of cities and their position within a world city hierarchy (Beaverstock et al. 1999a). The spatial logic of the knowledge economy shows that, in a minority of regions, the capacity to acquire new knowledge is much higher than in the majority of regions. As Simmie (2003) emphasises, much information is transferred between these regions, because they are often the locations of leading-edge knowledge in specialised activities. As a result, a functional urban hierarchy has emerged. This hierarchy, however, is not defined as command-and-control hierarchy – as found in the organisational chart of a company – but as *functional urban hierarchy* based on (i) the strategic locational choice of multi-branch firms, and (ii) their use of cities and regions as locations of value-adding activities. According to Simmie (2003), it is to be expected that – as a result of cumulative causation – these regions will tend to diverge from rather than converge with regions lower in the hierarchy (Simmie 2003). Indeed, many indicators point to a strengthening of the functional urban hierarchy in the world economy (Michelson and Wheeler 1994). Growth predicated on a global market orientation seems to induce more discontinuity in regional economies (Sassen 2001b). In this context, this hypothesis relates to the question to what extent the functional urban hierarchy within and between Mega-City Regions in Germany is associated with different spatial scales and sectors of knowledge-intensive activities. How has the globalisation of economic activity affected this highly polycentric 'national' urban system? Are German cities parts of two distinct urban configurations, one nation-based, reflecting the federal structure of Germany, the other linking into a global network of cities? Do global network economies increase disparities within the German national urban system? Does the mere size of an agglomeration automatically increase its functional significance? Previous studies of APS networks in European Mega-City Regions show that network connectivities vary with the geographical scale of services, with global services being highly concentrated in 'first cities' (Hoyler et al. 2008b; Taylor et al. 2008; Thierstein et al. 2008). In this contribution, we investigate whether this also applies to the German functional urban system as a whole; not only for APS but also for High-Tech companies.

Hypothesis 3: Knowledge-intensive firms choose their locations in order to optimise their intra-firm and extra-firm relations along the value chain and to benefit from geographical and relational proximity to suppliers, customers and knowledge resources.

This hypothesis underlines the strategic importance of proximity in the knowledge creation process. Firms facing competitive conditions must organise their production activities and their relationships with clients and suppliers in a highly flexible way. Sometimes, they must even be prepared to “change and recombine equipment and labour and to monitor shifts in the market on a day-to-day basis” (Scott et al. 2001:16). This implies that such knowledge-intensive firms must have almost instant access to a wide variety of information sources. Access to such resources requires relational, and in many cases also geographical proximity, which facilitates the transfer of non-codified forms of information and helps to reduce the costs for searching appropriate business partners (Lambregts 2008b). As we have seen in Section 3.1.3, geographical proximity facilitates regular personal communication. Short distances bring people together and enable them to exchange tacit knowledge on a regular basis. Relational proximity, on the other hand, allows stretching the spatial span of knowledge creation and offers a powerful mechanism for long-distance coordination (Torre and Rallet 2005). It is an enabling factor, providing stable conditions for the creation of knowledge and the development of social relations based on trust, friendship and experiences.

Part 2: Research Methodology

5. Research design

Recent academic work has raised fundamental questions about how we think about polycentric urban systems and functional urban hierarchies. The increasing importance of network economies has introduced new lines of thinking about space and place that understand regions as unbounded and relational spaces stretching over different geographical scales (Pike 2007). Regional theory increasingly tries to understand the roles that individual places play as nodes in the wider national and transnational networks (Simmie 2003). Based on previous attempts to handle hierarchical tendencies in Mega-City Regions analytically, we now present the design of the research project that has been applied to reveal the hidden geography of the knowledge economy in Germany. First of all, our main research perspective will be clarified, followed by the presentation of the sampling strategy and the spatial setting of the multi-scale analysis.

5.1 Research perspective – a network approach

For a considerable period of time, social sciences have been dealing with networks and their social and economic implications. As Smith (2003) notes, already in the 1960s and the 1970s – following the seminal publications of Haggett and his collaborators – networks were a favoured research topic for positivists (Haggett 1965; Haggett and Chorley 1969). In recent years, the idea has been rediscovered because of the rapid pace of globalisation and the increasing role of ICT. Today, the network approach can be found amongst all kinds of literature. It even builds the basis for new journals such as *'Global Networks: A Journal of Transnational Affairs'* (Smith 2003). Granovetter (1973) argues that the network approach provides the most fruitful micro-macro bridge: "In one way or another, it is through these networks that small-scale interaction becomes translated into large-scale patterns, and that these, in turn, feed back into small groups" (Granovetter 1973:1360).

Network approaches are highly influential in contemporary economic geography. Their popularity represents a kind of 'relational turn' (Storper 1997; Yeung 2005). One of the most important aspects of networks is that they entail 'relational thinking' (Dicken 2007:11). Networks encourage us to understand socio-economic phenomena as intertwined and mutually interdependent processes (Mitchell 2000), putting economic actors and their spatial behaviour at the core of the conceptual framework (Bathelt and Glückler 2003). Pike (2007), for example, argues that "[t]he topographical space of absolute distance is displaced by topological understandings of relative and discontinuous space, emphasising connections and nodes in networks" (Pike 2007:1144). According to Dicken et al. (2001), socioeconomic networks are able to create different forms of spatial patterns. Some networks are more embedded in specific locations, because they are based on traded and untraded interdependencies in localised systems of value chains. Other networks, however, are more footloose and controlled by key actors being spatially distant from the locations, where the production processes actually happen (Dicken et al. 2001). Thus, the major advantage of adopting a network approach is that it helps us to appreciate the interconnectedness of knowledge-intensive economic activities across different geographical scales. To think of economic processes in terms of connections of activities – linked through both physical and non-physical flows – is the key for understanding spatial development and economic dynamism in German Mega-City Regions.

Relational approaches are not only highly influential in contemporary economic geography; they have also a considerable conceptual overlap with global/world cities research (Friedmann 1986; Sassen 2001b). However, even though the latter is based on the idea of an emerging 'space of flows' (Castells 2000), many world city researchers concentrate on measuring data on world city *attributes*, including the presence of corporate headquarters of APS firms. But, as Taylor (1997:323) has pointed out, attribute data – on which many studies of world cities are based – can never show hierarchical structures. They produce ordered lists but give no insight into relations between the objects listed (Taylor 1997). What is needed, then, is a relational approach to Mega-City Regions, one that investigates how cities and towns cooperate as well as compete in the global circuits of financial, informational and embodied flows. A major problem for such a network approach, however, is the lack of suitable relational data between cities. Indeed, since Short et al.'s (1996) identification of the "dirty little secret of world cities research", it has become commonplace to criticise the paucity of relational data in this context (Beaverstock et al. 1999a; Taylor 2004b; Hall 2001; Derudder and Taylor 2005; Alderson and Beckfield 2004; Derudder 2006; Short et al. 1996).

According to Taylor (2007), the major reason why data describing inter-city relations are not available lies in the fact that – in most cases – the nation states are responsible for the collection of large-scale socioeconomic data sets. Therefore, the conventional analytical unit of the global economy is the country. Virtually all the statistical data on production, trade and investment are aggregated into national boxes (Dicken 2007). Taylor (2007) argues that this results in several fundamental flaws in analysing the rationale behind cities and towns in the global economy: first, attribute measures dominate over relational measures. Since the main concern of the nation state is taking stock within its territory, most statistics are lists of attributes assigned to specific territorial entities. As a consequence, cities are statistically treated as de-networked territories, even though the basic idea of them is their unbounded connections and trade relations to other cities and towns. Secondly, there are no statistics on transnational relations at the city level. There are some international data sets on trade and migration, but they totally neglect the city as analytical entity. For example, information on certain relations between the UK and the USA can easily be found, but relations between London and New York – one of the most significant geographical connections in today's global economy – are nowhere recorded. Thirdly, rankings are often interpreted as hierarchies – Beaverstock et al. (1999a) review more than two dozen (Beaverstock et al. 1999a). Since attribute data can easily be obtained from official statistics, cities are often ranked by various attributes – such as population, employment or headquarter totals. This, however, does not indicate an urban hierarchy, because the latter can *only* be defined on the basis of relations and not by the mere ranking of internal attributes (Taylor 2007). Alderson and Beckfield (2004), for example, show that hardly any of the world city studies have used relational data to capture functional urban hierarchies empirically (Alderson and Beckfield 2004).

5.2 Sampling strategy

Firms are the most important actors in producing the world city network. According to Beaverstock et al. (2002:116), their strategies to invest in specific office locations make world cities "the main places to be". When looking at a firm's value-creation process, it becomes obvious that these processes follow a functional and networked logic of independent as well as interdependent institutions throughout the value chain. These processes are not necessarily bound by the limitations of territorial borders. In this sense, we appeal not to put the territory at the centre, but to analyse economic activities and relations from a spatial perspective. Hence, this study does not consider geography first. Rather, it starts with the location behaviour of knowledge-intensive firms. Once such knowledge-intensive firms have been identified, the next stage is to examine the nature and geographical extent of the intra-firm and extra-firm linkages they have, and to evaluate how they interconnect cities and towns on different geographical scales.

In order to reveal the spatial logic of polycentric Mega-City Regions, this study analyses the location behaviour of knowledge-intensive firms focussing particularly on APS- and High-Tech firms. As emphasised in Section 2.1.2, these branches are important pillars of the emerging knowledge economy and can be interpreted as a role model for future economic activities (Tödtling et al. 2006). The sampling strategy followed a top-down approach in two steps.

In the first step, the APS- and High-Tech sectors were operationalised on the basis of the international NACE (Nomenclature statistique des activités économiques dans la Communauté européenne) classification at a four-digit level (see Table 2). Here, we referred to the classification proposed by Legler and Frietsch (2006). According to these authors, an economic sector can be defined as knowledge intensive, if its share in university graduates, engineers and scientists, as well as research and development activities (R&D) are higher than average (Legler and Frietsch 2006). For the *High-Tech sector*, Legler and Frietsch (2006) started their classification on the basis of the Oslo manual of the OECD (OECD 2005). In order to account for the specific characteristics of the German High-Tech industry, however, they refined the classification to a four-digit level using additional European and German data that is not available at the OECD level, such as the European and German R&D cost structure survey or patent investigations. For the *APS sector*, they used the share of highly qualified manpower (university graduates) as a proxy for knowledge intensive services. For this, the EU labour force survey provides data at a two-digit level. However, for a more detailed analysis of national and regional patterns in Germany, Legler and Frietsch (2006) considered additional data using the German Social Insurance Statistics as well as up-to-date micro census data (Legler and Frietsch 2006).

In the second step, the actual sample of knowledge-intensive firms was defined. The final selection is based on different information sources. In the first place, the data set of the commercial data provider Hoppenstedt was used. Hoppenstedt is one of the largest business data providers in Germany. Its database includes over 245,000 profiles of German companies, their branches and the major industrial associations in Germany. In the second place, the database of Hoppenstedt was supplemented by several rankings showing the top firms in different sectors, such as Forbes' Global 2000, Fortune's Global 500, the 2007 EU Industrial R&D Investment Scoreboard, and all in the prime standard of the Deutsche Börse AG listed firms (reference date: 29. July 2008). In order to be selected, the firms had to meet four criteria: first, they have to belong to a knowledge-intensive economic sector as defined by Legler and Frietsch (2006) (see Table 2). Secondly, they have to belong to the largest knowledge-intensive firms in Germany, measured by means of employment size. Thirdly, they have to be multi-branch enterprises with at least one office location in Germany. Having met these conditions, firms were finally selected on the basis of the quality of information available about them (e.g. whether a firm had an informative website). In all, we analysed *270 APS firms* in 9 economic sub-sectors: 30 in banking & finance; 30 in insurance; 30 in information and communication services; 30 in advertising & media; 30 in logistics (3rd and 4th party logistics); 30 in management- and IT-consulting; 30 in design, architecture & engineering; 30 in law; and 30 in accounting. In the *High-Tech sector*, we analysed *210 firms* in 7 economic sub-sectors: 30 in chemistry & pharmacy; 30 in machinery; 30 in electronics; 30 in computer-hardware; 30 in telecommunication; 30 in medical & optical instruments; 30 in vehicle construction (all firms are listed in Appendix B).

Table 2: Operationalisation of the knowledge economy with NACE codes
(Statistisches Bundesamt Deutschland 2003; author's compilation)

High-Tech	**Advanced Producer Services (APS)**
Chemistry & Pharmacy 2330, 2413, 2414, 2416, 2417, 2420, 2441, 2442, 2451, 2461, 2463, 2464, 2466, 2511, 2513, 2615	*Banking & Finance* 6511, 6512, 6521, 6522, 6523, 6711, 6712, 6713, 7011, 7012
Machinery 2911, 2912, 2913, 2914, 2924, 2931, 2932, 2941, 2942, 2943, 2952, 2953, 2954, 2955, 2956, 2960	*Advertising & Media* 7440, 2211, 2212, 2213, 2214, 2215, 9211, 9220, 9240
Electronics 3110, 3120, 3140, 3150, 3161, 3162, 3210, 3320, 3330	*Information and Communication Services* 6430, 7221, 7230, 7240, 7250, 7260
Computer-Hardware 3001, 3002	*Insurance* 6601, 6602, 6603
Telecommunication 3220, 3230	*Logistics (3p & 4p)* 6030, 6110, 6220, 6230, 6340
Medical & optical instruments 3310, 3340	*Management- and IT-Consulting* 7210, 7222, 7413, 7414, 7415
Vehicle construction 3410, 3430, 3511, 3520, 3530	*Design, Architecture & Engineering* 7420, 7430
	Law 7411
	Accounting 7412

5.3 Study area – a multi-scale analysis

An important point of the research design in this thesis is the multi-scale analysis. Polycentric Mega-City Regions cannot be studied in isolation. Each city is connected to other places in the world in many different ways and through many different actors. A particular strength of the network approach is that it integrates various spatial scales, rather than preferring any one of them (Dicken et al. 2001).

Our main focus is on Germany and its adjacent agglomerations in Germany's neighbouring countries. On this spatial scale, the analytical building blocks are *338 Functional Urban Areas (FUAs)* – or agglomerations – as defined by the ESPON research project 111 – Potentials for Polycentric

Development in Europe (ESPON 2004). They are defined as having an urban core of at least 15,000 inhabitants and over 50,000 in total population. For each of the FUAs, the potential area has been calculated that can be reached within 45 minutes by car from the FUA centre. This implies that the city-region is conceptualised as a functional entity rather than an administrative territory or a continuous built-up area. The 45-minutes isochrones were then approximated to municipal boundaries to make it possible to use population data at the NUTS 5 level for further investigations (ESPON 2004) (see Figure 75A in Appendix B).

The focus on Germany and its adjacent FUAs has several advantages. On the one hand, we do not have to start with an 'a priori' working definition that delimits Mega-City Regions in Germany in an approximate way. Based on the results of the interlocking network model (see Section 6.1), we can start directly to analyse the spatial connectivity patterns, from what we might identify polycentric Mega-City Regions. On the other hand, the inclusion of adjacent agglomerations up to 50 km distance from the German border makes it possible to identify and contextualise large-scale urban structures and hierarchies of cross border agglomerations. And finally, the fine grained covering of the study area with a multiplicity of FUAs makes it possible to identify the role of small and medium sized cities and towns that are located at the peripheries of, or between polycentric Mega-City Regions.

However, Germany is not a self-sustaining system. It should be accepted that any singular geographical scale is an inadequate means for analysing the spatial logic of the knowledge economy; in fact, there is a complex intermingling of different geographical scales. With this research design, we were able to assess how well connected cities and towns in Germany are, not only to other German locations, but also to European and global destinations. In all – based on the worldwide locations of our main sample of knowledge-intensive firms – *2926 cities and towns* from different continents and countries all over the world have been integrated in the final network analysis (see Figure 76A in Appendix B).

6. Research methods

In recent years, the methods to analyse relational data have increased in sophistication and sensitivity. Nevertheless, even today the analytical instruments remain quite polarised "between the binaries of positivist, often quantitative, and more theoretically diverse, typically qualitative, approaches" (Pike 2007:1143). There is clearly the necessity to combine both quantitative and qualitative approaches in studying the activities of the knowledge economy in space. Meeting the challenge of analysing and visualising polycentric development in Mega-City Regions can only be achieved through quantitative analyses and qualitative studies working in tandem. For this reason, this thesis uses a mix of three different research methods (Figure 24). Firstly, the so called interlocking network model of Taylor (2004b) is used to analyse intra-firm networks of APS and High-Tech firms on different geographical scales (Taylor 2004b). Secondly, the intra-firm analysis is complemented with a value chain analysis by looking at the partners with whom these firms have working relationships along individual chains of value and in particular where these partners are located. Here, both intra-firm and extra-firm relations are considered. And finally, a series of face-to-face interviews with senior business leaders and organisations are conducted in order to reveal softer case study evidence on strategic networking of knowledge intensive enterprises. In the following sections, these research methods are discussed in greater detail.

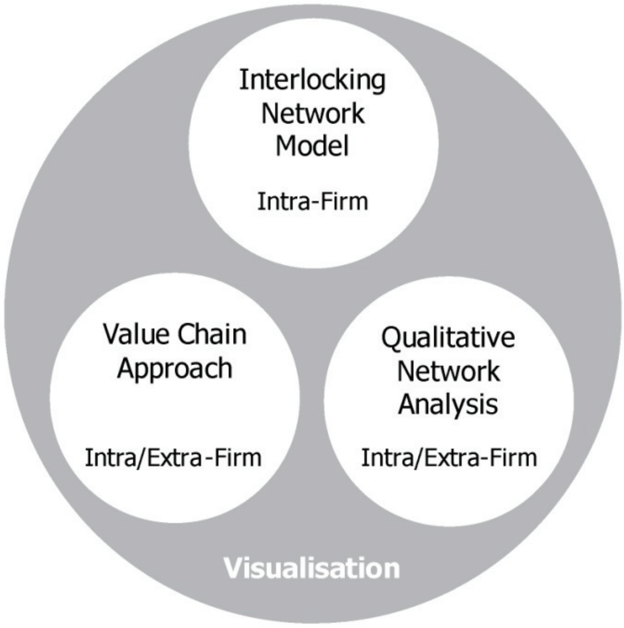


Figure 24: Triangulation of quantitative and qualitative research methods
(Author's illustration)

6.1 The interlocking network model

The analysis of intra-firm networks is based on the interlocking network model developed by the Globalisation and World Cities Study Group (GaWC) at Loughborough University (see also Section 3.3.1). It provides one specific way to address the question how inter-city relations can be empirically measured despite the chronic lack of data on inter-city information flows. The method was originally developed to measure the connectivity between global cities based on multi-branch APS firms as they organise business activities across their offices worldwide (Pain and Hall 2008). The model uses a *proxy* – i.e. intra-firm networks of multi-branch, multi-location enterprises – to estimate potential flows of knowledge-creating information between cities and towns. In this thesis, the model is adapted to measure relations between cities within and beyond polycentric Mega-City Regions. Here, it is assumed that all types of knowledge forms mentioned in Section 2.1.1 – explicit, tacit, analytical, synthetic and symbolic – are shared in intra-firm networks of the knowledge economy. According to Taylor et al. (2008), the main contribution of the interlocking network model to reveal the complexities of polycentric Mega-City Regions is threefold: first, inter-city relations *within* Mega-City Regions show how the corresponding cities are functionally connected with each other; secondly, the total connectivity of a city on a *regional scale* provides an initial measure for its position in the functional urban hierarchy; and thirdly, the total connectivity of a city on a *global scale* provides an alternative measure for its position in the functional urban hierarchy, emphasising particularly the outside orientation of a city in terms of APS activities (Taylor et al. 2008).

The empirical procedure of the model comprised several stages. Once the relevant knowledge-intensive firms have been identified, the first stage was to examine the geographical extent of the linkages and to evaluate how intensive these linkages are. The prime sources of this information were the firms' web sites. It was necessary to scavenge all relevant information available from these web sites, supplemented by additional material such as annual reports or company brochures. For each firm, two types of information were gathered. First, we looked for information about the *size of a firm's presence in a city*. In the best case, information could be found on the number of professionals working in the firm's office. Such information was widely available for law and consulting firms, but not for other economic sectors. Here, other information has been used, for example the number of the firm's offices in a city. Secondly, we looked at the *extra-locational functions of a firm's office in a city*. For this, not only headquarters functions have been recorded, but also other features like subsidiary headquarters or regional offices. By using this kind of scavenger method of data gathering, we collected any information that provided evidence about the size and the extra-locational function of a firm's office in a city (Taylor et al. 2002). Overall, this exercise took several months, running from December 2008 to May 2009.

In a second stage, this information was transformed into a manageable dataset. By converting information into data, there is always a trade-off between keeping as much of the original content as possible and creating a resilient dataset that represents the differences and similarities across all cases (Taylor et al. 2002). In our exercise, very detailed information could be found for some firms and much less for others. Therefore, we used a relatively simple scoring system to integrate all the information gathered from the firm's websites. All office locations were rated at a scale of 0 to 5. The standard values were 0 (no presence), 5 (company headquarters) or 2 (standard presence). If there was a clear indication that a location has a special relevance within the firm network (e.g. exceptionally large offices with many practitioners, regional headquarters) its value was upgraded to 3 or even to 4. If the overall importance of a location in the firm-network was very low (e.g. small agency) the value was downgraded to 1. The end result from this scoring process was a *'service activity matrix'* (see Table 3). This matrix is defined by cities in the lines and knowledge-intensive firms in the columns. Each cell in the matrix shows the rating of an office location in a city: the so-called *service value (v)*, which indicates the importance of a city to a firm. This matrix constitutes our basic dataset for the network analysis.

Table 3: Service activity matrix (Author's example)

	Firm 1	**Firm 2**	**Firm 3**	**…**	**Firm *m***
City 1	0	2	1	…	2
City 2	5	4	5	…	2
City 3	0	0	1	…	0
…	…	…	…	…	…
City *n*	3	2	2	…	1

In the third step, the interlocking network model established by Peter Taylor (2004b) was used to estimate the connectivity between cities and towns within and beyond German Mega-City Regions. The basic premise of this method is that the more important the office, the greater its flow of information will be to other office locations (Taylor 2004b). The primary output of this interlocking network analysis is network connectivity, a measure that estimates how well-connected a city is within the overall intra-firm network of knowledge-intensive enterprises. Here, different kinds of connectivity values can be calculated. The connectivity between two cities (a, b) of a certain firm (j) is analysed by multiplying their service values (v), representing the so-called *elemental interlock* (r_{abj}) between two cities for one firm:

$$r_{abj} = v_{aj} \cdot v_{bj} \qquad (1)$$

This approach seems reasonable when the following assumptions are made (Derudder and Taylor 2005:74p): first, offices generate more flows within a firm's network than to other firms in their sector, which is inherently plausible in a context where protecting global brand image through providing a seamless service is the norm. Secondly, the more important the office, the more flows are generated; and these have a multiplicative effect on inter-city relations. The first part of this assumption is very plausible again. The second part reflects (i) the fact that larger offices with more practitioners have the capacity to create more potential dyads, and (ii) the hierarchical nature of intra-firm networks, where larger offices have special functions, like control and provision of specialised knowledge. Based on these assumptions, we summarise the elemental interlocks for all firms located in two cities, in order to calculate the total connectivity between the two cities. This leads to the so called *city interlock* (r_{ab}):

$$r_{ab} = \sum_j r_{abj} \qquad (2)$$

Aggregating the city interlocks for a single city produces the *interlock connectivity* (N_a). This measure describes the importance of a city within the intra-firm network of all knowledge-intensive enterprises that have been analysed.

$$N_a = \sum_i r_{ai} \qquad (a \neq i) \qquad (3)$$

Finally, if we relate the interlock connectivity for a given city to the city with the highest interlock connectivity in the sample, we gain an idea of its relative importance in relation to all other cities that have been considered. These scores – creating a scale from 0 to 1 – will be used to indicate hierarchical tendencies within the German city system.

Even though Peter Taylor's approach is an innovative and smart way to calculate inter-city relations, some limitations have to be acknowledged. The main limitation of the interlocking network model is that it does not consider extra-firm networks in its conceptualisation. As we saw in Chapter 2, both intra-firm *and* extra-firm networks are important in analysing the functional and spatial patterns of the knowledge economy. Intra-firm networks are of interest because of the growing importance of TNCs in transferring results of R&D and knowledge between their worldwide office locations. In addition, extra-firm networks are of great relevance because they generate possibilities for increased economies of scale through flexible and networked production systems.

A second limitation is that the strength and importance of the *actual* linkages between cities and towns are not recorded by calculating the interlocking network connectivity. Pain and Hall (2008), for example, state that: "Whether information is passing between the cities – either virtually by email, telephone etc., or, in people's heads through business travel – can only be discovered by other means" (Pain and Hall 2008:1070). Smith (2003) argues that Taylor's approach is fine in terms of conceptualising the world city network through location strategies of APS firms, but in terms of empirical research it is "a little like counting door knockers" (Smith 2003:31). Therefore, he calls for a new approach, which goes beyond counting, to find out how firms are operating in networks and keeping contact over long distances (Smith 2003). Equally, Nordlund (2004) criticises that internal attributes (service values) can only be used as an estimation for structural values (connectivity values) if the relationship between them is supported by a profound theoretical concept. If this is not the case, the connectivity values are nothing more than a mathematical function of the service values, which is not the intention of social network analysis (Nordlund 2004).

A final critique concerns the mathematical function used for calculating the elemental interlock (equation 1). Nordlund (2004) scrutinises the assumption that the elemental interlock between two large office locations is greater than between a large and a small office location. In fact, there might be more interaction between large and small offices because of command, control and support factions (Nordlund 2004)? To this critique, Taylor (2004a) replies by making reference to traditional ideas from spatial-interaction research in human geography: "From spatial interaction modelling I borrow the idea that interactions between places are a product of some measure of the size of each place. In simplest terms, traffic flow between two cities is, in part, a product of their populations: all other things being equal, two large cities will generate much more traffic between them than two small cities (…). I call this a 'plausible assumption' and adhere to this position" (Taylor 2004a:297).

6.2 The value chain approach

As we emphasised in Section 2.2, information exchange and business activities do not only arise through intra-firm branch office networks, but also from the division of labour between companies. Outsourcing strategies in respect of single activities are sometimes more efficient and lead to a higher quality of products and services. Often, knowledge-intensive firms concentrate on their core competencies, which are produced in-house, while activities that do not belong to the core business are outsourced to other companies. From an empirical point of view – and in my mind with far-reaching conceptual consequences – a value chain approach is a promising tool to understand international trade and industrial organisation. The main conceptual reason for using a value chain approach is that it avoids both a firm-centric and a region-centric perspective. It provides a helpful analytical instrument for the investigation of business networks that transcends regional, national and international levels (Birch 2008). The following key questions were at the centre of the value chain analysis: Which elements of the value chain are kept in-house? Which activities are outsourced to other firms? On which spatial scales are the various knowledge-intensive operations located (Gereffi et al. 2005; Coe et al. 2008a, 2008b)?

By means of a web survey that combines relational data on firms' locations with the degree and importance of working interrelationships along individual firms' chain of value we shed some light on the value added process of APS- and High-Tech firms from a spatial perspective. The main focus of this survey was to detect the logic behind the firms' location decision. By overlaying a multiplicity of individual value chains, it is possible to identify patterns of spatial division of labour and localised value chain systems. How do APS- and High-Tech firms organise their value added chains spatially?

Where do upstream and downstream inputs come from? In order to answer these and other questions, three web survey sections have been developed. In a first section, information was gathered about the firms' business location and economic sector. In the second section – in order to relate the intra-firm and extra-firm relationships to a stylised value chain – the responding firms had to localise their business activities along the individual value chain elements of 'research & development', 'processing', 'financing', 'marketing', 'sales & distribution' and 'customers' (see Figure 25). For this, respondents were asked to provide the exact location of the three most important partners along the value chain. Data about the location of the three most important partners are, of course, only a proxy of the complete business network, but this information was easily given by the respondents and enabled us to draw the major lines of emerging value chain systems in Germany based on a relatively large-scale sample. Finally, the respondents were asked to give some information about the size of their firm and the function they occupy in their company. Overall, this procedure gave a comprehensive picture of the spatial value chain patterns of APS- and High-Tech firms in the German space economy (see Appendix C for the web survey).

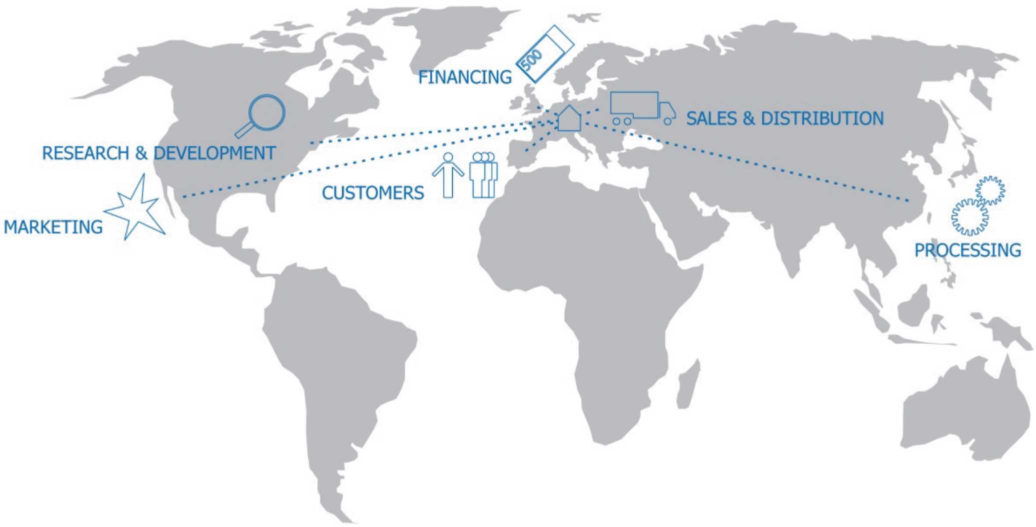


Figure 25: The value chain approach (Visualisation: Anne Wiese)

The questionnaire was e-mailed to *3541* knowledge-intensive firms in Germany. By this means, we approached all 270 APS and 210 High-Tech firms from the intra-firm analysis, plus additional knowledge-intensive firms from all sub-sectors of the knowledge economy. In order to increase the response rate, the firms were asked to forward the e-mail to similar enterprises. Furthermore, several local chambers of commerce and regional business development agencies have been asked to forward the questionnaire to their member firms. We started the survey in January 2010 and – after several follow-ups by e-mail and telephone – we finished the questioning in March 2010 (see Figure 26). All in all, *246 APS* and *145 High-Tech firms* filled in one or more locations of their most important partners along the value chain. Figure 77A in Appendix C shows the locations of the responding firms in Germany.

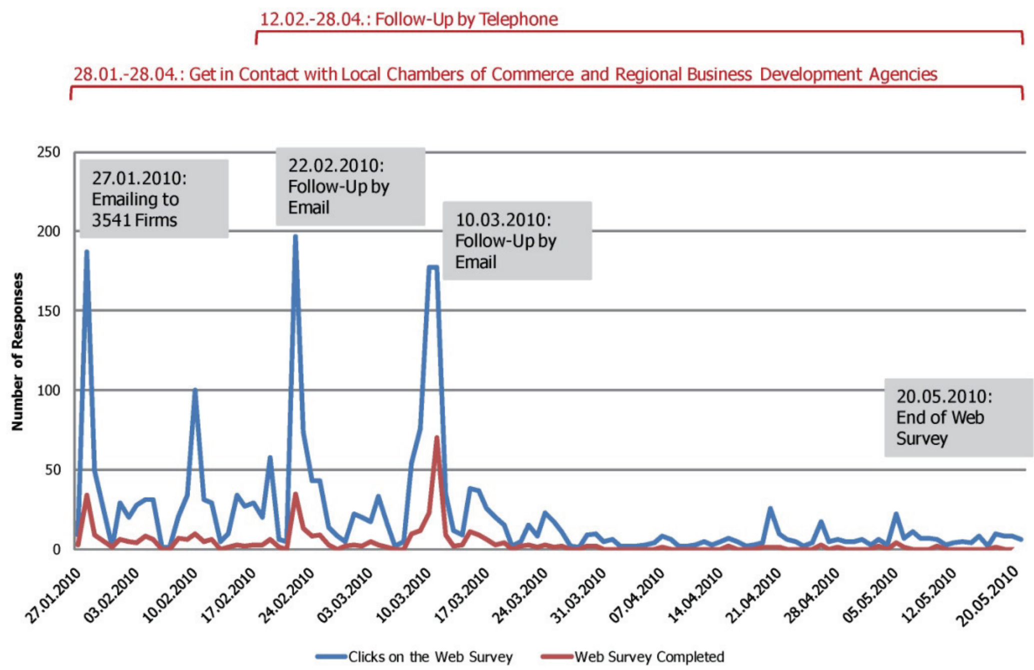


Figure 26: Response on the web survey (Author's calculation)

6.3 Qualitative network analysis

In addition to the quantitative network analysis, the research design included a series of in-depth face-to-face interviews with senior business practitioners and organisations. The interview method provided qualitative evidence complementing the quantitative data gathered by the other empirical steps. Whereas the quantitative analysis provided harder, more easily measurable evidence across the large relational firm data base, the in-depth face-to-face interviews elicited softer case study evidence on the subtle and strategic processes underlying the quantitative results. This produced an extensive and rich data source on the issues relevant to the study that could not be elicited by alternative means. Furthermore, it helped to understand better the interplay between location strategies of knowledge-intensive enterprises, geographical proximity and the development of polycentric Mega-City Regions.

The semi-structured questionnaire was designed to allow the interviewers to give information about the pattern, volume and quality of connectivities and flows related to the everyday experience of their business operations. Common, open-ended questions formed the basis for the interviews to ensure that the first responses were a true reflection of the issues that are seen as important by the respondents. The standardised question framework focused on three aspects: first, the firm's organisational strategy and location dynamics; secondly, personal networks, interactions and communication habits of the interviewee and the role of geographical proximity; and thirdly, regional, national and international networking activities along the value chain (see Appendix C). For each interview, the questions have been slightly adapted depending on the firm's specific organisational structures identified in the first two research modules. The discussions were tape-recorded wherever possible so that specific quotations could be used to illustrate the results appropriately. The quotations have been analysed by means of a computer based qualitative content analysis (software AtlasTi), a methodology originally developed for social sciences in order to analyse unstructured qualitative data.

All in all, *26 interviews* with senior executives were conducted *between August and October 2010*. The interviews covered all the major economic areas in Germany and considered both the APS- und the High-Tech sectors. The sample size of the interviews was not intended to allow a statistical analysis of the results. The data collected are qualitative and the findings are consequently suggestive rather than providing precise facts. Although the findings do not provide precise statistical measures of causes and effects, they offer an understanding of polycentric Mega-City Regions in globalisation as experienced and practiced by knowledge-based business decision-makers. The results identify similarities and differences between individual cases and could isolate qualitative causal relationships underlying our main research hypotheses. The principal variables of the analysis were business sectors, geographical scope and location, but also a variety of regional specificities has been taken into account in interpreting the results. Table 75A in Appendix C provides a list with the dates, locations and economic sectors of the interviews. For confidentiality reasons the names and the companies of the interviewees are not named.

Part 3: Research findings

7. The relational geography of the knowledge economy in Germany

The following chapter presents the main findings of the three empirical research modules: the interlocking network model, the value chain approach and the qualitative network analysis. As we have seen in the previous chapters, knowledge creation does not occur at one particular spatial level; it operates across different spatial scales simultaneously. Therefore, in order to reveal the networking structures of the knowledge economy in Germany, we start with the connectivity patterns on the global scale, and then zoom in to show the finer-grained hierarchical textures at a national and regional level.

7.1 Relational patterns on the global scale

Around 25 years ago, Kenichi Ohmae (1985) argued that the world is essentially organised around a tri-polar macro-regional structure comprising North America, Europe and East Asia as its main economic pillars (Ohmae 1985). Looking at statistical data, Dicken (2007) confirms that these three macro-regions together contain 86 per cent of both total world GDP and total world merchandise exports. Moreover, they are the focus of the vast majority of the world's foreign direct investment (Dicken 2007). A study of the EU Commission forecasts a long-term shift within this tri-polar macro-regional structure. While North America will be able to ensure its share of world production over the next 50 years, a continuous loss of its share is forecast for Europe. The remaining and growing share of world production will shift to the 'Pacific Rim', especially to East Asia and South America (McMorrow and Röger 2003). As we will see in the following section, our connectivity analysis on the global scale confirms this trend, especially in the High-Tech sector, where South America and East Asia are establishing themselves as important offshore locations for companies operation in Germany.

Figure 27 shows the top 20 agglomerations in terms of the interlock connectivity for *APS firms*. A big font size in dark red illustrates a high interlock connectivity, a small font size a low one: New York, London, Hamburg, Paris and Frankfurt show the highest connectivity values (see also Table 7A in Appendix A). Generally speaking, three regions seem to be of particular importance for APS firms located in Germany.

First of all, there is Germany itself; six German FUAs rank in the top 20: Hamburg, Frankfurt, Munich, Berlin, Stuttgart and Düsseldorf. These agglomerations can be regarded as a kind of 'urban circuit' that constitutes the top of the German functional urban hierarchy (Hoyler et al. 2008a:1102). For many enterprises, the German space economy seems to create enough demand and growth potential, leading to a strong national focus in terms of intra-firm locations and networks. APS firms originating from smaller economies – Switzerland for example – are forced to internationalise their businesses activities much earlier because of their small size in terms of national demand (Gugler and Michel 2009). This leads to a relatively strong international connectivity of Swiss cities – such as Zurich or Basel – in comparison with German FUAs (see Thierstein et al. 2006:61). But also cultural and linguistic requirements as well as specific national regulations and non-tariff barriers to trade tend to hamper internationalisation strategies. Especially in the APS sector, an export strategy is often waived in order to reduce complexity and therefore to increase the quality of the service that is offered. This corresponds to Porter's (1990) *focus strategy*, in which a specific segment of the market – such as a particular geographic area – is targeted. Thereby, firms are able to create competitive advantage either through being the lowest cost producer or by providing highly differentiated products in a specific niche market (Porter 1990). Thierstein (2003), for example, shows that nationally-oriented APS companies are indeed able to succeed. The Wegelin & Co. Bank – the oldest bank in Switzerland – focuses successfully on the national scale: "…it is the intimate knowledge of the Swiss tax regulation that allows the bank to take the most benefit possible out of the existing regulative system. Thus it is the national and cantonal tax regulations, the perspective knowledge as well as frequent information exchange with officials of the Swiss Federal Tax Administration and their cantonal counterparts that makes 'tax regulations' a localised or specific resource of the production and innovation system" (Thierstein 2003:211). In the course of the interviews, many business practitioners confirmed this finding by underlining the importance of national regulations for their business activities:

> *"...we are no longer doing business internationally (…). We are selling consulting, and here we have the problem that we cannot use any synergies. Even in Austria, where the language barrier does not exist. There are huge differences because of the different products, the different legal frameworks, and also because of the different tax situations, especially in the field of pension planning. In principle you must have the whole infrastructure twice" (APS firm, Wiesloch, 04.10.2010)[1].*

Further important destinations for APS firms located in Germany are cities in Western Europe. 14 European cities rank in the top 20. The political and economic integration of German cities in Europe seems to have had a considerable effect on the national urban system, especially in terms of its complementary functional and sectoral specialisation (Blotevogel 2001). The manifold integration in legal and formal regulations make some business activities easier, and others more difficult. Especially in an export-oriented economy – such as Germany – cross-border agreements and arrangements are particularly important. At the European level, some progress in harmonisation has already been achieved leading to more legal security in trans-European business transactions (Schneck 2006). However, it can also be argued that the more flexible and footloose knowledge-intensive firms are, the stronger gets the competition between cities and regions for talent and innovation, which are integrated within the firms of the knowledge economy. Hence, with the completion of the European single market, German city-regions no longer compete among each other alone, but also with London, Paris, Milan and other European metropolises. Although the European Union provides an important economic framework for cities to prosper, the latter have been largely neglected in policy circles as socioeconomic units (van den Berg et al. 2007). Only very recently, spatial development policies in the European Union have started to address the importance of cities for international competitiveness (Faludi 2007).

[1] All interviews have been conducted in German. For reasons of coherence they have been translated into English.

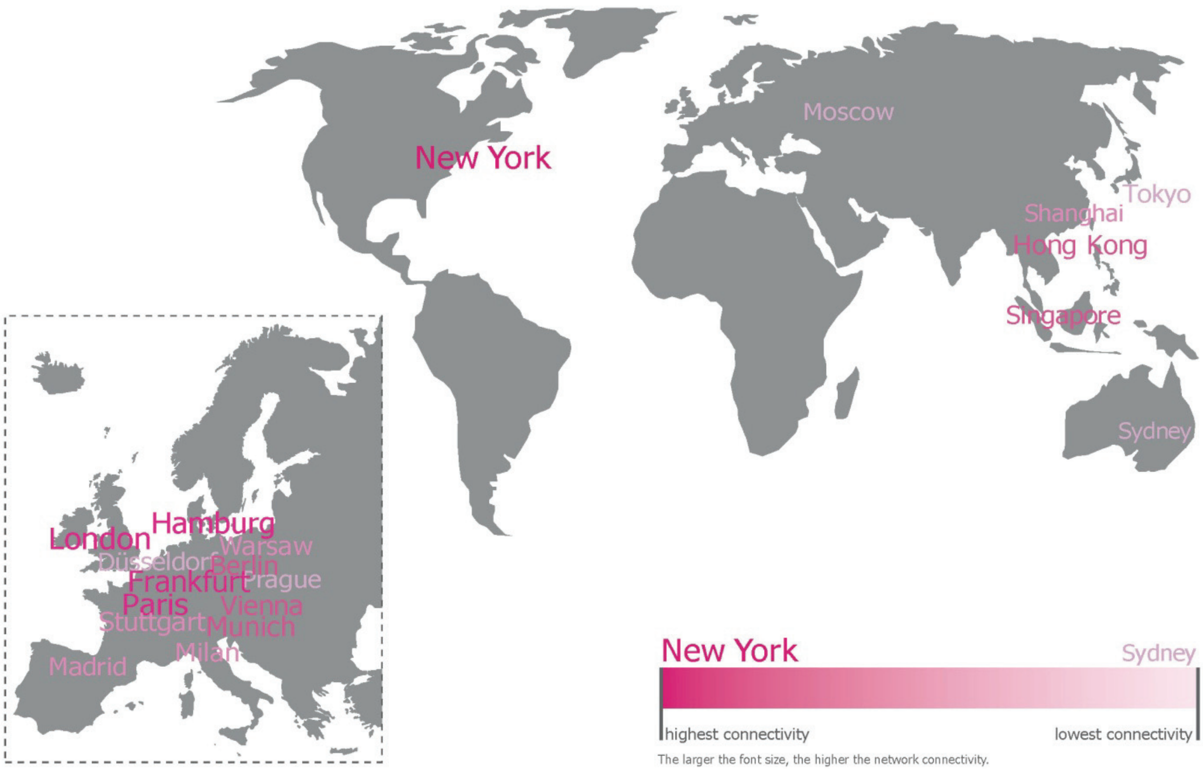


Figure 27: Global connectivity based on APS interlocking networks (Author's calculation)

Finally, there are four highly connected cities in East Asia: Hong Kong, Singapore, Shanghai, plus Tokyo as traditional global city. Hong Kong is ranked seventh, reflecting its important role as economic gateway to China. This repeats earlier findings and opposes the common hypothesis that Tokyo would be the most important city in the East Asian space economy (Taylor 2004b). Tokyo ranks only 16th, even below Singapore (9th) and Shanghai (14th). In the High-Tech sector, East Asian cities tend to be even more important (see High-Tech connectivity in Figure 28). In the coming years, however, this may adjust as many APS firms follow their international customers from the High-Tech industry in order to provide a seamless service to their clients across the world. Already in the 1980 and 1990s, many APS firms followed their global clients to become important TNCs in their own right (Dicken 2007). Due to new information and communication technologies, it has become possible to transfer data over long distances, so that companies such as Citibank or DATEV shifted their payment and accounting systems to foreign countries (Schneck 2006). While the globalisation of industrial production seems to be almost completed, the internationalisation of the service sector is just staring. In this context, an IT consultant from Essen, for example, stated that:

> *"China is very important… China is the market of the future, including for the IT sector. So we have to be present in China as well. On the one hand, because we have to get into the market, and on the other hand, because many of our customers have office locations in China" (APS firm, Essen, 07.10.2010).*

Taken together, East Asian cities clearly catch up with North America in terms of global network connectivity. For US cities, New York is alone in the top ten. Chicago is the second US city and ranks 46th, followed by Los Angeles ranking only 48th. This finding confirms previous analyses showing surprising low levels of connectivity for US cities (Taylor and Aranya 2008). According to Taylor

(2011a), this tends to be related to the high national demand for services in the US itself, which has resulted in a much more nationally-oriented connectivity pattern than in other countries (Taylor 2011a).

Figure 28 shows the top 20 agglomerations in terms of the interlock connectivity of *High-Tech firms*. In contrast to the APS sector, they seem to be networked much more with extra-European locations: Shanghai, Singapore, Paris and Sao Paulo are the most connected cities in the High-Tech analysis. Here, even more than in the APS sector, spatial division of labour seems to translate into worldwide connections with a series of intra-firm linkages between different operations along the value chain.

With Shanghai, Singapore, Tokyo, Seoul, Peking, Bangkok and Hong Kong, East Asia clearly emerges as the most important economic area for High-Tech industries located in Germany. The chemicals, mechanical engineering and the electronics sectors in particular are highly represented in East Asia. According to Borrus (2000), East Asian production networks have been particularly important for the development of the semiconductor industry: "The unique heterogeneity of Asia's regional economy, with different tiers of nations… at different stages of development, provided fertile ground for technical and production specialisation… e.g. software in Bangalore, process engineering in Singapore, component assembly in Malaysia, printed circuit board (PCB) assembly in Coastal China, semiconductor memory in Korea, digital design and final assembly in Taiwan" (Borrus 2000:58p). As a result, indigenous East Asian producers have developed their own specialised knowledge so that firms in Europe and North America can effectively exploit not only cheap labour but also increased technical expertise in East Asian countries (Borrus 2000). The importance of such globalisation processes has been confirmed by many of the face-to-face interviews. The emerging markets in East Asia seem to have a huge economic potential. Growing wealth and increasing demand for high-quality products and services are the main drivers behind this incredible economic growth:

> *"…demographic aspects play a very important role (…); especially in Asia. The demand for commodities is huge. Therefore, we are going to Asia as well: globalisation shapes our economic activities" (High-Tech firm, Gersthofen, 27.09.2010).*

Beyond East Asia there are three Central and South American cities represented as economic gateways to their respective countries: Sao Paulo 4th, Mexico City 10th, and Buenos Aires 11th. These cities clearly show the global spread of the world city network in the High-Tech sector, especially in comparison with APS, where no South American city appears in the top 20. The Mega-City Region of Sao Paulo, for example, is not only the leading economic centre of Brazil, but also the biggest industrial location of Latin America and one of the most important industrial sites in the world (Wehrhahn 2009). Automotive and mechanical engineering are just some of the industries that have settled in the region. Other leading industries are chemicals – represented for instance by Lanxess and Wacker – and mechanical engineering. According to the interlocking network analysis, Sao Paulo shows particular strengths in chemistry & pharmacy (rank 3 globally, after Shanghai and Singapore), electronics (rank 3 globally, after Singapore and Shanghai) and machinery (rank 2 globally, after Shanghai) (see Appendix A). Mexico City, on the other hand, ranks 2nd of all Central- and South-American cities in terms of High-Tech connectivity. According to Parnreiter (2007), it is considered as an important gateway to access Central and South American markets. Until 1980, Mexico City could still be described as an industrial city. Today, the share of financial, insurance and real estate value-added is much higher than in industrial production (Parnreiter 2007:210p). Nevertheless, Mexico City is also home of many High-Tech industries. Our High-Tech records include

16 companies from the medical technology and mechanical engineering sectors, as well as 18 companies from the chemistry & pharmacy sector. Similarly, in Buenos Aires, where the chemical, mechanical and medical engineering industries are the economic sectors most widely represented in our High-Tech company records. Buenos Aires shows particular strengths in chemistry & pharmacy (rank 9 globally) as well as medical & optical instruments (rank 7 globally) (see Appendix A).

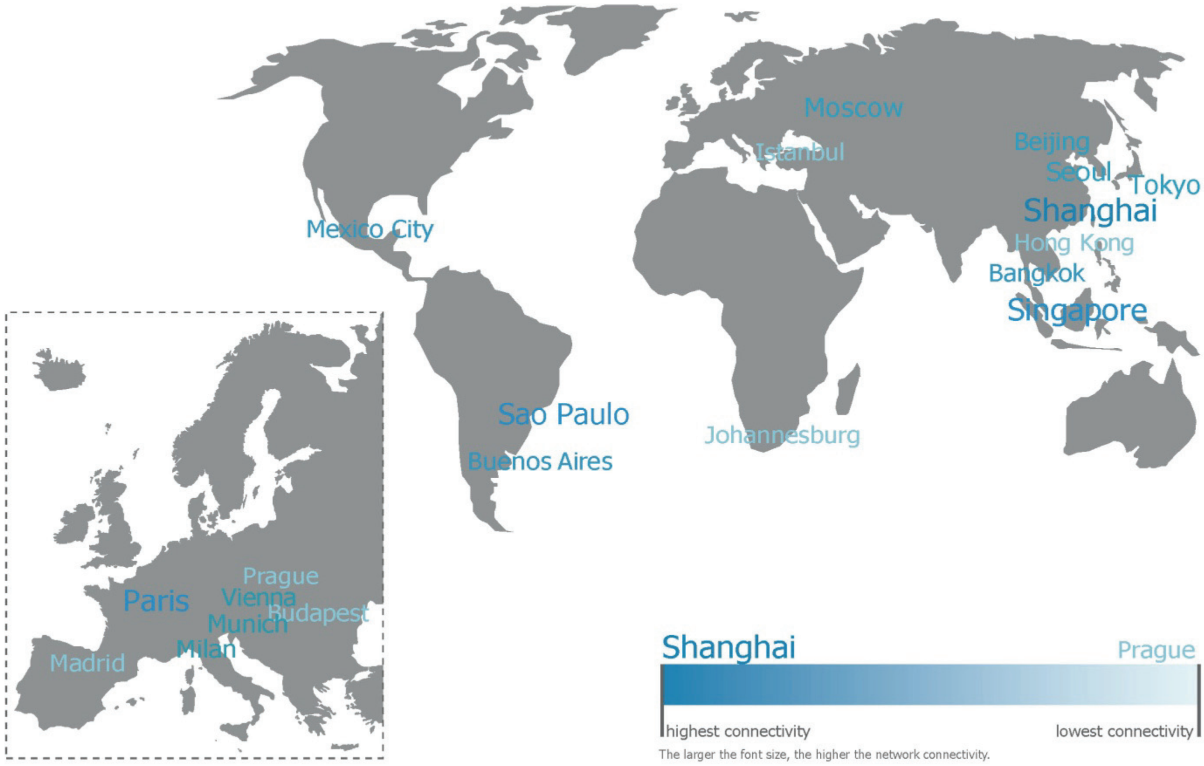


Figure 28: Global connectivity based on High-Tech interlocking networks (Author's calculation)

Not only East Asia and South America, but also three cities in the eastern part of Europe – Vienna, Budapest and Prague – are represented in the top 20 in terms of High-Tech connectivity. This means that many High-Tech firms located in Vienna also have office locations in Prague and Budapest. In this context, Vienna seems to act as an important gateway to Eastern Europe, a hypothesis that has been cited many times in the context of the eastward expansion of the European Union. An empirical analysis by Musil (2009), for example, shows that Vienna derived great benefit from its geostrategic position within the European Union. The transformation of Eastern European countries and Austria's own accession to the European Union has led to an increase of Foreign Direct Investments (FDIs) and to a re-orientation towards locations in Eastern Europe. Many foreign enterprises used Vienna to expand into Eastern European markets (Musil 2009). However, it is highly questionable whether Vienna can sustain this gateway position. It can be assumed that, in the course of the economic development of Eastern Europe, many firms may re-locate their offices from Vienna to other Eastern European cities such as Budapest, Prague or Warsaw:

> *"Our Eastern European headquarters were in Vienna (…). Vienna was the hub for our expansion into Eastern Europe (…). This is no longer the case. Now, we have established*

offices in these countries. Now, Vienna is back to covering more or less the Austrian market… We have more people in Warsaw than in Vienna (…). Poland is one of the countries providing a cheap IT labour force for standardised IT-skills" (High-Tech firm, Schwalbach am Taunus, 05.10.2010).

According to Dicken (2007), the completion of the European Single Market in 1992 dramatically reshaped the High-Tech sector in Europe because of the removing of the remaining technical and physical barriers to the flows of industrial components and products. The opening up of Eastern Europe created both a low-cost production location for sourcing components as well as the potential of a growing consumer market (Dicken 2007). In the automotive sector, for example, Eastern Europe has become an important node in the European car industry: "In just a few years all the major Czech, Hungarian and Polish automotive firms were privatised and sold to foreign investors, the existing car assembly and components manufacturing capacity was substantially modernised and extended, and new firms were established… The region has become integrated into the Western European automotive space through ownership links, production, procurement and sales networks" (Havas 2000:239). Our High-Tech records confirm that Volkswagen, for example, has developed a pan-European production network focused on Germany, Spain and its Eastern European plants in the Czech Republic and Slovakia. The organisational convenience – based on cultural and institutional proximity – tends to encourage may High-Tech firms in Germany to locate their offshore subsidiaries in Eastern Europe. Dicken (2007) argues that Eastern European countries are attractive because they provide low-cost production, a well-educated labour force and strong cultural ties to Western Europe. But geographical proximity is also important, especially in the context of just-in-time processing and transportation costs. In a vertically-integrated production sequence, in which individual production units are tightly interconnected, an interruption in the supply chain can seriously affect the other production units. In an extreme case, a whole segment of the TNC's operations may be halted (Dicken 2007). Thus, speed, flexibility and reliability are essential factors in the management of supply chain activities, as the following statement by a medical engineering company confirms:

"Romania is heavily sought-after by our industry… Many firms have opened manufacturing plants there (…). [The distance to East Asia] is a problem for many firms. You have to operate just-in-time (…). The availability of commodities and flexibility is very important (…). The skills [in East Asia] have not yet reached the level of those in Europe (…). Training… [in Eastern Europe] is much easier (…). The Chinese need more time…" (High-Tech firm, Barsbüttel, 12.10.2010).

All in all, the connectivity patterns on the global scale confirm that knowledge-intensive firms located in Germany – especially High-Tech firms – spread their activities globally, which results in an international division of labour whose main agents are multi-branch, multi-location firms with complex spatial organisational structures. These organisational structures are influenced by a number of strategic business activities, such as sourcing localised knowledge, entering into emerging markets and decreasing production costs. In the High-Tech sector, the fragmentation of the value chain across various locations has given rise to considerable restructuring in firms, including offshoring certain business functions. South America and East Asia seem to be important *farshoring* destinations for High-Tech firms, whereas Central and Eastern Europe provide alternative *nearshoring* locations. In the APS sector, by contrast, the interlocking firm networks are strongly focused on the German and Western European space economy. Especially cultural and linguistic requirements as well as specific national and European regulations seem to be the major reasons for this regional "focus strategy" (Porter 1990), which enables APS firms to benefit from detailed knowledge of the existing regulative system.

7.2 Relational patterns on the national scale

As we can see from the global perspective, APS and High-Tech activities have quite different global geographies. Such a global perspective is useful, but it obscures the finer-grained texture of what is actually happening at country level. Therefore, in this section, we focus on the national scale, i.e. on the German space economy. Within Europe, Germany is by far the biggest economy in global terms: it is the third-largest manufacturing producer (after the US and Japan), the third-largest commercial services exporter, and the third most important source of foreign direct investment (Dicken 2007:42). However – as Dicken (2007) indicates – for a long period of time, Germany's GDP growth has been below the world average and it still faces problems in integrating the former East Germany into the world economy. Table 4, for example, shows large differences between German Mega-City Regions in terms of their socioeconomic importance, making clear that the German city system is not only influenced by state-based interventions, but also by spatial development processes on global and European scales. Nevertheless, the decentralised German federal government system has led to a distinct spatial division of labour, distributing metropolitan functions among a series of FUAs: "Munich, for example, specialises in the research and High-Tech industry sectors; financial services and the chemical industry are especially concentrated in Frankfurt; knowledge-based producer services and the media sector have developed an above-average presence in Hamburg, Frankfurt, Düsseldorf, Cologne and Berlin; Stuttgart and parts of the Rhine-Ruhr region have specialised in classical technologically oriented industries, such as automotive and mechanical engineering" (Knapp et al. 2006a:154). The following sections will examine this hypothesis of polycentric urban development in greater detail.

Table 4: Socioeconomic characteristics of Mega-City Regions in Germany (IKM 2008)

	Population Development in percent (1997-2006)	**Employment Development in percent (1997-2006)**	**Staff in R&D per 1000 Employees (2005)**	**GDP Development in percent (1997-2006)**	**Patents per 100'000 Inhabitants (2000-2005)**
Berlin-Brandenburg	-0,79	-14,1	4,7	10,1	159,7
Bremen-Oldenburg	2,66	1,2	2,6	20,8	128,6
Hamburg	3,89	0,7	3,8	21,9	192,6
HBGW*	-0,61	-3,4	10,4	18,8	339,3
Munich	6,29	7,0	18,2	34,6	646,4
Nuremberg	0,94	-1,1	7,3	22,0	431,7
Rhine-Main	2,08	1,1	10,7	22,8	378,1
Rhine-Neckar	1,59	-0,6	14,4	21,3	460,3
Rhine-Ruhr	-0,86	-4,5	4,9	17,1	258,8
Saxony Triangle	-6,55	-15,9	4,2	21,4	155,7
Stuttgart	2,92	0,9	18,7	21,9	729,7

* HBGW=Hannover-Braunschweig-Göttingen-Wolfsburg

7.2.1 Office locations of knowledge-intensive firms

An initial simple indicator of the importance of an FUA in the context of the knowledge economy is the number of office locations and headquarters in knowledge-intensive industries. Some authors argue that the geographical concentration of knowledge-intensive firms proves the importance of spatial knowledge spillovers (Audretsch and Feldman 1996). As described in Section 3.3.1, command and control functions of cities as indicated by the number of headquarters of major firms were an integral part to Friedmann's (1986) world city concept and Sassen's (2001b) global city approach (Friedmann 1986; Sassen 2001b). According to Krätke (2005), the regional concentration of command and control functions have a strong influence on the economic performance of cities and regions (Krätke 2005). More recently, command and control functions in the world economy have been analysed in greater detail by Alderson and Backfield (2004) and Taylor et al. (2011a) (Alderson and Beckfield 2004; Taylor et al. 2011a).

Figure 29 shows the number of office locations for *APS firms* in Germany and adjacent agglomerations. With 180 office locations, Munich ranks first, followed by Hamburg (164), Berlin (158) and Frankfurt (151) (see also Table 9A in Appendix A). The colours in each peak indicate the range of the service values within every single FUA. A service value of 5 corresponds to the company headquarters; a service value of 2 indicates a standard office of the firm; 3 is a particularly large office; and 4 indicates an office with responsibilities beyond the city-region (see Section 6.1). In terms of headquarter functions, Munich ranks first, with 23 APS headquarters, followed by Frankfurt (18), Stuttgart (16), Cologne (15) and Hamburg (14). This finding shows the importance of Munich and Frankfurt as leading German command-and-control centres in the APS sector. The corporate headquarters in these FUAs are responsible for all the major strategic investment decisions that shape the intra-firm networks of the whole enterprise. This means that Munich and Frankfurt are highly integrated with the world economy. Thus, structural change within these FUAs is highly influenced by the dynamism of the global economic system.

Similar patterns can be observed in the *High-Tech sector* (see Figure 30). Munich, with 93 office locations, ranks first, followed by Prague (92), Berlin (81), Stuttgart (75) and Hamburg (71). Munich also has the highest number of High-Tech headquarters (29), followed by Stuttgart (13) and Düsseldorf (7). Note that only few high-level offices are located in Prague and Berlin, even though these FUAs have many office locations in total. Strategic business decisions in the High-Tech sector tend not to be made in Prague and Berlin; rather, they are highly concentrated in Munich and Stuttgart, which emerge as the main High-Tech command-and-control centres in Germany. Generally, in terms of attribute data – such as the number of office locations – Berlin tends to achieve good results, but in functional terms, it usually falls behind other German FUAs such as Munich, Hamburg or Frankfurt (see next section). A similar result is presented by Jähnke and Wolke (2005) in a comparative analysis of Berlin and Munich, showing that Berlin has a relatively low proportion of high-level "global services" (Jähnke and Wolke 2005:267).

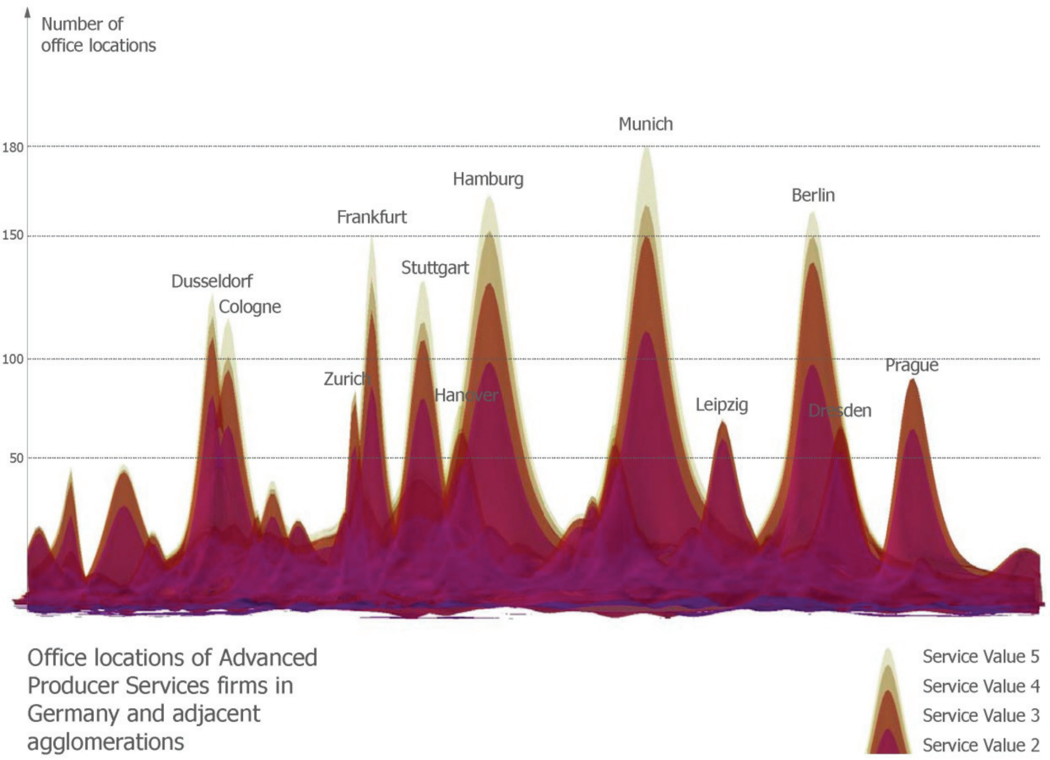


Figure 29: Office locations of APS firms in Germany and adjacent agglomerations
(Author’s calculation; visualisation: Anne Wiese)

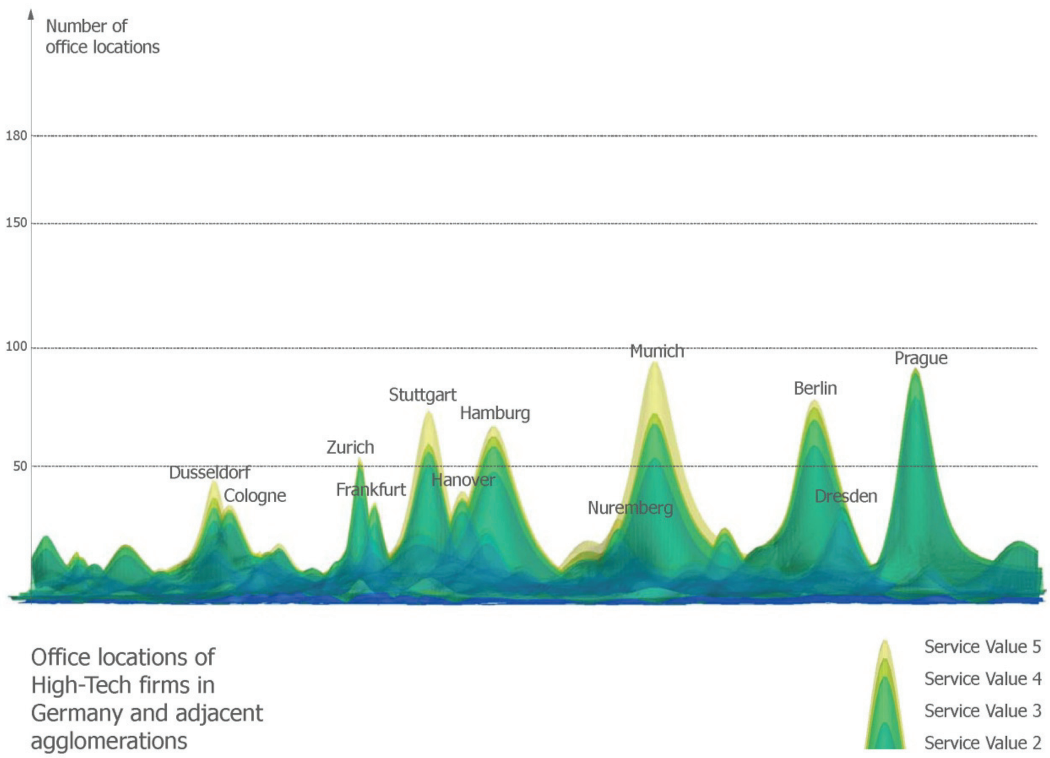


Figure 30: Office locations of High-Tech firms in Germany and adjacent agglomerations
(Author’s calculation; visualisation: Anne Wiese)

All in all, this section has illustrated that headquarter functions – more than office locations in general – are highly concentrated in just a few German FUAs. The geography of command and control in the German knowledge economy is quite uneven. High-level functions tend to be concentrated in a few agglomerations with privileged endowments, while medium- and low-level functions are scattered over more and various locations (Castells 1989). According to Sassen (2001b), the characteristic functions of corporate headquarters define their particular locational requirements. On the one hand, they require a strategic location close to global transportation and communication hubs in order to maintain contact with their globally-dispersed subsidiaries. On the other hand, they require local access to a particular range of labour market skills and to high-quality external services such as financial services, business consultancy, accountancy or marketing. These requirements lead to strong agglomerative forces, since much corporate headquarters activity involves interaction with the head offices of other organisations. Face-to-face contact with the top executives of other knowledge-intensive organisations is facilitated by geographical and relational proximity as well as by locations that are rich in social and cultural amenities (Sassen 2001b). In Germany, the Munich FUA seems to meet this mix of requirements the best.

7.2.2 Functional urban hierarchy in the German space economy

There is a strong tradition of research on hierarchical urban systems in Germany. Among others, this goes back to Christaller's (1933) central place theory, which had a considerable influence on Germany's academic debate and policy (Christaller 1933). The decentralised federal organisation and the division of the country during the Cold War have led to the development of a relatively polycentric urban system (Hoyler 2011b). Metropolitan functions and attributes – such as command-and-control functions, innovation and competitive functions, or gateway functions – are distributed across a series of agglomerations with no obvious primary city (BBR 2005:177-190). However, as Hoyler (2011b) argues, there is no substantial study on the equally important geographies of inter-city relations. Most studies focus on attribute data when analysing the German polycentric urban structure. But, as we have seen in Chapter 5, attribute data – such as the number of office locations in an agglomeration – says nothing about the hierarchy in a functional urban system. Functional urban hierarchies are defined by the *relations* between cities, and not by the clustering of city *attributes*; a fact that is widely acknowledged in regional science (BBR 2002; Blotevogel and Schulze 2009). In contrast to an attribute-based analysis, the interlocking network model developed by Taylor (2004b) can be used to analyse the functional urban hierarchy in the German polycentric urban system on different spatial scales. The following figures show the functional urban hierarchy in the German space economy by comparing connectivity patterns generated by global and regional interlocking networks.

Figure 31 indicates the functional urban hierarchy in the German space economy for *global interlocking networks*. On the X-axis are the top 20 German agglomerations with the highest global connectivity values. On the Y-axis, the global connectivity relative to the top FUA is displayed. These values illustrate how well a FUA is connected to *extra-European* destinations such as New York, Tokyo, Sydney etc. The size of the circles illustrates the sum of employees and inhabitants, giving an impression of the overall size of the agglomeration in question. The slightly concave curve progression for both APS and High-Tech firms indicates a *relatively* polycentric national urban pattern. In the case of APS, there is a top group of 6 FUAs: Frankfurt – the country's leading financial centre (Schamp 2003) – in the first position, followed by Hamburg, Munich, Düsseldorf, Stuttgart and

Berlin. These are also the leading core cities of the six German Mega-City Regions initially defined by the Framework for Spatial Planning Policy Implementation (Raumordnungspolitischer Handlungsrahmen) in 1995 (MKRO 1995). In the case of High-Tech firms, there is a top group of 4 agglomerations: Munich in the first position, followed by Stuttgart, Hamburg and Berlin. Interestingly enough, Frankfurt – which is in the first position in APS networks – does not emerge in a top position in the High-Tech sector.

Figure 32 shows the same setting for *national interlocking networks*; i.e. these values illustrate how well the top 20 German agglomerations are connected with all other FUAs in Germany. Again, the curve progression indicates functional polycentricity. For APS firms, the distinction between the top group and the rest of the German agglomerations is not as clear as in the case of global connectivity: Hamburg ranks first, followed by the FUAs of Munich, Berlin, Frankfurt and Stuttgart. In the High-Tech sector, by contrast, the gap between the top FUAs and the remaining agglomerations is very pronounced: Munich is clearly in the first position, followed by Stuttgart, Hamburg and Berlin; the remaining FUAs seem to be less integrated into national intra-firm circuits of High-Tech companies.

All in all, the interlocking network analysis in Figure 31 and 32 reveals a geography of APS and High-Tech connectivity that is quite polycentric in character, especially compared with countries such as the UK or France, where economic activities are strongly concentrated in London and Paris respectively (Halbert 2006; Pain 2006). Nevertheless, the functional urban hierarchy in Germany proves to be steeper than is claimed by the federal structure and many policy-makers. A maximum of six FUAs – Munich, Frankfurt, Hamburg, Düsseldorf, Stuttgart and Berlin – can be regarded as important gateways in the German knowledge economy.

Furthermore, the functional-urban hierarchy emerges as a scale-dependent phenomenon, depending on the organisational architectures and scalar reach of the different business networks: the larger the spatial scale of internal relations, the steeper the functional urban hierarchy. In the APS sector, for example, the FUA ranked 20th has 32 per cent of the top FUA's *national* connectivity. In terms of *global* connectivity, by contrast, the FUA ranked 20th has only 23 per cent of the top FUA's connectivity (see also Table 11A and 13A in Appendix A). This means that firms that are engaged in international businesses are mainly located in a few top German FUAs, whereas smaller agglomerations are rarely home for global firms of the knowledge economy. In other words: from a global perspective, the German space economy tends to be much less polycentric than from the perspective of national connectivities. The same conclusion is drawn by Taylor (2008) for a series of European Mega-City Regions: "…from the outside (the perspective of global business) the MCRs appear much less polycentric than their internal regional-scale integration previously suggested" (Taylor et al. 2008:1088p).

Figure 31 and 32 not only show the functional urban hierarchy in the German space economy; in some cases, they also illustrate a pronounced discrepancy between the mere size of a FUA – measured by the sum of inhabitants and jobs – and its global or national connectivity. The mere size of an agglomeration seems not to correlate automatically to its functional significance. Rather, it is a combination of different urban qualities and the locational strategies of knowledge-intensive firms that make an agglomeration a highly connected place on the global and national scale.

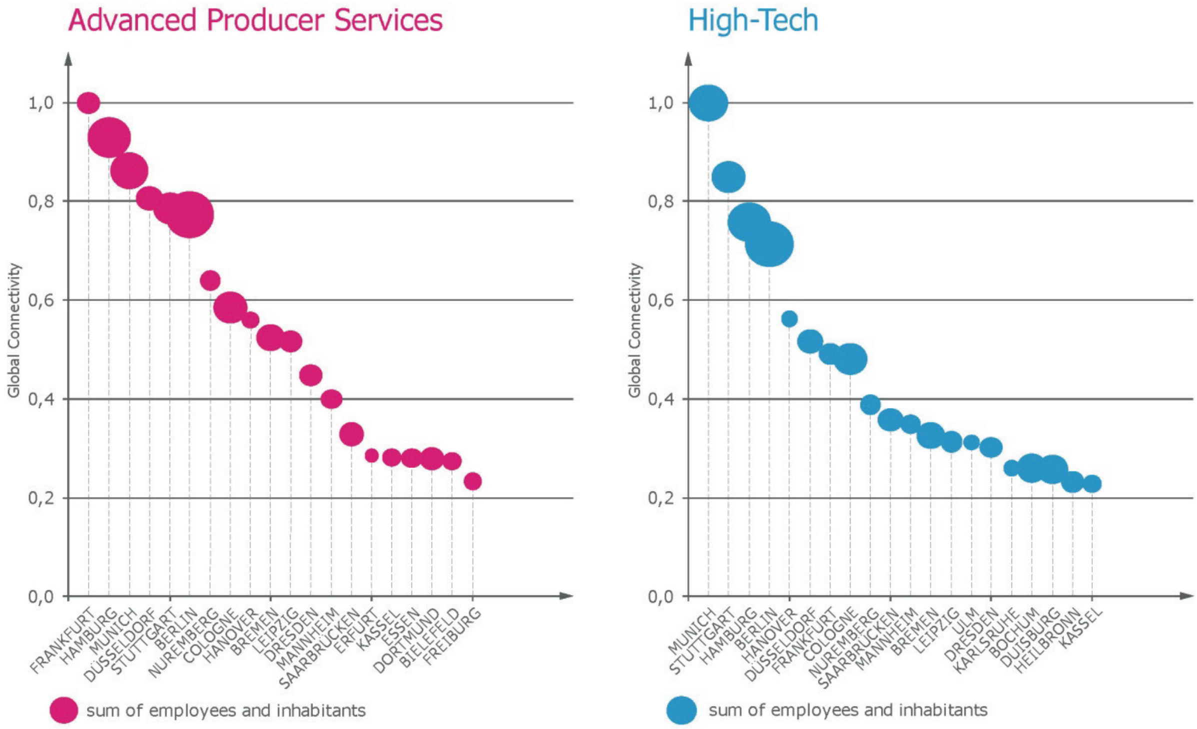


Figure 31: Functional urban hierarchy based on extra-European connectivity (Author's calculation)

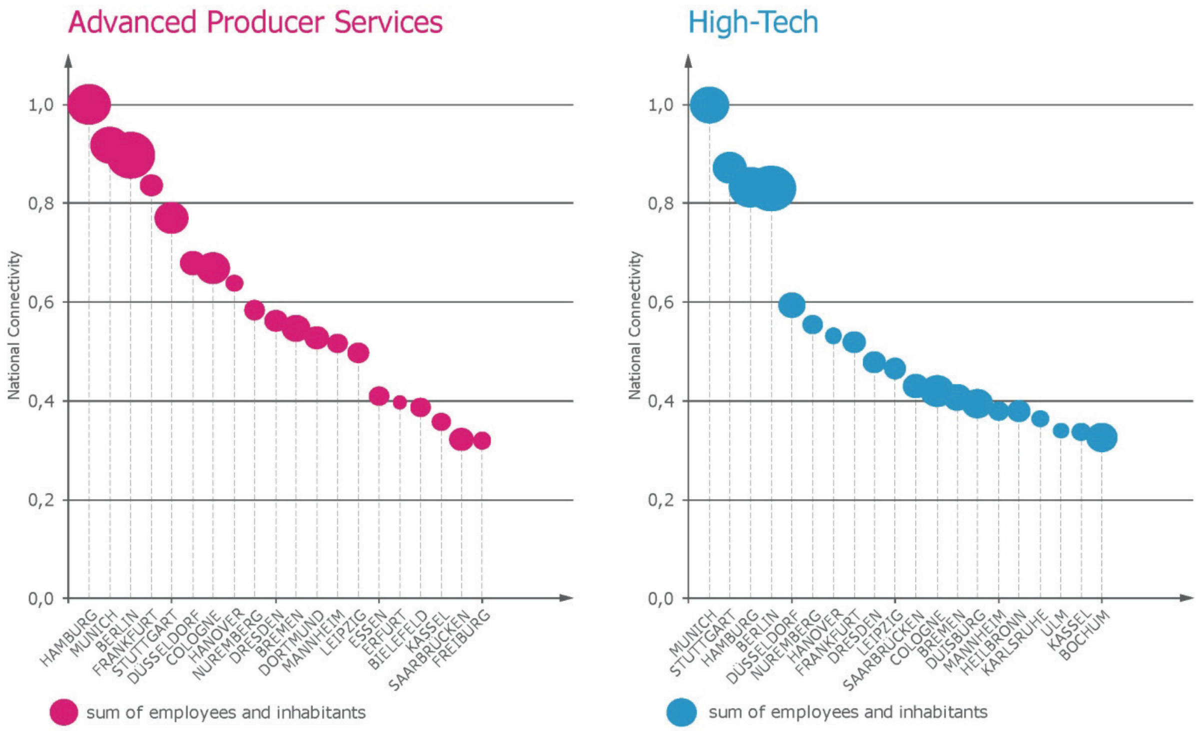


Figure 32: Functional urban hierarchy based on national connectivity (Author's calculation)

Generally, two spatial patterns can be observed. On the one hand, the biggest German FUAs – Berlin, Hamburg, Munich, Stuttgart and Cologne – always rank within the first 12 agglomerations in terms of connectivity. It seems that a certain critical mass has to be reached in order to generate a minimum degree of connectivity. On the other hand, however, critical mass is not enough to get to the first position in the connectivity ranking. In the APS sector, for example, Berlin is only ranked sixth, even though it is by far the biggest agglomeration in Germany. Frankfurt, by contrast, ranks first, even though it is rather small in terms of inhabitants and jobs. In broader assessments of metropolitan functions based on a wide range of attribute data, Frankfurt usually falls behind Berlin (Blotevogel and Schulze 2009) (see also Figure 29). In relational terms, however, Frankfurt clearly takes the top position, at least in terms of global network connectivity in the APS sector. A similar situation can be observed for national connectivities in the High-Tech sector, in which Cologne – the biggest FUA in Rhine-Ruhr – ranks only 12th and clearly falls behind the smaller FUA of Düsseldorf. This finding will be supported in Section 7.3.2, where seven FUAs in the Rhine-Ruhr region are analysed in greater detail.

The discrepancy between size and connectivity can also be seen in Figure 33, which shows the relative significance of the top 20 FUAs in Germany in terms of the total network connectivity of *APS firms*. In order to show the relative significance of an agglomeration in comparison to the other FUAs shown in the Figure, we related the total interlock connectivity for this agglomeration to the sum of its inhabitants and jobs. This relative significance is illustrated in the following way: the pink circle illustrates the connectivity value for the FUA; the black ring shows the sum of its inhabitants and jobs. A pink circle larger than the black one indicates a higher connectivity than would be expected in terms of inhabitants and jobs. This represents a surplus of significance. A smaller pink circle, in contrast, indicates a lower connectivity than expected, representing a deficiency of significance. In absolute terms, Hamburg shows the highest total connectivity – indicated by the size of the pink circle – followed by Frankfurt, Munich and Berlin. In relative terms, however, Hanover stands out as the best-connected agglomeration, followed by Frankfurt, Erfurt and Nuremberg (see Table 15A in Appendix A). Despite its small size, Hanover seems to engage in above-average volumes of economic information exchange with other locations worldwide. It is not the sheer size, but the number and the specific functions of APS office locations that generate this high degree of connectivity. Our database shows that many insurance companies have significant office locations in Hanover, e.g. the Hannover Re Group, the Concordia insurance company or the VHV insurance Group. Hanover – the capital city of Lower Saxony – seems to position itself successfully as an exhibition and university location in the wider metropolitan orbit of the Hanseatic city of Hamburg. Indeed, the interlocking network analysis shows that Hanover is highly connected to Hamburg via the intra-firm networks of knowledge-intensive enterprises. In this sense, Hanover can be understood as a complementary location to Hamburg, providing affordable local conditions and geographical proximity to Hamburg, the main service centre in northern Germany.

Figure 34 shows the relative importance of the 20 most networked FUAs in Germany for *High-Tech companies*. New in the top 20 are Ulm, Karlsruhe, Heilbronn, Duisburg and Bochum. Compared to the APS sector, Freiburg, Erfurt, Essen, Dortmund and Bielefeld are no longer on the map. It is striking that there are a number of High-Tech centres in the Rhine-Ruhr region. In relative terms, however, only Düsseldorf indicates a surplus of significance. The other FUAs – Cologne, Duisburg and Bochum – show a clear deficiency of significance.

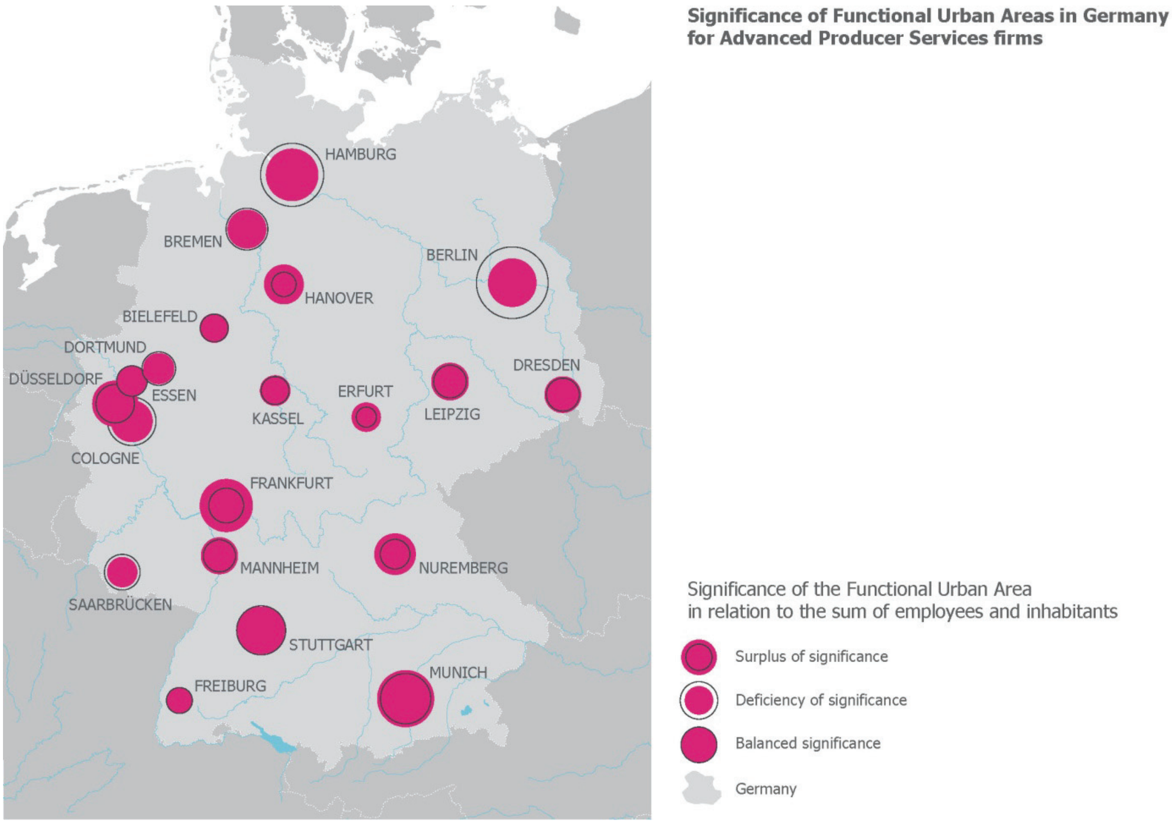


Figure 33: APS significance of German FUAs in comparison to each other (Author's calculation)

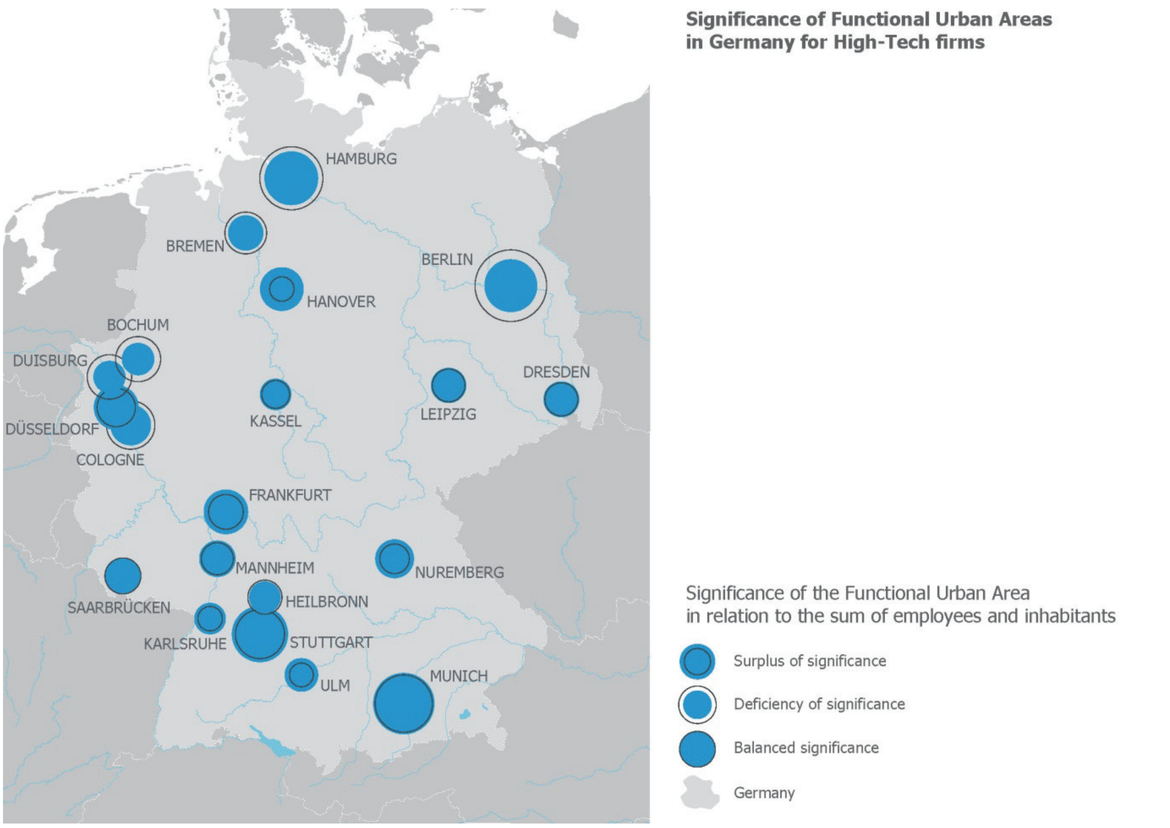


Figure 34: High-Tech significance of German FUAs in comparison to each other (Author's calculation)

Another cluster of High-Tech centres is located in southern Germany. In contrast to Rhine-Ruhr, however, they mostly show a surplus of significance. Nuremberg, for example, is highly integrated into the international networks of High-Tech companies such as DIEHL, Triumph-Adler and Grundig. Furthermore, various research institutions such as Fraunhofer, Max Planck and others are located in the Greater Nuremberg area (Metropolregion Nürnberg 2009).

Particularly striking in both the APS and the High-Tech sector is Berlin's distinct deficiency of significance. Even though Berlin is much bigger than Hanover or Nuremberg in terms of inhabitants and jobs, and even though it has gained significantly as a location of political decision-making after unification, it demonstrates a relatively low degree of total network connectivity. The urban development of Berlin – especially the ambitious construction projects at the Potsdamer Platz and the government quarter – suggest that the relocation of the government seat from Bonn to Berlin in the 1990s is expected to recover Berlin's economic situation. However, a complete restructuring of the existing functional and sectoral specialisation in the German urban system can hardly be expected to happen in the near future. This is also confirmed by Geppert (2005), who argues that Berlin ranks currently far behind in the hierarchy of major European agglomerations. And also its economic growth was relatively weak in recent years. Hence, there is little evidence that the position of Berlin will improve dramatically. Geppert's (2005) analysis shows that the European functional urban hierarchy is very stable over time. There are only a few shifts in the rankings, and these are largely influenced by nation-based macroeconomic factors (Geppert 2005). In fact, Berlin *does* have a high density of R&D employment, but this – in contrast to Munich for example – is mainly the result of publicly funded research institutions (Jähnke and Wolke 2005). Hence, the challenge for Berlin's regional economy is mainly structural. Many companies *do* have an office in Berlin, but the company's strategic decisions are made in other FUAs. In this context, an APS company in Mering near Munich noted that:

> *"In Berlin, we work from the Berlin office (…). We work for the Senate in Berlin. They said: if you want to work with us, than you have to have an office location here, or we might not talk further. Because of that we have a small office in Berlin staffed with four to five people (…). Many companies are sitting there just so they can say they have an office in Berlin. But the headquarters are somewhere else; the actual decisions are made elsewhere" (APS firm, Mering, 04.10.2010).*

The main opportunity for Berlin lies in its attractiveness as a place of residence for highly-skilled employees in the knowledge economy. An interviewee of a consulting company, for example, stated that Berlin was the biggest branch office in Germany in terms of the number of consultants, simply because many employees want to live in Berlin or spend their weekends there. Similarly, Yeung et al. (2001) argue that TNCs are willing to accommodate their operations to suit the preferences of key employees such as top executives or high-class researchers (Yeung et al. 2001). Hence, the argument of Florida (2002) that 'jobs follow people' seems to have some justification, at least in the context of the knowledge economy (Florida 2002).

Another opportunity for Berlin lies in its role as complementary business location to the established command-and-control centres in Germany. The proximity to German policy-makers might play a role here. Berlin has many office locations with a service value of 3 (see Figure 29), suggesting that it is an important location for *regional* business headquarters. Regional headquarters constitute an intermediate level in the corporate organisational structure. Thereby, they act as a kind of "strategic window" (Kriger and Rich 1987:45) for firms operating on a global scale (see Chapter 3.2.3). In the long run, this could move Berlin into a favourable position within the organisational networks of knowledge-intensive firms.

Until now, we analysed the connectivity patterns for the top FUAs in the German space economy. However, an essential feature of Mega-City Regions is that in different degrees they are polycentric, comprising several FUAs, which are functionally networked and clustered around one or more larger central cities (Hall and Pain 2006). The various FUAs making-up a polycentric Mega-City Region may be able to achieve sufficient scale to sustain competitive advantage. Van Winden et al. (2007) for example argue that the sheer size of metropolitan regions matters as an attraction factor for both companies and knowledge workers. A large urban size supports facilities and amenities such as international schools or inter-continental hub-airports (van Winden et al. 2007).

In order to account for both connectivity *and* critical size, we aggregated the FUAs according to the eleven politically-designated Mega-City Regions in Germany: Munich, Stuttgart, Rhine-Neckar, Nuremberg, Rhine-Main, Rhine-Ruhr, Saxony-Triangle, Hanover-Braunschweig-Göttingen-Wolfsburg, Berlin-Brandenburg, Bremen-Oldenburg and Hamburg. The spatial delimitation of these Mega-City Regions is based on different information sources: the delimitation of Rhine-Main is based on Freytag et al. (2006); the delimitation of Rhine-Ruhr is based on Knapp et al. (2006a); the delimitation of the Mega-City Region of Munich is based on Lüthi et al. (2010b); the remaining Mega-City Regions are delimited according to the official political definition based on IKM (2010) (see Table 74A in Appendix B for details) (Freytag et al. 2006; Knapp et al. 2006a; Lüthi et al. 2010b; IKM 2010).

The following Figures compare the total connectivity with the sheer size of all Mega-City Regions in Germany. On the X-axis, the sum of employees and inhabitants is displayed, relative to the mean score of all Mega-City Regions (=1). On the Y-axis, the average interlock connectivity per FUA is shown, also relative to the mean score of all Mega-City Regions (=1). Based on this analysis, four groups of Mega-City Regions can be distinguished (see Figures 35 and 36):

- I. Mega-City Regions with a high connectivity and a large urban size
- II. Mega-City Regions with a high connectivity despite of their small urban size
- III. Mega-City regions with little connectivity and a small urban size
- IV. Mega-City Regions with little connectivity despite of their large urban size

Figure 35 confirms many of results of the analyses above. In the *APS sector*, the Mega-City Regions of Rhine-Ruhr, Hamburg, Rhine-Main and Munich show above-average connectivities per FUA. Obviously, Rhine-Ruhr dominates because of its large size. The Mega-City Region of Munich shows the third largest urban size, but it is only slightly above-average regarding total connectivity. The Mega-City Region of Hamburg achieves high connectivity values, although it is relatively small in terms of inhabitants and jobs. Rhine-Main falls back in comparison to Hamburg. Apparently, Rhine-Main as a whole is not able to replicate the dominance of the FUA of Frankfurt in terms of global APS connectivity (compare Figure 31). The remaining Mega-City Regions in Germany show below-average connectivity patterns. The Saxony-Triangle, Berlin-Brandenburg and Stuttgart create little connectivity despite of their large urban size. In the Mega-City Regions of Rhine-Neckar, Bremen-Oldenburg, Hanover-Braunschweig-Göttingen-Wolfsburg and Nuremberg, the little connectivity might be because they do not reach the necessary critical size.

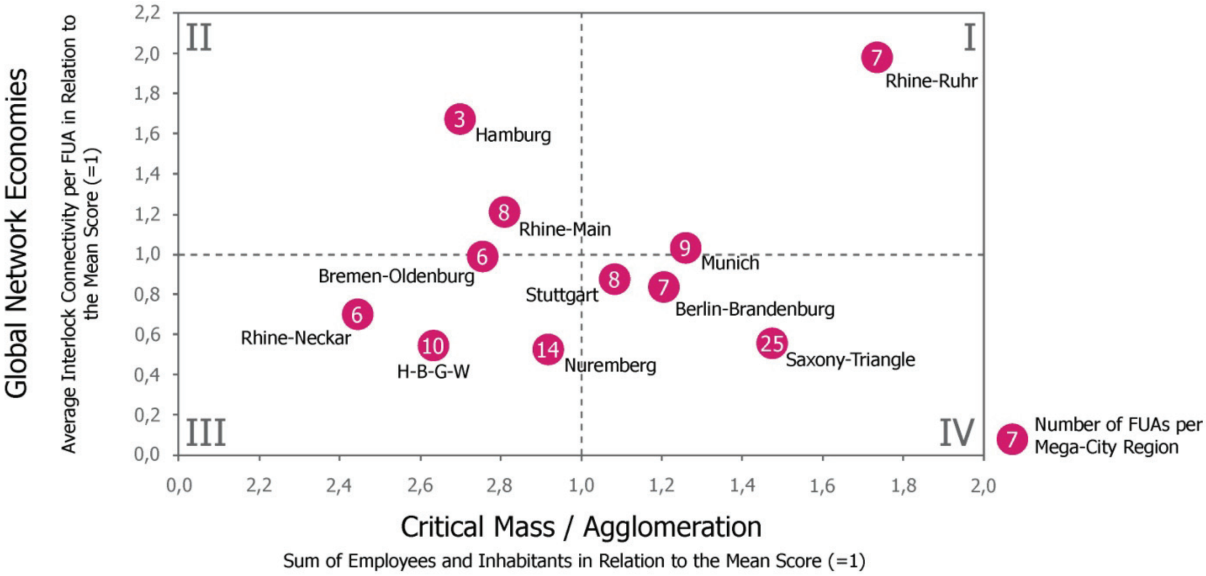


Figure 35: APS connectivity and critical mass in German Mega-City Regions (Author's calculation)

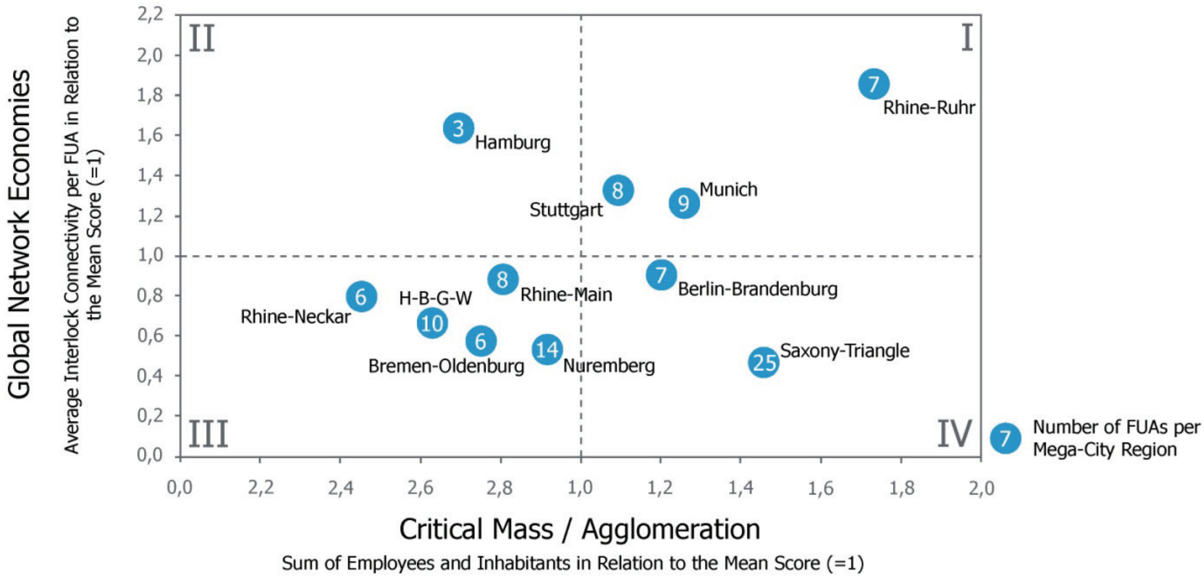


Figure 36: High-Tech connectivity and critical mass in German Mega-City Regions (Author's calculation)

In the *High-Tech sector* (see Figure 36), the previous analyses are also mostly confirmed. The Mega-City Regions of Rhine-Ruhr, Hamburg, Stuttgart and Munich show above-average connectivities per FUA. Again, Rhine-Ruhr dominates because of its huge urban size. The Mega-City Region of Hamburg ranks second in terms of total connectivity. The Mega-City Region of Stuttgart and Munich indicate similar connectivity patterns. Compared to the previous analyses on the FUA level, however, they lose their top positions. Similarly to Frankfurt in the APS sector, the Mega-City Regions of Munich and Stuttgart as a whole seem not able to replicate the dominance of their core FUAs in terms of High-Tech connectivity (compare Figure 31 and 32). The remaining German Mega-City Regions indicate below-average connectivities. Again, the Saxony-Triangle and Berlin-Brandenburg generate low connectivity values despite of their large size in terms of inhabitants and jobs. The rather low connectivity of Rhine-Neckar, Bremen-Oldenburg, Hanover-Braunschweig-Göttingen-Wolfsburg, Nuremberg and Rhine-Main, on the other hand, tends to be the result of their small urban size. Furthermore, note that the Mega-City Regions of Stuttgart and Rhine-Main changed their positions in comparison to the APS sector. Stuttgart moved up into the upper-right quadrant, Frankfurt, on the other hand, moved down into the bottom-left quadrant of the High-Tech Cartesian system.

All in all, the analysis in this section makes clear that the functional urban hierarchy in Germany tends to be steeper than is claimed by the political debate on Mega-City Regions. On the FUA level, a maximum of six FUAs – Munich, Frankfurt, Hamburg, Düsseldorf, Stuttgart and Berlin – can be regarded as the most important knowledge hubs in the German space economy. This hierarchy is even steeper if only global connectivities to non-European cities like New York or Sydney are considered. Furthermore, the mere size of an agglomeration does not necessarily correlate with its position in the functional urban hierarchy. The Berlin FUA, for example, indicates an unexpected deficiency of connectivity even though it is the biggest German FUA in terms of inhabitants and jobs. The same piece of evidence is offered on the Mega-City Region level. Only Rhine-Ruhr, Hamburg and Munich show above-average connectivity in both the APS and the High-Tech sectors. Rhine-Main indicates above-average connectivity only in APS, and Stuttgart only in the High-Tech sector. All other politically designated Mega-City Regions indicate below-average connectivity, some despite of their large urban size and others because of their small urban size.

7.2.3 Globalism and localism in the German space economy

Globalisation is a process that can be found in all agglomerations. Each FUA is linked simultaneously on the global and the local scale. The crucial question is which of these two processes is predominant? The direct comparison between local and global connectivities in a FUA reveals its main geographical orientation: each FUA is networked locally – i.e. within their own country – and globally – i.e. outside the country. The ratio of global and local networks determines whether a FUA is more globally oriented (globalism) or more nationally networked (localism). Figure 37 shows these measures for the top 20 APS and High-Tech locations in comparison to each other (see also Table 19A and 20A in Appendix A). The coloured ring illustrates the measure of 'globalism': the connectivity to all FUAs outside Germany. The grey circle shows the measure of 'localism': the connectivity to all FUAs inside Germany. A coloured ring larger than the grey one indicates a surplus of globalism; a larger grey circle shows a surplus of localism. If the coloured ring and the grey circle have the same size, globalism and localism are balanced in comparison to the other FUAs in the Figure.

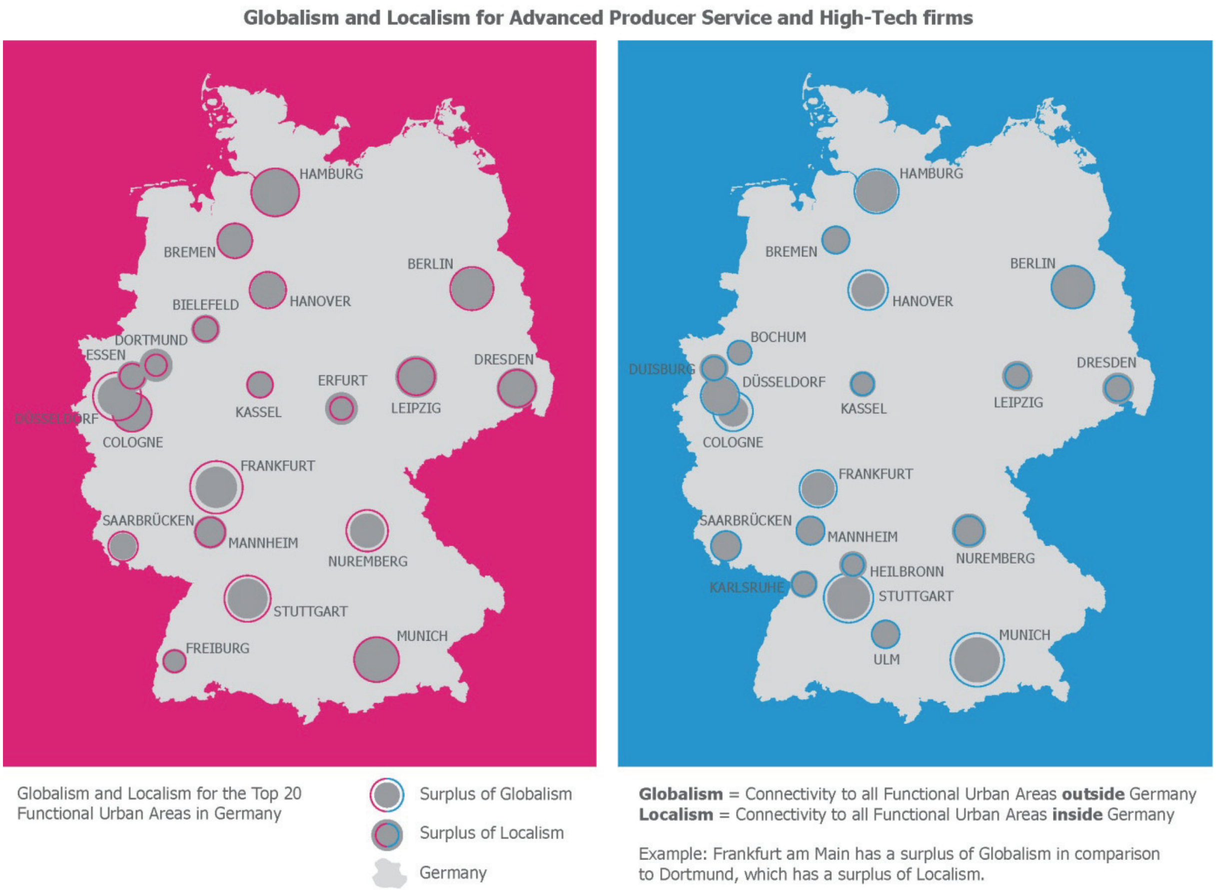


Figure 37: Globalism and localism for APS and High-Tech firms (Author's calculation)

Figure 37 shows to what extent the various German FUAs are involved in global and national intra-firm networks of the knowledge economy. Global *APS companies* are mainly concentrated in Frankfurt and Düsseldorf. As economic centre and 'first city' of Rhine-Main, Frankfurt houses APS firms in all the sectors analysed in this study, with particular strengths in banking & finance (rank 1 globally), law (rank 1 globally) and accounting (rank 6 globally). Düsseldorf, on the other hand, shows a particular strengths in advertising & media (rank 4 globally) (see Appendix A). In the *High-Tech* sector, Cologne, Hanover, Munich and Stuttgart stand out as the most 'non-local' FUAs. In the case of Hanover, the surplus of globalism is rather surprising. It is the result of a disproportionately large number of global companies being on site, such as Siemens, Robert Bosch or BASF. Munich and Stuttgart, on the other hand, are well-known and therefore confirmed as German High-Tech centres with global importance (see also Figures 31 and 32). Munich shows a particular strength in computer hardware (rank 1 globally) and telecommunication (rank 4 globally); Stuttgart shows a particular strengths in machinery (rank 4 globally) and vehicle construction (rank 3 globally) (see Appendix A).

These findings make it clear that there are only a few gateways within each individual sub-sector, through which information is sourced or exported globally. The most important of these gateways in the APS sector is Frankfurt. Note also the differences between Düsseldorf and Cologne in terms of APS and High-Tech connectivity. In the APS sector, the contrast between 'local' Cologne and 'global' Düsseldorf highlights the different emphases of these FUAs in providing advanced services in the knowledge economy. In the High-Tech sector, however, their roles seem to be reversed. Cologne shows a clear surplus of globalism; Düsseldorf, in contrast, indicates a more balanced ratio between national and global connectivities. Other FUAs such as Dortmund in APS or Heilbronn in High-Tech are less directly integrated in global intra-firm networks of the knowledge economy. Knowledge-intensive enterprises in these agglomerations tend to source information from the main knowledge-hubs in the German urban system, where this knowledge is produced or imported by specialised companies or research institutions. The general assumption, however, that medium-sized FUAs themselves act as regional gateways for even smaller agglomerations has not been confirmed by the interlocking network analysis (see Figure 38). A "nested hierarchy" – as proposed by Camagni (1993) – cannot be observed in the German urban system (Camagni 1993). In other words, knowledge-intensive firms in small FUAs are directly linked to large German FUAs, without making a detour through regional gateways. Similarly, Taylor (2011b) argues that with the current communication technologies, it is no longer necessary to squeeze information and business activities through a single gateway: "knowledge flows can criss-cross through economic space along all manner of routes" (Taylor 2011b:197). In this sense, our empirical analysis also underlines Amin and Cohendet's (2004) argument of overlapping and trans-scalar knowledge activities: "We propose, against a geography of scalar nesting, a map of knowledge practice as tracings in criss-crossing and overlapping networks of varying length and reach, thus allowing an understanding of individual sites as a node of multiple knowledge connections of varying intensity and spatial distance, as a place of trans-scalar and non-linear connections, and as a relay point of circulating knowledge that cannot be territorially attributed with any measure of certainty or fixity. This is an important dimension of spatiality that we wish to add to the rich vein of works that has grown in economic geography on the territorial moorings of knowledge" (Amin and Cohendet 2004:93).

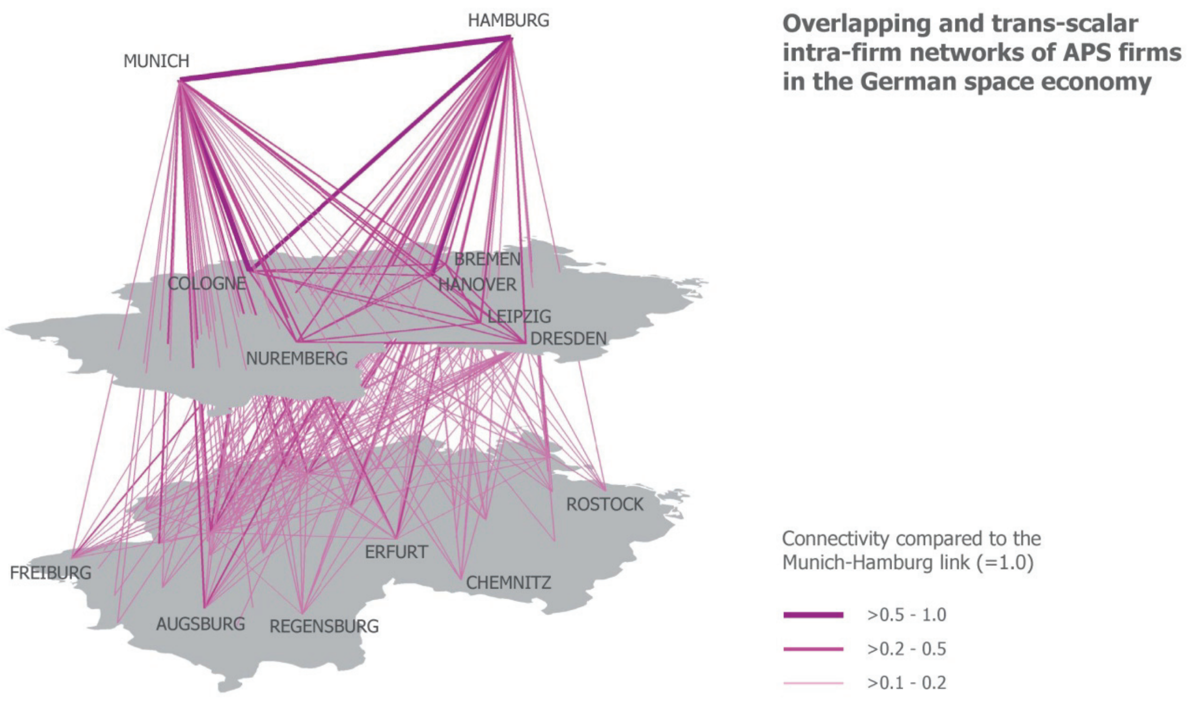


Figure 38: Overlapping intra-firm networks of APS firms in the German space economy (Author's calculation; visualisation: Anne Wiese, Michael Bentlage)

The interlocking network model not only allows the comparison of local and global connectivity, it also allows the identification of connectivity patterns to very specific cities throughout the city network. For example, the relative connectivity of German FUAs to New York and London (traditional globalism) or to Beijing, Hong Kong and Shanghai (new globalism) can be investigated. The traditional globalism of a FUA measures its combined connectivity with London and New York (NYLON), traditionally the leading city dyad. New globalism, on the other hand, measures the combined connectivity to the emerging city triad in China based upon Beijing, Shanghai and Hong Kong.

These hinterworld dimensions (Taylor 2004b; Hoyler 2011a; Taylor et al. 2011b) are calculated as shown in the following example for Hamburg's connections to the New York-London (NYLON) dyad, with *r* representing the *city interlock*, and *N* representing the total *interlock connectivity* (see also Chapter 6). Positive values of this measure indicate a higher connection to NYLON than the average FUA in Germany (overlinkage); negative values indicate a relative 'underlinkage':

$$Hamburg\ (NYLON) = \frac{\sum r_{Hamburg-NYLON}}{N_{Hamburg}} - \frac{\sum r_{Germany-NYLON}}{\sum N_{Germany}}$$

Figure 39 compares traditional and new globalism for the 10 most intensively networked German FUAs in the *APS sector* (see also Table 21A and 22A in Appendix A). The westbound arrows illustrate traditional globalism; the eastbound arrows represent new globalism. In order to analyse the results more easily, the average connectivities of all German FUAs with the corresponding destinations are shown by a reference indicator.

Again, the largest German agglomerations dominate the map. Munich shows the highest connectivity in both traditional and new globalism, followed by Frankfurt and Düsseldorf, the latter being the prime location for Japanese firms in Germany (Hoyler 2011b). These FUAs seem to be not only highly connected to New York and London, but also well equipped with their service connections to face the challenges in the context of the growing East Asian economy (Kunzmann et al. 2009). A second stratum is formed by Berlin, Hamburg, Cologne and Stuttgart. All these FUAs are overlinked, i.e. their connectivity to NYLON as well as Beijing, Hong Kong and Shanghai is above average compared to all German FUAs; Bremen and Hanover, in contrast, are underlinked. An interesting case is Nuremberg, which is overlinked to Beijing, Hong Kong and Shanghai, but underlinked to the traditionally leading city dyad NYLON. The strong link to East Asia is mainly forged by some large logistics companies like Schenker or Logwin having not only high-grade locations in Nuremberg (Service Value 4) but also important offices in Peking, Hong Kong and Shanghai.

Michael Hoyler (2011b) conducted a similar analysis for the APS networks in the German urban system from a global perspective: his benchmark was not the average connectivity of all German FUAs, but the average connectivity of all 525 cities examined worldwide. Hoyler's results are slightly different: Frankfurt clearly ranks top in both traditional and new globalism, followed by Munich. A second stratum is formed by Düsseldorf, Cologne and Hamburg, which also indicate positive scores and therefore a relative over-linkage in their business service connections to NYLON and the Chinese city-triad (Hoyler 2011b).

This difference to our analysis – which takes the perspective of Germany-based companies – is no accident. Obviously, from a global top-down perspective, Frankfurt clearly ranks top as the location of choice for many global service firms centred on NYLON or Beijing-HongKong-Shanghai. From a national bottom-up perspective, however, a much more polycentric urban pattern comes to light with the FUAs of Munich, Frankfurt and Düsseldorf showing relatively strong connections to both NYLON and the emerging city-triad in China.

Figure 40 shows the same situation for the ten most intensively networked German FUAs in the *High-Tech sector* (see Tables 23A and 24A in Appendix A). Generally, the difference between the top 10 FUAs and the German average is not as pronounced as in the APS sector. Obviously, internationally-oriented High-Tech companies are spread more evenly over the German space economy: Frankfurt shows the strongest connection to NYLON, followed by Munich, Düsseldorf, Hamburg and Cologne; Berlin, Nuremberg and Stuttgart are only slightly above the national average; Hanover and Saarbrücken are slightly below average. With regard to the High-Tech connectivity with Beijing, Hong Kong and Shanghai, six FUAs are above the German average: Munich ranks first, followed by Cologne, Düsseldorf, Berlin, Hamburg and Stuttgart. Interestingly, Frankfurt is overlinked to the traditional world cities of New York and London, but underlinked to the emerging High-Tech markets in China, which again tends to reflect the close post-war economic ties of Frankfurt with the USA and Western Europe (Hoyler 2011b).

Comparing the composition of the High-Tech connectivity of Frankfurt for 'traditional globalism' and Munich for 'new globalism', some interesting functional patterns emerge. The connectivity of Frankfurt to NYLON is formed above all by subsidiaries of large foreign companies such as IBM, HP, Avaya, Nokia or Ericsson. Mostly, these are subsidiaries with a service value of 2, representing offices with no special responsibilities within the company's internal network. In other words, in the High-Tech sector, Frankfurt can be interpreted as a '*passive connectivity space'*, often chosen by international companies as the main German subsidiary. Again, it becomes clear that in the view of many international knowledge-intensive firms – i.e. from a global perspective – Frankfurt still tends to be one of the most important international knowledge hubs in Germany.

The connectivity of Munich with Beijing, Hong Kong and Shanghai, by contrast, arises mainly from many High-Tech companies that have their headquarters in Munich, from where they follow a strategy of expansion into East Asian markets. Our High-Tech records include 14 companies which have their headquarters in Munich and at least one office location in Beijing, Hong Kong and/or Shanghai. Companies such as MAN, Siemens, Knorr Bremse AG, Süd-Chemie and Linde, for example, are strongly represented in East Asian markets (service value at least 3). Hence, the FUA of Munich can be understood as an *'active connectivity space'*, because the headquarters of these High-Tech companies initiate and organise the connectivities into the emerging markets in China themselves. Recent studies in the context of the current financial and economic crisis have shown that regions with strong connectivities to East Asia have better coped with the challenges of the economic crises (Berube et al. 2010) (see also Chapter 8). Thus, the Munich FUA seems to be well positioned to benefit from the economic growth of the rising East Asian markets.

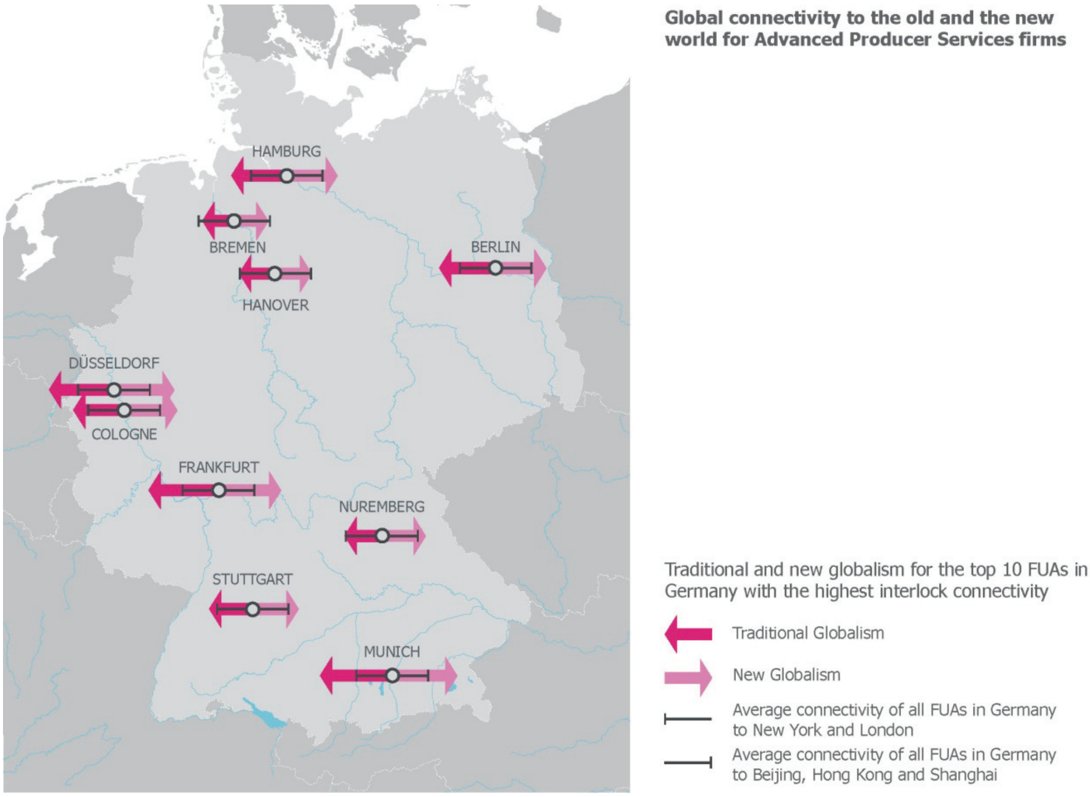


Figure 39: Traditional globalism and new globalism in Germany based on APS networks (Author's calculation; visualisation: Anne Wiese)

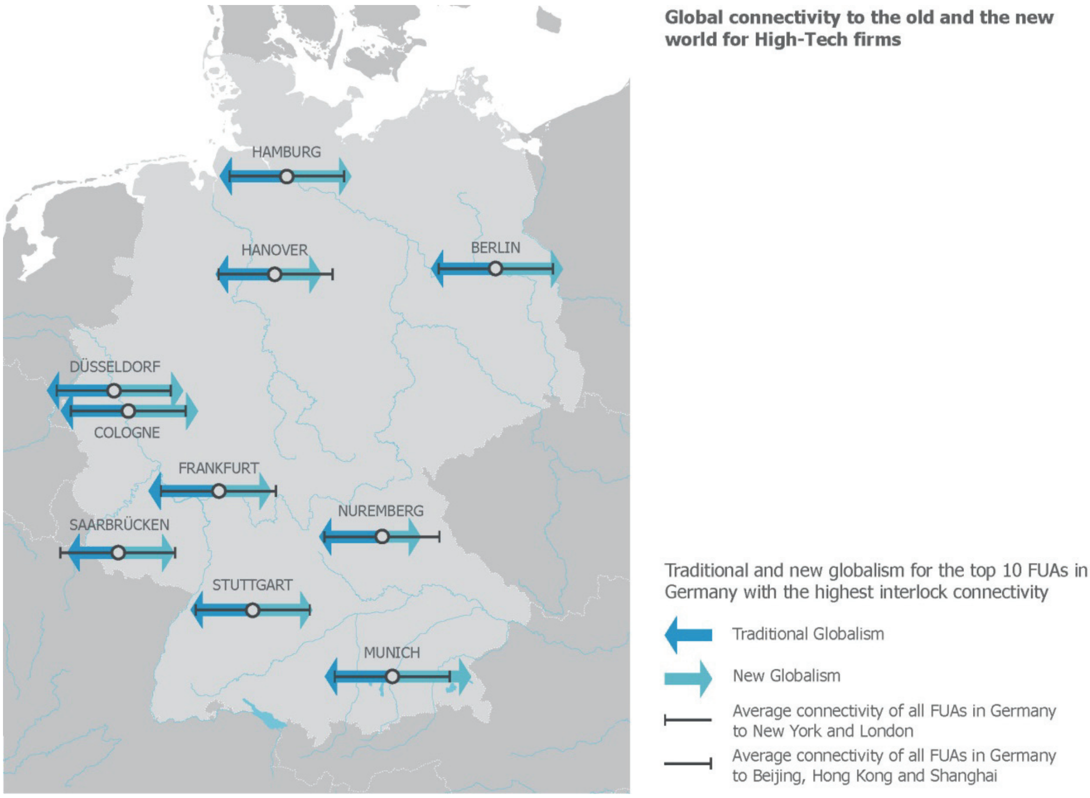


Figure 40: Traditional globalism and new globalism in Germany based on High-Tech networks (Author's calculation; visualisation: Anne Wiese)

7.2.4 Localised systems of value chains in the German space economy

Information exchange is not only emerging through internal branch networks, but also through cooperative collaborations between firms along the value chain (sees Section 2.2). Most of these economic activities do not fall within clearly defined geographical boundaries. Companies organise their business activities in a variety of different locations. This gives rise to communication networks, in which information is exchanged and shared, and new knowledge is produced. This knowledge creation process is organised along the value chain, whose elements are embedded in spatial and social contexts. If a sufficient number of such localised value chains are superimposed, it is possible to draw a kind of 'value added map' that identifies functional urban hierarchies and geographical specialisation patterns. In order to reveal localised systems of value chains in the German space economy, a web survey has been conducted, in which the companies were asked to provide the locations of their most important partners in the course of the preparation of their products or services. The analysis focused especially on the geographical distribution of these partners and the spatial reach of the various business relations along the value chain (see also Section 6.2 and Appendix C). The web survey was e-mailed to 3541 knowledge-intensive firms in Germany; of these, 391 responses could be used for the final analysis (Figure 77A in Appendix C shows the locations of the responding firms in Germany).

Figure 41 presents the result of the web survey, aggregated according to the eleven politically-designated Mega-City Regions in Germany (see Table 74A in Appendix B for details concerning their spatial delimitation). Each Mega-City Region displays a stylised value chain with the elements 'research & development', 'processing', 'financing', 'marketing', 'sales & distribution' and 'customers'. The font size of these elements illustrates the amount of value-adding activities as stated by the responding APS and High-Tech firms in the web survey. All in all, 331 firms indicated 1346 value-adding activities in at least one German Mega-City Region. The locations with the coloured terms in one value chain element cover over 50 per cent of the corresponding value-adding activity. For example: the Mega-City Regions of Munich, Rhine-Ruhr and Hamburg together cover over 50 per cent of the 'marketing' relations generated by the responding APS and High-Tech firms.

First of all, it becomes clear that all politically-designated Mega-City Regions in Germany are integrated to some extent into the value-added networks of knowledge-intensive enterprises. Above all, customers tend to be relatively evenly spread over the German territory. Munich and Rhine-Ruhr seem to be the top Mega-City Regions in terms of the density and variety of value-added expertise, followed by Stuttgart, Hamburg and Frankfurt. In these Mega-City Regions, many elements of the value chain are strongly represented; making them to highly diversified localised systems of value chains. These Mega-City Regions are characterised by a wide range of vertical integration along the value chain, i.e. companies located in these areas are potentially able to source many elements of their value-added activities within their own Mega-City Region. This finding confirms that for knowledge-intensive firms urbanisation economies are crucial. Highly specialised and knowledge-intensive firms benefit from locating close to other firms who produce key inputs for their products or services. According to Sassen (2001b), for example, an accounting firm is able to service its customers at a distance, but the creation of the service itself depends on proximity to other specialists such as lawyers, programmers or financial service providers. The translation of such a service into a specific performance requires the simultaneous participation of several specialised firms providing legal, accounting, financial, marketing and other knowledge-intensive services (Sassen 2001b).

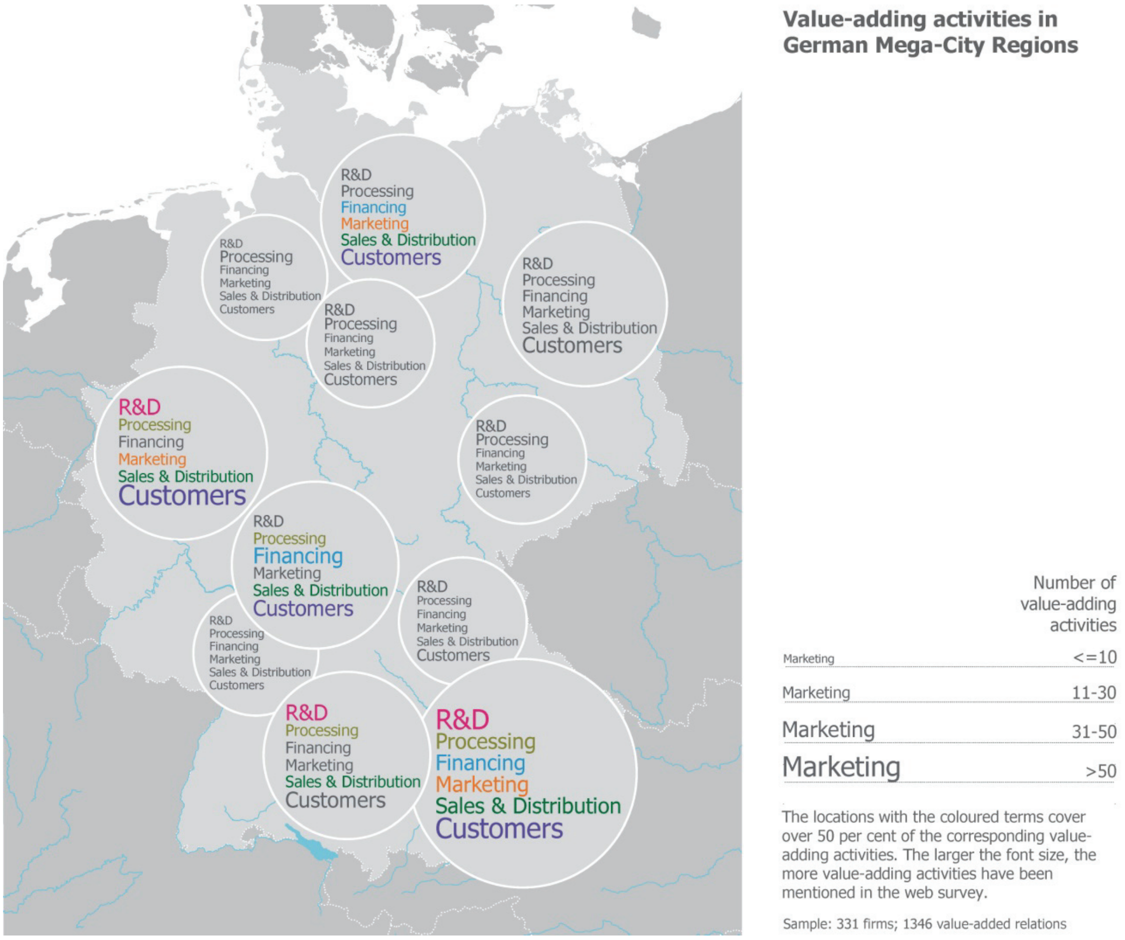


Figure 41: Value-adding activities in German Mega-City Regions (Author's calculation)

In order to reveal patterns of functional specialisation in the German space economy, Figure 42 shows the degree of *localisation* of the specific value chain elements (V) in the German FUAs based on the responses from the web survey (see also Table 26A in Appendix A). The map indicates the activities along the value chain based on the highest *Localisation Quotient (LQ)* in each FUA. The LQ compares the share of a specific value chain element (j) in a FUA (i) with the share of the same value chain element in the whole area. The LQ provides a value greater than 1.0 where the proportion of the value chain element in a FUA is greater than its share in the whole area. Otherwise, the value is less than 1.0. The higher the LQ the stronger the localisation of the value chain element in a FUA. Since this is a double ratio, the sheer size of a FUA has no effect on the LQ (Bathelt and Glückler 2002:86):

$$LQ_{ij} = \frac{v_{ij}/V_i}{V_j/V}$$

In Figure 42, a value chain element is mapped only if it reaches the highest LQ within the FUA and – at the same time – if it received at least 4 references in the questionnaire. Hence, the map shows the relative functional specialisation in the German space economy, with Munich, Stuttgart, Frankfurt and Hamburg having outstanding intensities of high value-added activities such as R&D, financing and marketing. In Nuremberg, Dresden and Mainz, there is a relative concentration of processing, while customers of knowledge-intensive companies are mainly located in Berlin, Hanover and in the Rhine-Ruhr region.

Frankfurt indicates a high degree of localisation in the financial sector, which underlines its role as Germany's undisputed financial centre (Grote 2004). Nevertheless, business relations in financing show two different kinds of geographies. On the one hand, financial services appear in small agglomerations such as Lübeck or Münster, illustrating the huge networks of branches of retail banks and other financial services supplying final demand. On the other hand, high-order financial services are heavily concentrated in Frankfurt am Main. The widespread deregulation of financial services during the 1980s and 1990s had a significant impact on Frankfurt and the global network of financial centres as a whole. Martin (1999) for example argues that such developments "…made it possible for footloose financial firms to set up directly in the world's leading metropolitan centres rather than serving them from a distance… International firms want to locate in these different metropolitan financial centres because each has a different financial specialisation, and each is the hub of a different… continental global region. Foreign banks and related institutions have moved into these centres precisely because of geography, that is to expand their presence, to gain access to specific markets, to capitalise on the economies of specialisation, agglomeration and localisation… available in these centres, or to specialise their own operations and activities geographically" (Martin 1999:19p). However, in spite of the widespread deregulation of financial services, the different regulatory environments from country to country still have a huge influence on the locational strategies of international financial service firms (Dicken 2007). In future, it will be interesting to see how external shocks – such as the recent financial and economic crisis – will influence the position of Frankfurt within the functional urban hierarchy of the global financial centres. Western European cities may move down to make way for Asian financial centres such as Hong Kong or Singapore. The political efforts in Europe to regulate financial markets more strictly may increase the pace of this process even more. Already today, Derudder et al. (2011) observe a relative decline of Frankfurt in terms of global network connectivity, especially because the significant rise of East Asian cities into the top league of financial centres worldwide (Derudder et al. 2011).

In southern Germany – especially in Munich and Stuttgart – a specialisation on R&D can be observed. This finding is also reflected in statistical analyses based on patent data or employment figures. For example – as a study of Prognos (2007) shows – in Baden Wuerttemberg and Bavaria, 22'900 patents have been applied for in 2005 (according to the residence of the inventor). Thus, 51.2 per cent of all patent applications come from the south of Germany. Moreover, 44'300 people in Stuttgart and Munich work in the field of R&D, which is 14.9 per cent of all R&D employees in Germany (Prognos 2007). As we have seen in Section 7.2.1, Munich and Stuttgart also indicate the most headquarters in the High-Tech sector. Hence, many knowledge-intensive firms seem to concentrate their R&D activities close to their corporate headquarters. Dicken (2007), for example, argues that many TNCs continue to show a very strong preference for keeping their high-level R&D activities at home, whereas support laboratories tend to be spatially more widely spread, especially close to production units (Dicken 2007). In a detailed empirical analysis of patent data for almost 600 firms, Patel (1995) for example found that less than 8 per cent of these firms located more than half of their technological activities outside their home country, and more than 40 per cent performed less than 1 per cent of their technological activity abroad (Patel 1995).

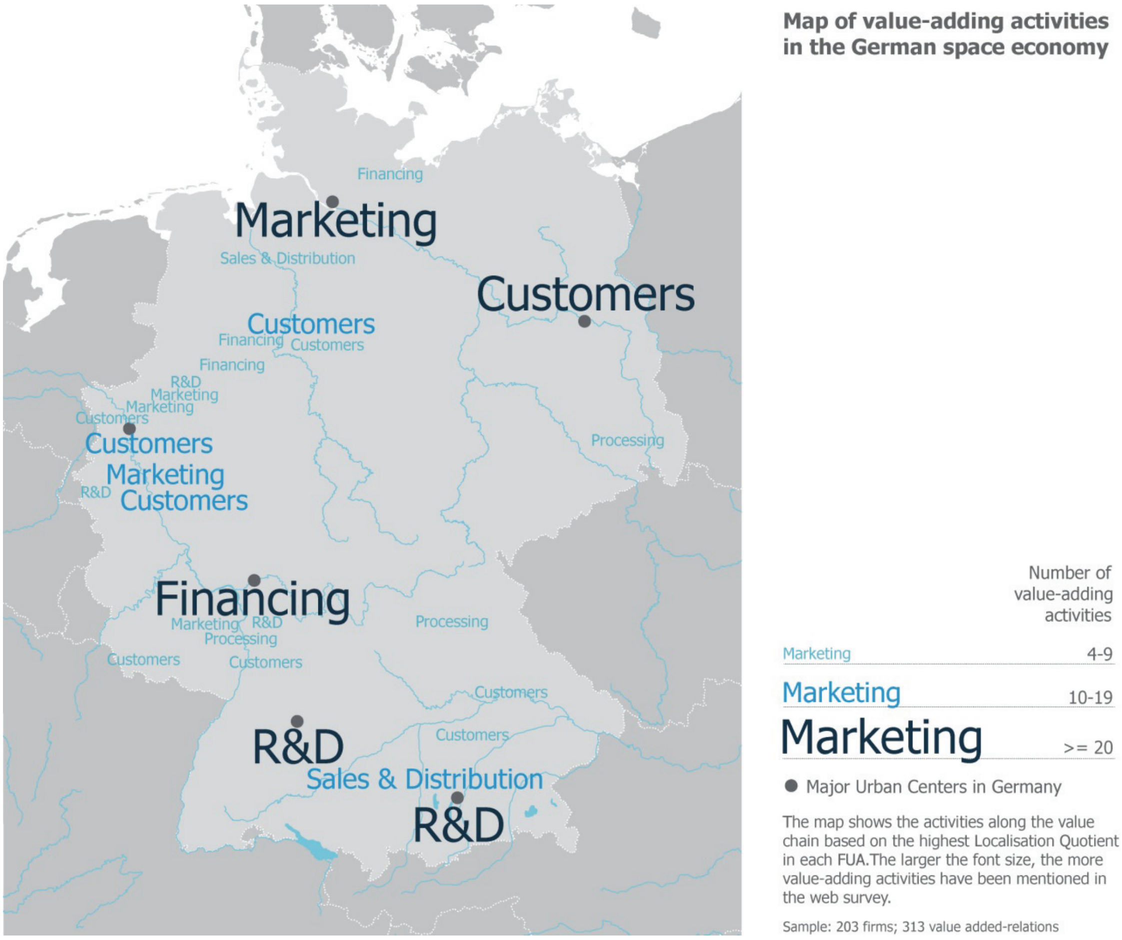


Figure 42: Map of value-adding activities in the German space economy
(Author's illustration; calculation: Michael Bentlage)

All in all, the value chain analysis on the national scale shows that activities based on new and up-to-date knowledge – for example R&D, marketing or financing – are highly concentrated in central FUAs such as Munich, Stuttgart, Hamburg or Frankfurt. This kind of knowledge is not necessarily available in secondary agglomerations. Nevertheless, the great economic opportunity for smaller agglomerations is to supply high-quality inputs for the knowledge-intensive sectors in primary FUAs, for example highly specialised products for the High-Tech industry (Thierstein et al. 2006). The result of this spatial division of labour are localised systems of value chains, in which suppliers, customers and service providers are connected with each other through flows of goods, labour, technology and information. The functioning of such localised production systems is based on a well-developed transport infrastructure. Small FUAs are dependent on a good accessibility to the major national and international knowledge centres, so that they are able to participate in the rapidly-evolving knowledge economy and to position themselves successfully within the "Global Production Networks" (Coe et al. 2008a).

7.2.5 Locational strategy in the knowledge economy

Today's spatial concentration processes are influenced by the rules of the knowledge economy. Unlike former times, when concentration trends arose on the basis of the availability of raw materials and the optimisation of transport costs, nowadays global competition and the desire to lead the way with new innovations are the determining factors. Awareness and optimisation of their own value added chains are therefore a comparative advantage for firms in the knowledge economy, whereby locational strategies and the resultant intra-firm and extra-firm locational networks are based on an informed economic calculation. An important factor is not only the global production system, but also localised skills and specialist qualifications, as well as consistency of standards, rules and traditions. The functional division of labour is based on the mutual interrelation of locally-embedded knowledge resources and the organisation of companies and company networks. Information on such locational strategies is difficult to obtain by means of standard quantitative surveys. For this reason, 26 face-to-face interviews were carried out with managing directors of knowledge-intensive firms. The interview method was in line with the principles of qualitative social research (see Chapter 6). On the basis of these interviews, Figure 43 shows the most important spatially-relevant activities of the knowledge economy: finding talent, acquiring innovative firms, linking specialised knowledge, speaking face-to-face, local clustering and global sourcing. In the following section, these activities are illustrated by a series of quotations and positioned in the context of the knowledge economy.

Figure 43: Locational strategy in the knowledge economy (Author's illustration)

Finding talent

One of the most important locational factors for knowledge-intensive firms is access to knowledge. Highly educated and specialised personnel are integral parts in the innovation process. According to Porter (1990) they provide a decisive and sustainable basis for competitive advantage (Porter 1990). The importance of talented and highly-qualified staff is also illustrated by the following statement of an APS company in Kronberg near Frankfurt am Main:

> *"It is important to us to know where we can get the best people, and to have locations around that point (...). Our business is a purely people business. Every year we look for the best talent. Our business depends on winning these talented people for ourselves and then developing even further (...). We have no other assets than our people." (APS firm, Kronberg am Taunus, 19.10.2010).*

Acquiring innovative firms

The acquisition of innovative firms is another important strategy for bringing skills into a company. The focus here is above all on companies which provide the optimum complement to the acquirer's portfolio, i.e. which are thematically not too similar nor too different, in line with the concept of "related variety" (Boschma and Iammarino 2009). For many companies, developing a location is a passive process which happens fairly indirectly through the acquisition of other companies. Space plays a dual role here. On the one hand, the purchase of a company involves taking over the corresponding socioeconomic environment: the local labour market, the "local buzz" (Bathelt et al. 2004). An interviewee from a High-Tech company, for example, emphasised the fact that acquisitions had enabled them to successfully establish themselves in Silicon Valley and benefit from the talent and the dynamic local business environment there. On the other hand, the question of location has an important role during periods of business restructuring and development, for example if locations are merged following wide-ranging acquisition activities. As we have seen in Section 3.2.2, locational adjustment becomes important when economic advantage can be realised for example through transport and supply advantages or through closer market proximity (Picot et al. 2008).

> *"Our acquisition activities mean that we are very scattered spatially (...). And now we have said that we will be consolidating. For example, we have three different locations in Frankfurt, which will be merged to form one. Then the locations in North Rhine-Westphalia – Cologne, Düsseldorf and Essen – will be merged into one… in order to be closer to our most important customer." (APS firm, Essen, 07.10.2010).*

Linking specialised knowledge

Knowledge creation has increasingly become integrated into various forms of business networks on different spatial scales. There is a large variety of knowledge sources to be used by firms. As these knowledge sources are often scattered over space, an increase of information exchange is required. If each individual holds some specialised knowledge, there is need to link all these skills in order to develop new products and services. Division of labour requires a strategic organisation of knowledge and skills in networks, as explained by the following quotation:

> *"With regard to networks, we observed that the more pronounced division of labour means we can no longer work in star formation radiating out from the central headquarters... but will build up a network within the company (...). The question is who does what best – and possibly cheapest – for the whole group (...)? A partial function which is essential to the whole group could be located in Atlanta, and at that moment all attention is on Atlanta (...). The important thing about this network way of thinking is not only to have the network in place..., but... to work within this network." (High-Tech firm, Beckum, 08.10.2010).*

The strength of such an integrated network organisation is that firms can capture scale efficiencies and still retaining a dispersed geographical structure (Bartlett and Ghoshal 2002). It combines the strategic advantage of global-scale operations with the ability to exploit local market opportunities. However, such a network approach is based on many and varied interactions between economic players. The crucial factor is that new knowledge is not merely the result of research activity, but that it results to a great extent from interactions along the value chain and the associated learning processes. One challenge involved in this learning process is the fact that innovation cycles are becoming ever shorter. Identified trends must be developed into products ever more quickly, and production continually needs to be speeded up. If the finished product cannot be successfully marketed and sold within the shortest possible time, business will be lost (Picot et al. 2008). As confirmed by Porter (1990), it is therefore not only a case of managing individual aspects of the value chain, but also of the optimum organisation of the whole value added system (Porter 1990).

Linking specialised knowledge is also a matter of organisational proximity. Organisational proximity is achieved through the optimised organisation of business processes. It facilitates the interaction and communication between the different parts of the organisation and offers a powerful mechanism for long-distance coordination (Torre and Rallet 2005; see Section 3.1.3). Documented procedures codified in manuals and blueprints as well as clearly defined responsibilities and tasks enable global teams to be managed more easily:

> *"If the work has been described well – that is, the processes are well-organised – then it doesn't matter where people are based (...). In our company we use various business process analyses (...). This means the workflows are much more clearly documented." (High-Tech firm, Beckum, 08.10.2010).*

Organisational proximity is particularly important where different cultures are working together. Conflicts often arise from language difficulties and different perceptions of areas of activity and responsibilities:

> *"In India we have a very different understanding of what these people's tasks are. We say they are an extended workbench for us... They regard themselves much more as technological experts, on the basis of their education and training and also the status they are accorded in their country (...). This is a difference which can sometimes also lead to conflicts." (APS firm, Essen, 07.10.2010).*

The problem of language barriers has also been identified in a case study analysing the intra-firm and extra-firm business relations in the Mega-City Region of Northern Switzerland (Thierstein et al. 2006). The authors observed that many intra-firm networks exist across the German-French language barrier in Switzerland. Extra-firm networks, on the other hand, are much rarer across language barriers. This reveals an important component of the locational strategy of knowledge-intensive firms. The inhibition threshold to cooperating with an external partner across a language barrier is relatively high. However, if a company wishes nevertheless to deal with a foreign market in another language, they establish a location from where they can serve customers and business associates with local staff who speak the language and know the cultural background (Thierstein et al. 2006). Such transnational internationalisation strategies depend on the recognition that business advantages can be achieved not only from coordination and standardisation, but also from differentiation and division of labour. This strategy adapts the structures and processes to the circumstances of the relevant cultural environment, while at the same time taking account of the central objectives and abilities of the parent company (Scholz 1996).

Speaking face-to-face

The role of face-to-face contact in the knowledge creation process and in the management of business organisations is assessed differently by the various interviewees. In the area of R&D, communication is often virtual. This is a case of "analytical knowledge" (Asheim et al. 2007b), which is available in codified form and can be communicated relatively easily in standardised language. In the area of management, on the other hand, face-to-face communication is often preferred.

Management activities require “synthetic knowledge” (Asheim et al. 2007b), where innovation mainly emerge through combining existing skills and solving specific problems during the interaction process with customers or suppliers. The strategic themes and trust involved here make face-to-face contact indispensable and reduces the risk of wrong decisions:

> *“…they also meet with one another face-to-face. But this is more on the project management side, for example for the reviews. Where do we stand? How far on are we with (...)? I don’t necessarily see that in R&D. The developers of today have a very global mindset. They can find a mutual language..., even when teleconferencing (...). The vast majority happens electronically, in these virtual user communities, where they have their web conferences (...). They are networked worldwide.” (High-Tech firm, Schwalbach am Taunus, 05.10.2010).*

Face-to-face contact is more than anything a decisive factor in the context of customer relations, when it is important to build trust and to perceive sophisticated customer needs. A prime example of a customer relationship involving trust is that between lawyer and client, where regular face-to-face contact is indispensable. The customer is also an important player in the innovation process for knowledge-intensive firms. This highlights among other things the function of the *key account manager*, who is not only involved in marketing and sales but also in strategic activities. The key account manager supports customers during the development of new products, with the task of identifying trends and translating them into relevant product requirements:

> *“…we are currently involved in the planning of a new car, through people who are active on location (…). They maintain the contact between us and our customers (...). They support customers during the design process... and also receive their queries (...). The closer the contact, the better the implementation possibilities (...). And there is also the personal level..., which simply means having trust.” (High-Tech firm, Giessen, 05.10.2010).*

It can basically be said that the trend for intra-firm communication is moving towards virtualisation, while communication with customers and business partners along the value chain is still face-to-face. Internal virtual communication requires practice and is often a matter of company culture. Experienced companies are in a better position to substitute internal face-to-face contact with organisational proximity. Globally-active consultancy companies, for example, optimise the interplay of virtual and face-to-face communication, as they often work at the customer’s premises for several days at a time:

> *“The project team works… four or five days a week on site with the customer. This means living either in apartments hired for the project or a hotel (...). Sometimes they are there all week; at other times they only need two days (...). This means an exchange between cultures, and an exchange of different skills.” (APS firm, Kronberg am Taunus, 19.10.2010).*

Local clustering

The importance of face-to-face contacts in communication still makes geographical proximity to a crucial factor in the innovation process, especially in the context of customer support. In the case of expanding companies it is often the larger customers who – if they cannot be given sufficient support from the current location – trigger the establishment of new locations. One globally-active APS company, for example, has chosen Essen as its German headquarters, because it wanted to show its loyalty to its most important customer. The importance of geographical proximity to customers is also emphasised by Jähnke and Wolke (2005). Their standardised survey of 1080 companies in Greater Berlin and Greater Munich shows that more than 40 per cent of the companies have at least one regional customer (Jähnke and Wolke 2005).

In Germany, customer relations appear to be particularly regional in nature. Some interviewees attribute this to Germany's federal structure. Unlike France or the UK, where all major customers and business associates are found in Paris or London, in Germany companies have to have a presence in several locations:

> *"Spatial proximity is still indispensable to customer relations (...). The development of a customer relationship still requires regional proximity, especially in Germany (...). Germany also has a very regional bias in terms of its economic centres. I believe that most computer firms have experimented with different ways of positioning themselves. And they have all... gone back to a regional model (...). We also intended at one stage to introduce a strong verticalisation, but it didn't work." (High-Tech firm, Schwalbach am Taunus, 05.10.2010).*

While the significance of proximity to customers was confirmed by most of the interviewees, there was an ambivalent attitude to relations with competitors. In contrast to the argument of Porter (2000a) geographical proximity to competitors is not necessarily considered as an advantage. This does not mean, however, that there is no contact with competitors. According to the statements of an international APS company, it is difficult to involve informal contact with competitors in a strategic decision-making process. In order to access market information, specific analysts are hired, who provide verifiable information as the basis for decision-making. As part of a comprehensive locational consolidation, this company considered whether to move its German headquarters from Essen to Düsseldorf. It decided on Essen, one of the criteria being that fewer competitors were located there:

> *"As a technology company, we found that in Düsseldorf we were one of many. In Essen – which has a completely different history – we were definitely the biggest IT company. We prefer being here as the biggest than... just one of many. We are pulling away from the competition simply by staying in Essen (...). Here we have a completely different positioning (...). [Our customers] are much more aware of us here (...). If the mayor holds an event where people get together we don't... find 15 of our competitors there as well." (APS firm, Essen, 07.10.2010).*

Global sourcing

Some companies seek to gain up-to-date knowledge for themselves by tapping new labour markets in additional office locations worldwide. On this way, firms not only have access to low-cost labour and materials, they can also tap into an international pool of technological and managerial resources in order to create innovation that often occurs in response to specific local problems. In a telephone interview, a High-Tech company explained its new 'local-for-local' strategy, whereby responsibility is devolved to various locations worldwide. In this way, local customer requirements can be better determined and technological possibilities used more efficiently. This strategy often leads to the establishment of local 'Centres of Excellence', as the following statement of another High-Tech company shows:

"Globalisation has two aspects. Firstly, the markets in which we want to be involved. And secondly, the resources: know-how and the low-cost production of software. Based on this, we have developed a strategy which should cover both aspects. It means tapping emerging markets PLUS ensuring the relevant human capital – brain resources – within these markets, for the global enterprise (...). And so, centres have been established... in Bangalore, in Peking and in St. Petersburg. We call these 'Centres of Excellence', where several hundred developers are based." (High-Tech firm, Schwalbach am Taunus, 05.10.2010).

Global knowledge sourcing together with the necessity of face-to-face contacts in the innovation process gives rise to intensive travel. Accessibility in terms of journey time is a decisive factor for many companies. Almost all of the companies questioned have international relationships, and good accessibility is essential, in order to be able to hold intra-firm meetings at the lowest possible cost. International hub airports are frequently referred to as a central gateway infrastructure, ensuring intercontinental, European and sometimes also domestic connections and providing the basis for global business activities. Accessibility by high-speed train is also referred to as a positive locational factor. Good regional, national and intercontinental accessibility makes face-to-face contact over large distances much easier:

"No business location in Germany is as well-connected logistically as Frankfurt. The airport is essential to us. We are 25 minutes from it and from the main train station which connects to the south, the north, everywhere." (APS firm, Kronberg am Taunus, 19.10.2010).

All in all, the increasingly rich and diversified infrastructure of global travel and communication tends to qualify the assertion saying that firms have a strong tendency to locate close to one other because of frequent interactions requiring face-to-face contact. Geographical proximity helps, but it is neither a necessary nor a sufficient condition for knowledge creation to take place. The functional logic of the knowledge economy requires locations that facilitate the creation of new knowledge and ensure a smooth organisation of knowledge resources. The production and application of knowledge in the value creation process requires not only urbanisation economies in the form of thick and diversified regional markets, but also high-quality inter-continental and European accessibility to global knowledge hubs in the world economy. Bentlage et al. (2010) for example identify a clearly positive correlation between the physical accessibility of an FUA and its non-physical connectivity based on intra-firm networks of knowledge-intensive enterprises (Bentlage et al. 2010). Similarly, Jähnke and Wolke (2005) argue that for regional customer and supplier relations not only "local buzz" (Bathelt et al. 2004:21) but especially organisational proximity is relevant (Jähnke and Wolke 2005). Mega-City Regions with well-developed international *and* regional accessibility tends to meet these requirements best because they are able to combine agglomeration economies and global network economies in a highly efficient 'regional innovation and production system' (Crevoisier et al. 2001).

7.3 Relational patterns on the regional scale

After investigating the global and national connectivity patterns and the locational strategies of the knowledge economy in Germany as a whole, we now focus on the regional scale. Three exemplary economic areas are at the centre of the analysis: the Greater Munich area, the Rhine-Ruhr region and the cross-border metropolitan region of the Upper Rhine. The aim of the following analysis is to find evidence of how these regions create inter-linkages between FUAs at an extended regional scale and to what extent they can be interpreted as functionally-networked polycentric Mega-City Regions as stated in the first hypothesis of Section 4.3.

7.3.1 The Greater Munich area

Munich is one of the most dynamic and competitive metropolitan areas in Germany (IHK 2003; Institut der deutschen Wirtschaft Köln Consult GmbH 2005; IKM 2008) (see Table 4 in Section 7.2). The core of the metropolitan area, which includes Munich, Augsburg, Ingolstadt, Landshut, Rosenheim and the surrounding cities and towns, has a population of around 4.65 million (Thierstein and Lüthi 2008). Recent studies show that the functional Mega-City Region of Munich extends outwards widely, as far as Regensburg in the north, Kaufbeuren in the southwest and Garmisch-Partenkirchen in the south (Lüthi et al. 2010b). Several companies operating on the global scale – such as Siemens, BMW and Allianz – have their headquarters or major offices in or around Munich. Universities and research institutions with excellent reputations contribute to a highly qualified labour market (Prognos 2010b). In many rankings based on economic indicators and soft location factors, Munich is the leading agglomeration in Germany. The gross domestic product (GDP) in the planning region of Munich is EUR 46,600 per capita, the highest value in the German space economy (BBR 2006).

The Greater Munich area is characterised by a heterogeneous economic spatial structure. Generally speaking, the secondary FUAs around Munich show a high concentration of High-Tech sectors (see Table 5). For example, the high share of High-Tech industries in Ingolstadt can be explained by the local automotive sector – especially the headquarters and main plants of AUDI Motorcars – and its numerous local suppliers. An important exception, however, is Freising, which is located just next to Munich's international hub airport. The FUA of Freising shows a remarkable share of APS, which proves the increasing importance of hub airports as outstanding location factors for knowledge-intensive services.

The development of the employment figures within and beyond the Greater Munich area confirms Brenner's (1999) hypothesis that socioeconomic activities are increasingly re-scaling on a regional level (Brenner 1999). The share of knowledge workers within the Greater Munich area is higher than in the rest of Bavaria. As early as 1999, the Greater Munich area employed 35 per cent of its workers in knowledge-intensive economic sectors, significantly more than the rest of Bavaria (28.9 per cent). From 1999 to 2006, this share showed an increase of 4.7 per cent within the Greater Munich area; in the rest of Bavaria, there was a smaller increase of 3.6 per cent. All in all, a positive structural effect can be observed: the share of fast-growing industries in the Greater Munich area increases above average in comparison to the whole Free State of Bavaria (Thierstein et al. 2007).

Table 5: Population and employment in the Mega-City Region of Munich (Thierstein et al. 2007)

Functional Urban Areas (FUAs)	Population (2005)	Employment (2006)	Shares of Employment in APS* (2006)	Shares of Employment in High-Tech (2006)
Munich	2,216,000	1,002,000	23.88	14.44
Augsburg	631,000	183,000	12.26	16.04
Ingolstadt	451,000	141,000	11.21	31.90
Regensburg	426,000	143,000	10.97	26.88
Rosenheim	402,000	106,000	11.62	11.36
Kaufbeuren	344,000	74,000	7.81	20.48
Landshut	320,000	85,000	10.30	16.65
Freising	283,000	86,000	30.96	11.19
Garmisch	216,000	47,000	8.90	15.80

* APS=Advanced Producer Services

Regional connectivity patterns in the Greater Munich area

The linkages of the knowledge economy in the Greater Munich area are facing pronounced structural change due to the reorganisation of its value chain, the emergence of new economic players and the outsourcing tendency within the APS and High-Tech sector. This has implications for the spatial division of labour and the regional organisation of intra-firm networks.

Figure 44 shows the spatial patterns of the intra-firm connectivity between *APS firms* on the *regional scale*. The thickness of the links illustrates the total connectivity between two FUAs. These connectivity values are related to the highest interlock connectivity of the study area, which is the connection between Munich and Augsburg. This high value is due to the fact that many APS firms have relatively important and therefore highly-rated locations in the FUAs of both Munich and Augsburg. In addition to the Munich-Augsburg link, the connection between Munich and Regensburg also emerges as an important axis within the Greater Munich area. This finding supports the recent case study of Lüthi et al. (2010b), which identified Regensburg as being functionally more strongly networked with Munich than with Nuremberg, even though the latter is geographically closer to Regensburg (Lüthi et al. 2010b). Also striking is the only tangential connection between Augsburg and Regensburg. This link is mainly built up by financial services, insurance providers and various logistics companies. Primarily, however, the Figure 44 underlines the importance of Munich for its surrounding secondary agglomerations. The agglomerations to the northwest of Munich in particular show strong connectivities to the FUA of Munich. Obviously, APS firms based in Munich are strongly oriented towards the centre of the Pentagon, the major geographical zone of global economic integration in Europe (ESPON 2004). The service values in the APS data records show that proximate FUAs to the northwest of Munich tends to gain complementary service functions (service value 2), while global command-and-control functions are mainly concentrated in Munich itself (service value 5). Interlocking networks of APS firms link these different agglomerations together, defining the Greater Munich area as a physically separated but functionally networked socioeconomic space.

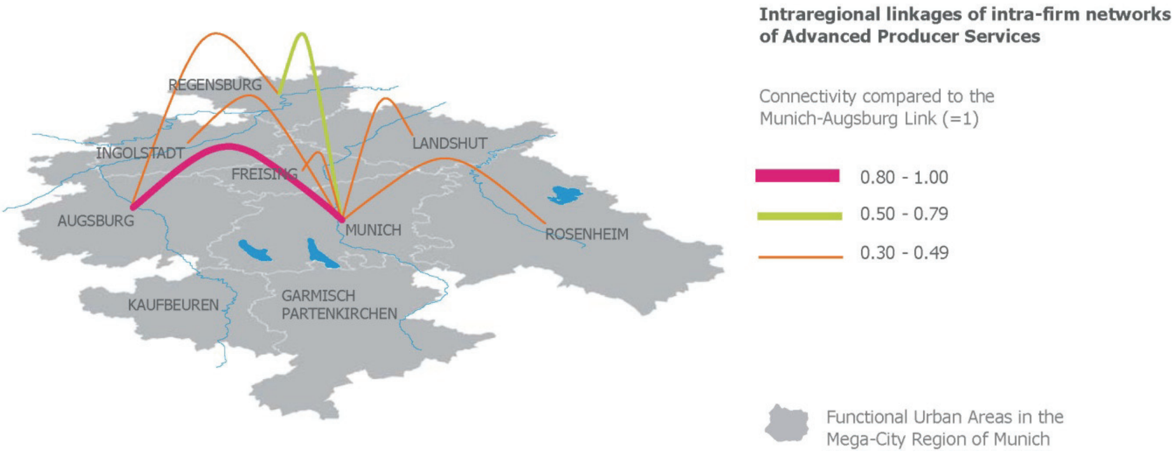


Figure 44: Regional connectivity of APS firms in the MCR of Munich
(Author's calculation; visualisation: Anne Wiese)

In the *High-Tech sector*, the spatial patterns of intra-firm networks are only slightly different (see Figure 45). There are strong relations between Munich and Augsburg as well as between Munich and Regensburg. The connectivity between Munich and Augsburg is produced almost exclusively by intra-firm networks of mechanical engineering companies such as MAN, FESTO or Freudenberg. This underlines the historical significance of Augsburg as an important industrial centre (Zorn 2001). The connection between Munich and Regensburg is mainly formed by companies from the mechanical engineering, vehicle construction and electronics sectors. Based on BMW's move to the region in the 1980s, the automotive industry has become an important economic sector in the Regensburg FUA (Kleinhenz et al. 2006); and sensor technology – represented by companies like Infineon, Osram, or Siemens – is also well established. All in all, regional specialisation in similar sectors of industry means that the individual High-Tech centres within the Greater Munich area complement each other very well – in line with the concept of related variety (Boschma and Iammarino 2009) – and therefore drawing enormous economic strength from functional division of labour.

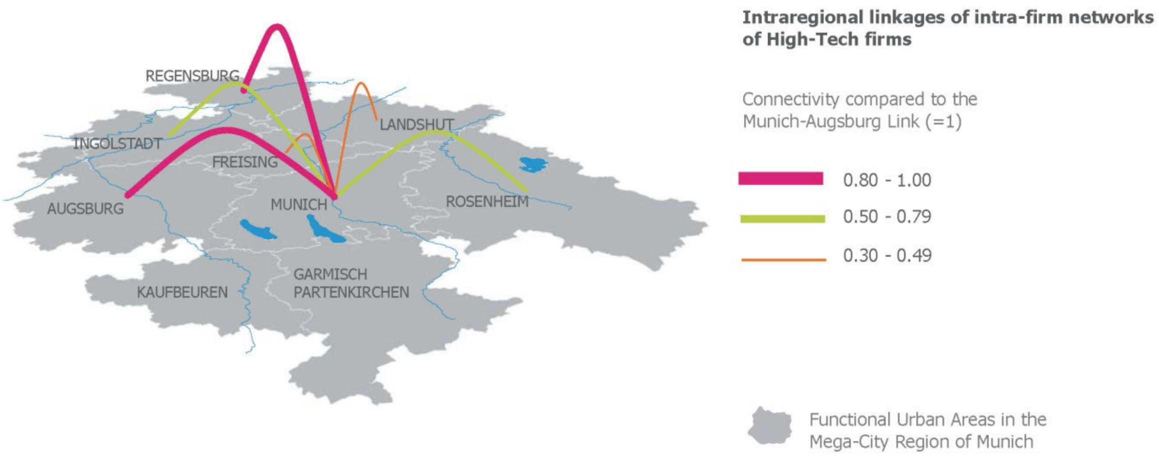


Figure 45: Regional connectivity of High-Tech firms in the MCR of Munich
(Author's calculation; visualisation: Anne Wiese)

Another way to analyse connectivity patterns in a spatial context is the use of *social network analysis*. There has been a considerable growth of interest in the potential that is offered by these relatively new analytical techniques. Texts and sources on this issue have been produced mainly by experts with a mathematical background. It is important to understand the basic concepts of social network analysis techniques in order to interpret the research findings of this thesis meaningfully and to understand them in the knowledge economy context.

A common framework for social network analysis techniques is the mathematical approach of graph theory offering a translation of matrix data into formal mathematical concepts. Graph theory analyses sets of elements (points) and the relations between these (lines). *Points* are the individual elements within the networks – in our case the FUAs; *lines* are the relations between these elements – in our case the city-interlocks. A matrix describing the relations between cities can be converted into a *graph* of points connected by lines. Such a graph is also called *sociogram* or *network diagram*. Points may be directly connected by a line, or they may be indirectly connected through a sequence of lines. Such a sequence of lines in a graph is called a *path*. The length of a path is measured by the number of lines that makes it up (Scott 2000).

The drawing of sociograms has remained a crucial means of illustration of networks. However, conventional sociograms have some limitations as a method of representing relational data. More than 20 points often result in a thicket of lines that are difficult to interpret. In order to overcome this limitation, various forms of alternative network visualisations have been developed (Scott 2000). McGrath et al. (1996), for example, suggest that the physical distance between points should correspond as closely as possible to the theoretical distances between them on the graph (McGrath et al. 1996). The mathematical approach behind McGrath's suggestion is termed *multidimensional scaling*. It uses concepts such as space and Euclidean distance to map relational data. If a configuration of points and lines can be converted into such a metric map, then it is possible to measure distances differently from those in graph theory. In graph theory – as mentioned above – the distance between two points is measured by the number of lines that connects them. The Euclidean concept of distance, by contrast, is much closer to the everyday understanding of physical distance. In other words, multidimensional scaling is an attempt to convert relational measures – such as city-interlocks – into metric measures analogous to physical distance. A number of social network analysts and computer scientists have explored the possibilities of combining multidimensional scaling with powerful techniques of structural modelling that can help to visualise and explore network structures in a more intuitive way. Algorithms for multidimensional scaling use geometrical principles to ensure a fit between the given relational data and the final configuration of points in the map (Scott 2000).

The following graphs in this thesis have been produced using the social network analysis software Gephi (http://gephi.org/), an interactive visualisation and exploration platform for all kinds of networks and graphs. We have chosen Gephi not only because it can convert relational measures into metric measures, but also because it is able to geo-reference points based on geographic coordinates. This makes it possible to compare geographical proximity with relational proximity (see see Section 3.1.3). In order to visualise relational proximity we used what is known as the Force Atlas algorithm, a special force-directed algorithm using variables such as inertia, attraction, repulsion and gravity (Mathieu et al. 2009).

Figure 46 shows the *APS connectivity patterns* in the Mega-City Region of Munich and adjacent agglomerations. It shows two different kinds of graphs. On the one side, the FUAs are localised in their exact geographical location, i.e. the graph represents the geographical proximity between the FUAs. On the other side, the relational proximity between the FUAs is displayed, i.e. the stronger the FUAs are connected through city-interlocks, the closer they are located to each other. Figure 46 shows only city-interlocks greater than 2.5 per cent of the strongest connection in the whole of available records (Munich-Hamburg = 100 per cent). FUAs located within the case study area are coloured pink; FUAs outside the case study area are shown in purple. This makes the network diagrams easier to read and interpret. If the FUAs of the Mega-City Region of Munich are close to each other not only in geographical but also in relational terms, this provides evidence for strong intra-regional connectivity patterns.

Figure 46 confirms Munich's function as main gateway of the Mega-City Region, as it is located in the centre of the relational map. In a second ring around this gateway, Augsburg, Regensburg, Ulm and Kempten emerge as highly connected agglomerations on a regional scale. The strong regional connectivity of Augsburg and Regensburg already came to light in Figure 44. Ulm and Kempten, however, are new on the map: these FUAs seem to be integrated into regional networks of APS firms to the same extent as Augsburg and Regensburg. The regional connectivity of Kempten is primarily based on the location networks of financial services, such as Deutsche Bank, Commerzbank etc. As a medium-sized centre in the holiday region of Allgäu, quite a number of banks are represented with small offices in the FUA of Kempten. However, the most important global company with its headquarters in Kempten is Dachser, one of Europe's leading logistics providers.

The regional connectivity of Ulm, on the other hand, arises primarily – in addition to the retail operations of banks and insurance companies – from firms in the field of design and engineering services. Many mid-sized engineering companies such as YACHT TECCON, Ferchau Engineering, Brunel or Euro Engineering have a location in Ulm and, at the same time, in several FUAs in proximity of Munich. These companies provide a central interface for the automotive and electronics industry, which is also relatively well-represented in the agglomeration of Ulm (see High-Tech analysis below).

In the *High-Tech sector*, a similar picture is revealed (see Figure 47). Again, only city-interlocks greater than 2.5 per cent in comparison to the strongest connection in the High-Tech records are shown (Shanghai-Singapore = 100 per cent). FUAs located inside the initially-defined Mega-City Region are indicated by orange points; FUAs outside this area are designated by green points. Again, the Munich FUA lies at the centre of the relational map, surrounded by the secondary FUAs of Augsburg, Regensburg, Rosenheim, Ulm and Heidenheim. Note that Garmisch-Partenkirchen and Kaufbeuren are no longer on the map, because they have a city-interlock smaller than 2.5 per cent compared to the strongest link in the sample.

The relatively strong regional connectivity of Augsburg, Regensburg and Rosenheim has already been shown in Figure 45. Ulm and Heidenheim, by contrast, emerge as hidden centres rendering unexpected services to the High-Tech networks in the Mega-City Region of Munich. Ulm is traditionally an industrial location, with a long history of industrialisation (Nestler 2003). The most important economic sectors are the automotive and the electronics sectors, represented for example by firms such as Nokia, Daimler, EADS or EvoBus. In total, 29 companies of our High-Tech firm sample are present in the FUA of Ulm.

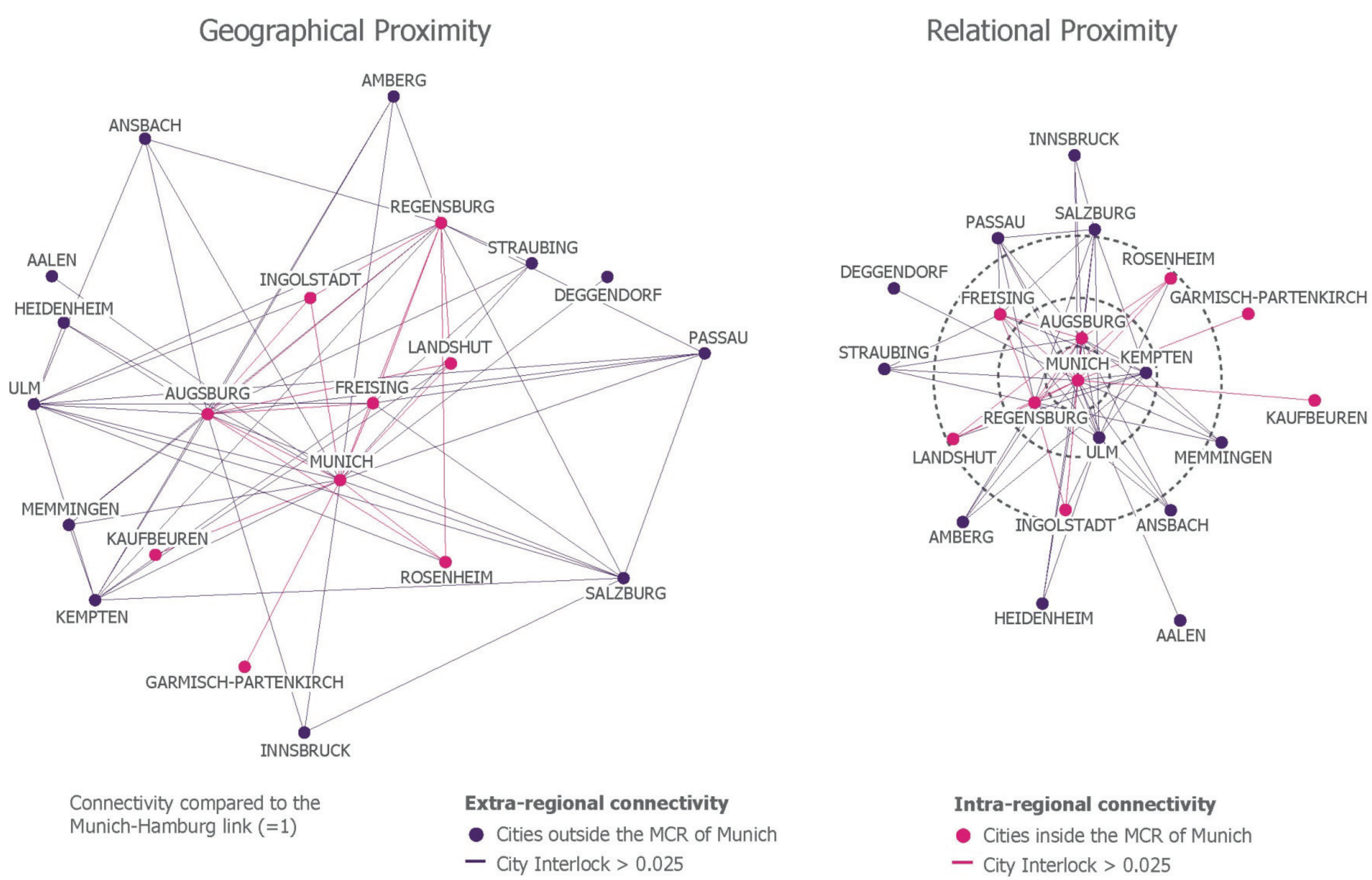


Figure 46: Geographical vs. relational proximity of APS firms in the MCR of Munich
(Author's calculation; visualisation: Anne Wiese, Michael Bentlage)

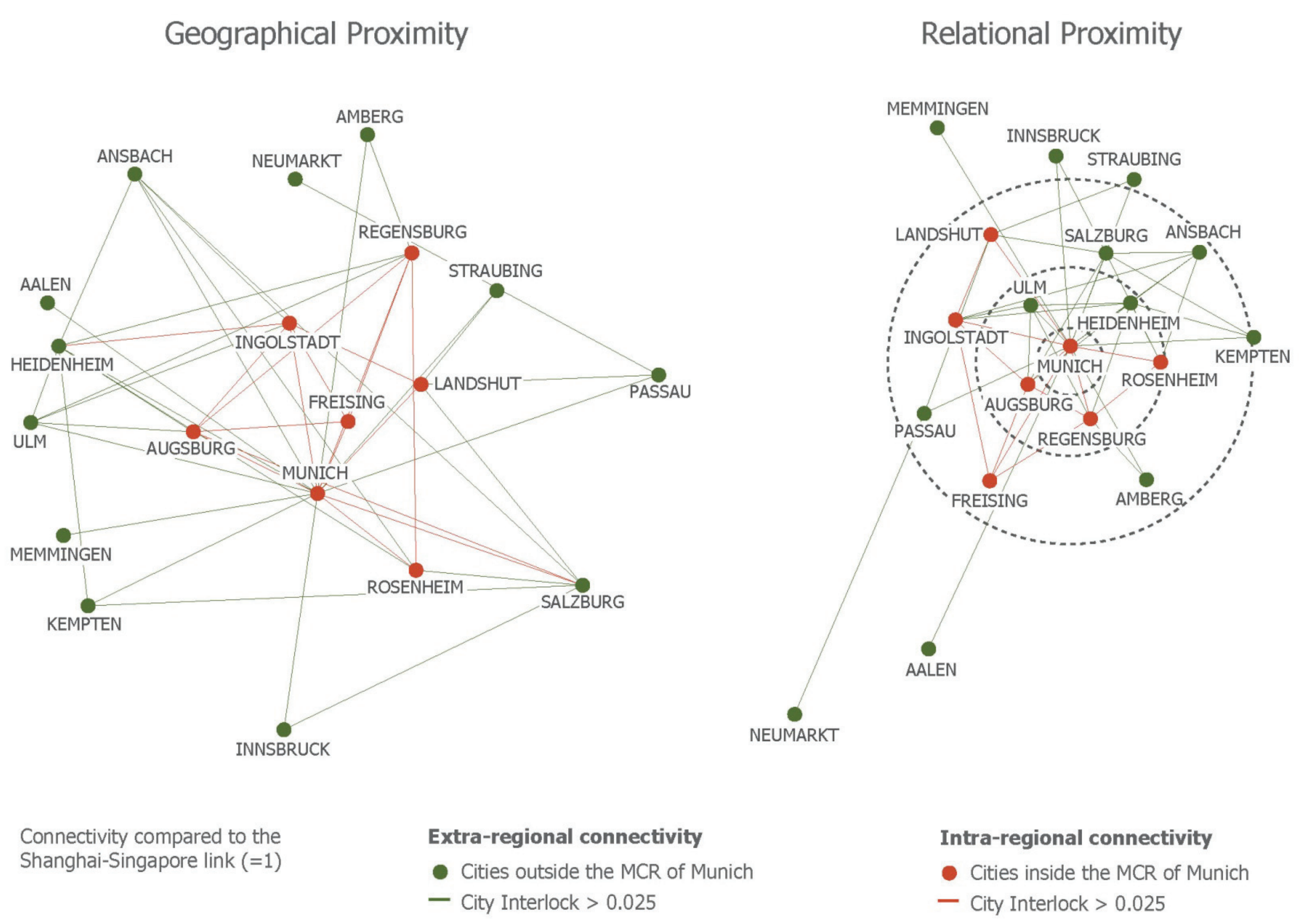


Figure 47: Geographical vs. relational proximity of High-Tech firms in the MCR of Munich
(Author's calculation; visualisation: Anne Wiese, Michael Bentlage)

Heidenheim is also a traditional industrial location. In contrast to Ulm, however, its regional network connectivity is not the result of a high number of High-Tech companies, but of a few firms having relatively important office locations in the FUA; for example, the mechanical engineering company Voith and the medical engineering company Hartmann have their headquarters in Heidenheim. But, only 11 of all High-Tech records (210 in total) have an office location there. This shows that not only the number of companies, but also their service values have a significant impact on the total network connectivity of an agglomeration.

All in all, the analysis of the city-interlocks on the regional scale between proximate FUAs in the Greater Munich area shows that the latter can be understood as a functionally monocentric Mega-City Region, in which intra-firm linkages are concentrated to a considerable extent. In relational terms, the core of the Mega-City Region is clearly formed by Munich. The axes between Munich and Augsburg as well as between Munich and Regensburg show the highest regional connectivity. The Augsburg-Regensburg link is the only noteworthy tangential connection in the whole Mega-City Region. The FUAs of Munich, Regensburg, Augsburg and Ulm are highly interconnected through both APS and High-Tech intra-firm networks. The FUAs of Rosenheim, Freising, Landshut and Ingolstadt indicate a high regional connectivity in at least one sub-sector of the knowledge economy. Thus, there seems to be an urban core network – composed by the FUAs of Munich, Augsburg, Regensburg and Ulm – and a kind of extended city network, which incorporates different cities and towns depending on the economic sub-sector in question.

Global connectivity patterns in the Greater Munich area

As we have seen in Chapter 4, Mega-City Regions are not only determined by regional, but also by national and global information flows. It is the interplay between agglomeration economies and network economies on different spatial scales that define Mega-City Regions as important interfaces between the functional and the spatial logic of the knowledge economy. Therefore, Figure 48 shows – for each agglomeration in the Greater Munich area – the five most intensely-networked locations in the *APS sector* as well as the position of the most connected location outside Germany. The size of the circle represents the total connectivity – i.e. the sum of all intra-firm links – for each agglomeration. The Figure shows that the intertwining structure of the Greater Munich area is strongly influenced by the German FUAs of Hamburg, Berlin, Frankfurt and Stuttgart. Again it becomes clear that these agglomerations are the main nuclei of the national urban hierarchy, being able to attract a large number of high-quality business locations and therefore a large share of intra-firm connectivity. Nevertheless, the strong connectivity of Munich to so many German FUAs is also a surprising finding, because it could be assumed that – in an increasingly globalised world – international intra-firm linkages would occur more often in the APS sector. Note that – with the exception of Munich and Freising – no international location is placed in the top six. This means that APS firms in the Greater Munich area mainly have subsidiaries in German urban centres, whereas offices in European or even extra-European locations are quite rare.

Munich and Freising are the only FUAs in the Greater Munich area having a non-German location within the Top 10. In the case of Munich, London ranks sixth. The data records show that this connectivity is largely generated by international legal firms such as Clifford Change or Taylor Wessing. These companies have their headquarters in London and also an important branch in Munich, the headquarters of the European Patent Office.

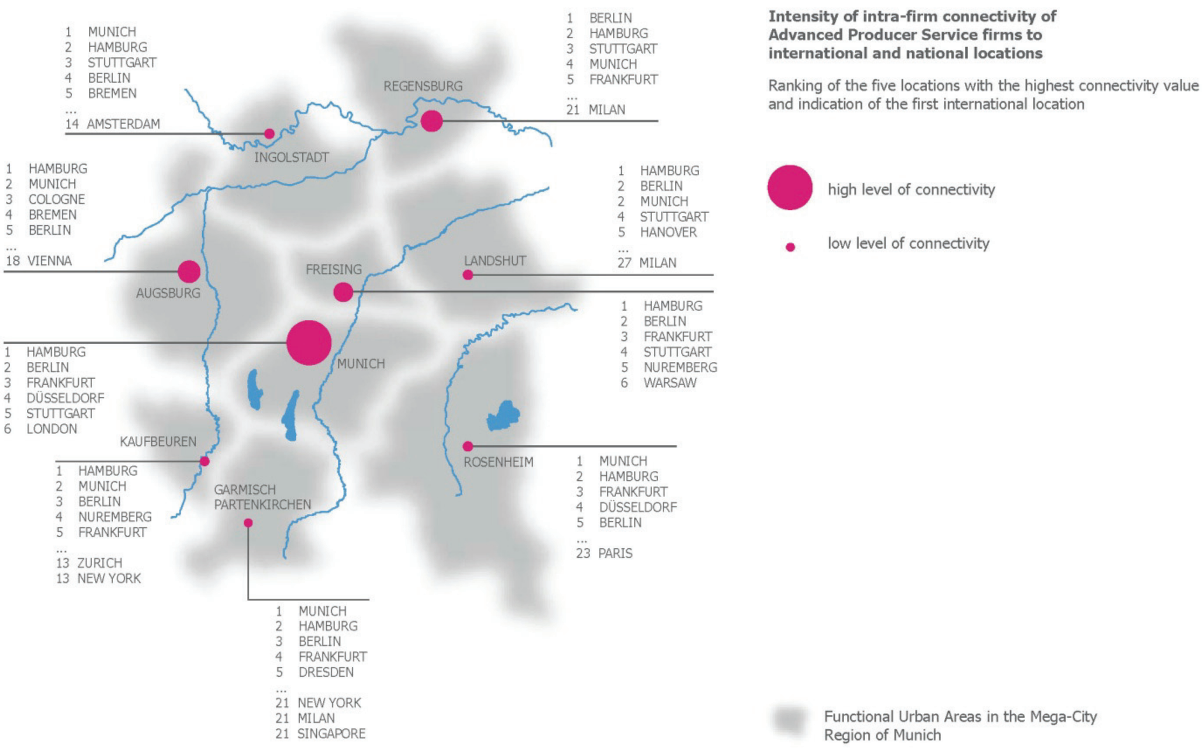


Figure 48: International connectivity of APS firms in the MCR of Munich
(Author's calculation)

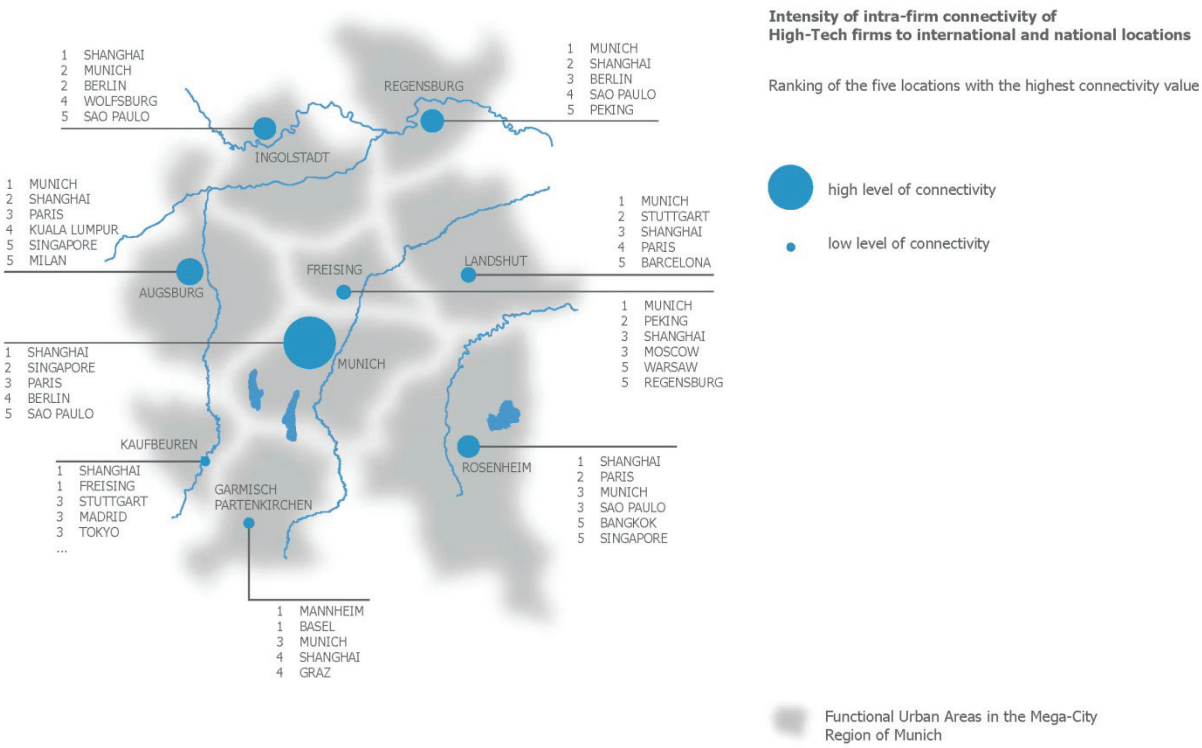


Figure 49: International connectivity of High-Tech firms in the MCR of Munich
(Author's calculation)

In the case of Freising, on the other hand, Warsaw ranks sixth, followed by Milan in the ninth and Paris and Hong Kong in the 11th position (see Table 31A in Appendix A). This global connectivity is the result of the international hub airport located immediately adjacent to the city of Freising. Well-developed international accessibility is a major advantage for global companies of the knowledge economy. By their locational choice in proximity to the airport they contribute significantly to the high global connectivity of the Freising FUA.

In the *High-Tech sector*, the interlocking firm networks seem to be much more globalised than in the APS sector (see Figure 49). Both Munich and the surrounding secondary FUAs are dominated by international connectivities. Thus, the finding of the global-scale analysis in Section 7.1 is clearly confirmed: APS firms are predominantly focused on the German space economy, whereas High-Tech intra-firm networks are much more globalised. The same conclusion is drawn by an OECD (2008) study, showing that High-Tech and medium High-Tech industries are on average more internationalised than less technology-intensive industries or service sectors. High-Tech production has a great industrialisation- and modularisation potential, whereby the various stages are optimally located across different sites as firms find in advantageous to source more of their inputs globally (OECD 2008). According to Gereffi et al. (2005), some value chains have breaking points, at which tacit knowledge can be integrated into products or standards. Clearly-defined technical standards reduce the risk of misunderstandings so much that even complex information can be communicated over long distances. Thanks to standardised interfaces, different technical modules can be combined in new ways and thereby be merged into new products. Because of standardisation, complex information can be exchanged with little explicit coordination (Gereffi et al. 2005). As a consequence, many High-Tech companies have focused on their core competencies in order to produce highly specialised niche products, which have to be developed together with other highly specialised suppliers and customers. The market for these niche products, however, is so small – and the degree of specialisation so high – that these companies are forced to organise themselves in global networks of specialists, in order to achieve the necessary critical mass for doing business. However, as we will see in the value chain analysis below, the globalisation of intra-firm networks does not mean that geographical proximity is unimportant. De Backer and Basri (2008), for example, show that location decisions for research and development facilities are not only based on the host country's technological infrastructure, but also on the presence of other firms and institutions, which may create spillover benefits that investing firms can absorb (De Backer and Basri 2008). In a similar way, Simmie (2003) argues that knowledge-intensive firms combine a strong local knowledge capital base with high levels of connectivity to similar regions in the international economy. By doing so they are able to combine and decode both codified and tacit knowledge originating from multiple regional, national and international sources (Simmie 2003).

The Greater Munich area as a hierarchical urban system

The quantification of regional and global connectivity patterns in the Mega-City Region of Munich makes it possible to arrange its agglomerations in a functional urban hierarchy, similarly to many world city studies (Friedmann 1986; Sassen 2001b), but on a smaller spatial scale. One way to do this is to plot the connectivity values in a graph. Figure 50 shows the functional urban hierarchy in the Mega-City Region of Munich on both the global and the regional scale as well as for the APS and the High-Tech sector. On the X-axis are the nine FUAs that have been under investigation. On the Y-axis, the connectivity values relative to the FUA of Munich are displayed. A strongly concave curve progression indicates a steep functional urban hierarchy, whereas a strongly convex progression shows a flat functional urban hierarchy indicating a rather pronounced functional polycentricity (compare Figures 31 and 32 in Section 7.2.2).

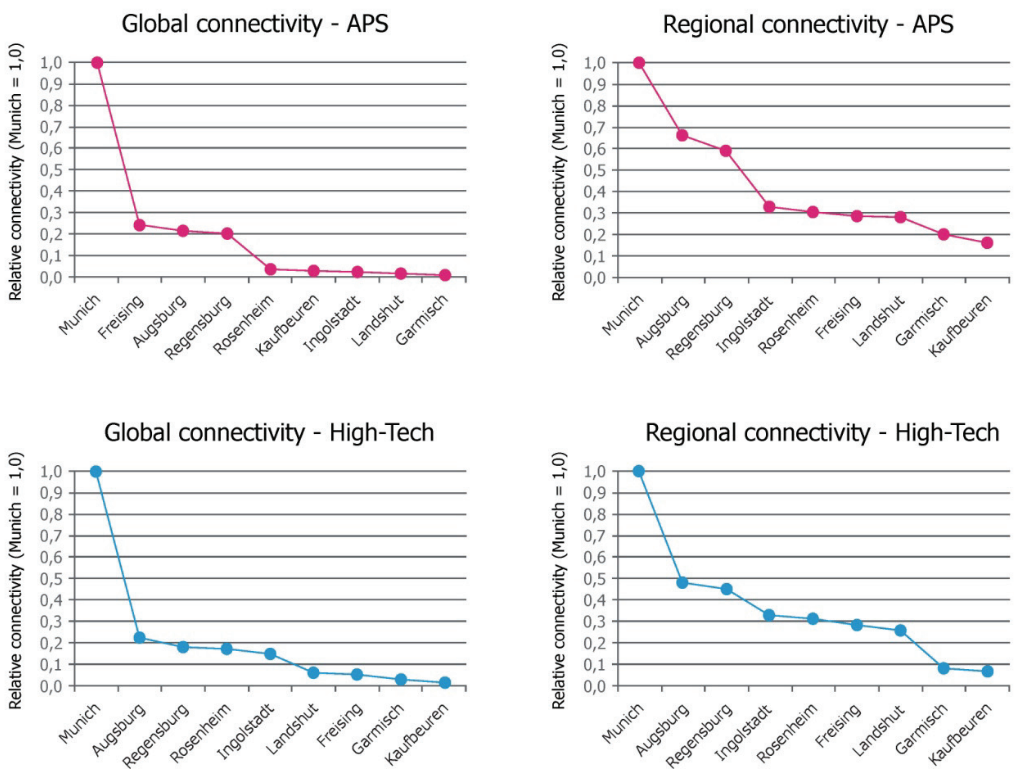


Figure 50: Global and regional connectivity in the MCR of Munich (Author's calculation)

Legend: Global Connectivity illustrates how well the nine FUAs are connected to extra-European destinations such as New York, Tokyo, Sydney etc. Regional Connectivity illustrates how well the nine FUAs are connected among one another. The connectivity values are related to the maximum value (=1).

Figure 50 shows considerable differences between the global and the regional scale. On the *global scale*, the gap between Munich and the other FUAs of the Mega-City Region is remarkably wide. In the High-Tech sector, for example, Augsburg shows only 23 per cent of the global connectivity of the Munich FUA (see also Table 33A in Appendix A). On the *regional scale*, in contrast, the secondary FUAs achieve a considerable proportion of the connectivity value of Munich: the functional urban hierarchy is clearly less pronounced. In the APS sector, Augsburg and Regensburg show around 60 per cent; Ingolstadt, Rosenheim, Freising and Landshut around 30 per cent of the regional connectivity compared with the FUA of Munich. Generally speaking, the larger the geographical scale of intra-firm networks, the higher the dominance of the FUA of Munich in comparison with its surrounding secondary agglomerations. In other words: while Munich acts as an important hub for global intra-firm networks of the knowledge economy, the surrounding FUAs are of particular regional importance.

The dominance of the FUA of Munich is also due to its large urban size in comparison to the other agglomerations in the Greater Munich area. The larger the agglomeration, the greater the number of company locations, and therefore the higher the total network connectivity. In order to better assess this size effect, Figure 51 considers the total connectivity in relation to the sheer size of the FUA – defined by the sum of inhabitants and jobs – compared with all agglomerations in the Mega-City Region of Munich. The pink circle illustrates the total network connectivity; the black ring shows the sum of inhabitants and jobs. If the pink circle is larger than the black ring, then the connectivity is larger than expected on the basis of population and employment figures. In this case, we speak of a surplus of significance. If the pink circle is smaller than the black ring, then the connectivity is less than one might expect. In this case, we speak of a deficiency of significance (see also Figure 33 in Section 7.2).

In the *APS sector*, Freising, Regensburg and Munich are the only FUAs with a surplus of significance. Kaufbeuren and Augsburg show a more or less balanced significance, while the remaining FUAs indicate a clear deficiency of significance, at least in terms of global branch networks of knowledge-intensive service companies (see also Table 34A in Appendix A). Once more, the airport location at Freising emerges as an important APS centre within the Mega-City Region of Munich: in Figure 48, it is the only FUA that does not have Munich within the top six of the connectivity ranking; in Figure 50, it moves from the sixth position in terms of regional APS connectivity to the second position in terms of global APS connectivity; and in Figure 51, it shows the highest surplus of significance in the APS sector. Despite its small size, the airport location at Freising seems to benefit from a dense network of global companies owning branch offices in several international locations. Much of this connectivity is formed from the global networks of logistics companies such as Dachser, Kuehne & Nagel or Panalpina. Our APS records show that eleven of the thirty surveyed logistics companies have at least one location within the FUA of Freising. The hub airport is clearly the main driver here. It creates international accessibility, which is crucial for enabling knowledge-intensive firms to acquire and create knowledge effectively. International networks conducted by face-to-face contacts and facilitated by frequent and direct flights to the world's major business centres are important competitive assets for international firms in the knowledge economy.

In the *High-Tech sector*, Regensburg shows the highest surplus of significance, followed by Munich and Ingolstadt. The latter became an important location in the High-Tech industry because of the headquarters and the largest production site of the car manufacturer Audi (Audi AG 2010). Besides Audi, many suppliers to the car industry are located in Ingolstadt – for example Dräxelmaier, the Schäffler Group, Johnson Controls or the Continental Corporation. Together, these companies make up the majority of the High-Tech connectivity of Ingolstadt. According to Dicken (2007), the clustering of the automotive industry in the same agglomeration is the result of recent changes in the nature of the assembler-supplier relationship: increasing pressure is being exerted by assemblers to deliver just-in-time, to deliver at lower costs and to raise the quality of components. As a consequence, much greater degrees of organisational interdependence between automobile manufacturers and component suppliers have developed, so that suppliers – especially first-tier suppliers delivering complex modules and systems – have to locate geographically as close as possible to their customers (Dicken 2007).

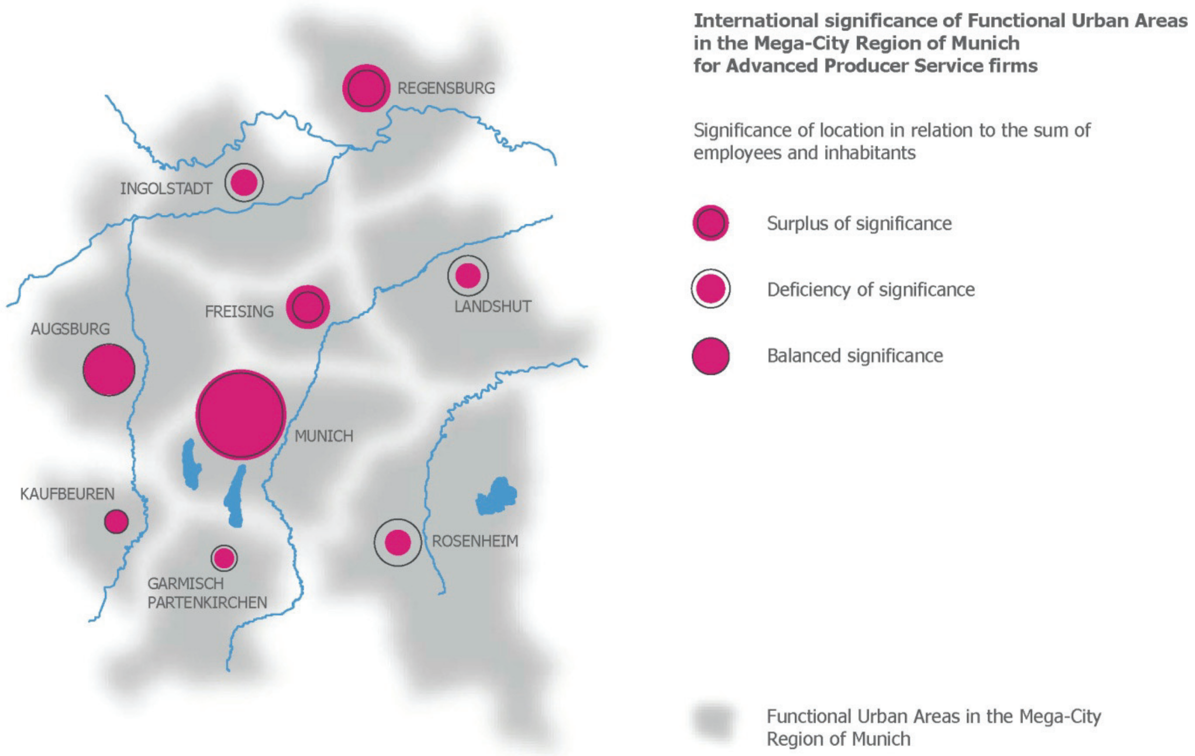


Figure 51: APS significance of FUAs in the MCR of Munich in comparison to each other (Author's calculation)

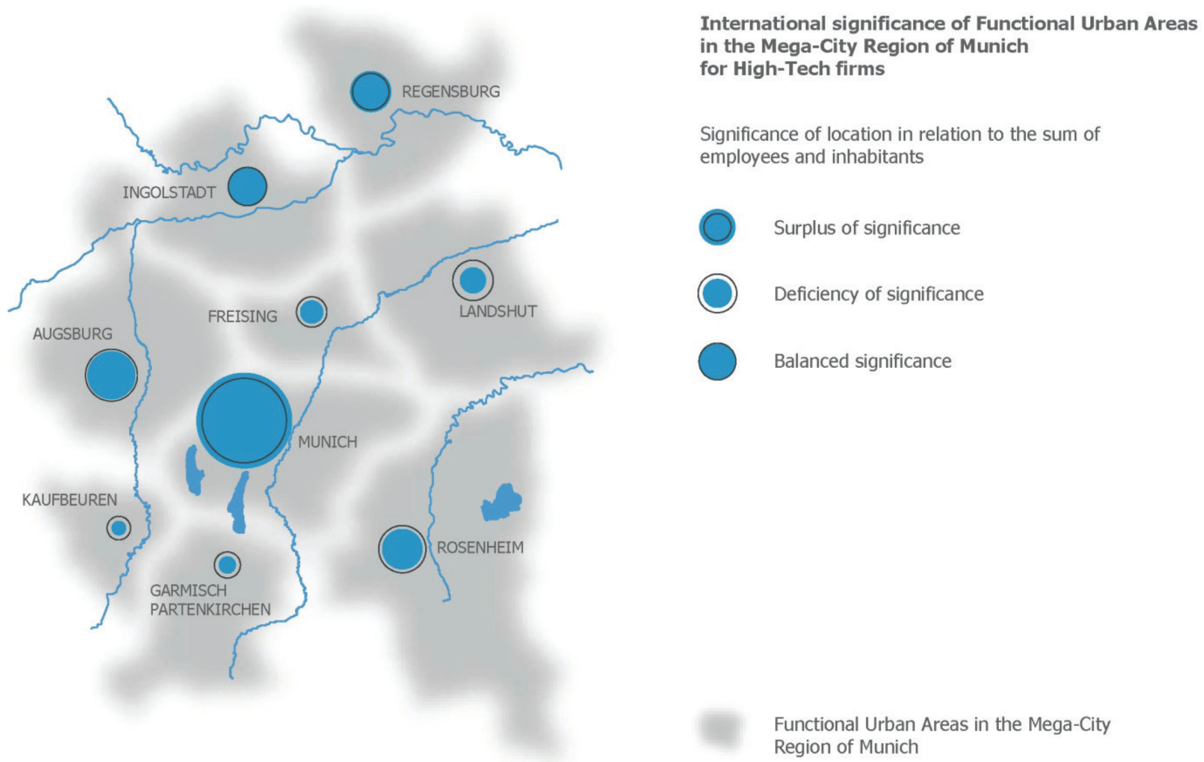


Figure 52: High-Tech significance of FUAs in the MCR of Munich in comparison to each other (Author's calculation)

Overall, the analysis in this section shows that the Mega-City Region of Munich is pretty hierarchical in character. The larger the geographical scale of intra-firm networks, the higher the dominance of the FUA of Munich in comparison to its surrounding secondary cities. There are some remarkable differences between the APS and the High-Tech sector. Some agglomerations are disproportionally integrated into APS networks and others are more involved in High-Tech networks. Basically, three types of FUAs can be distinguished. Firstly, FUAs like Munich and Regensburg, which indicate a surplus of significance in both the APS and the High-Tech sector. Because of their sheer size, they provide enough diversity and urbanisation economies in the context of the knowledge economy to create high APS- and High-Tech connectivity. Secondly, there are agglomerations such as Freising and Ingolstadt, which show a strong functional specialisation in a specific sub-sector of the knowledge economy and therefore generate localisation economies and high network connectivities in particular industries. And finally, there are agglomerations such as Landshut or Garmisch-Partenkirchen, which show a clear deficiency of significance in terms of their integration into international APS and High-Tech networks. They tend to be too small to provide enough critical mass to be highly integrated into global networks of knowledge-creating information exchange. This, however, does not mean that these agglomerations have no relevance within the Mega-City Region of Munich. Beyond the networks of the knowledge economy, they provide important complementary functions – for example in the field of housing or tourism – and thereby contribute to the functioning of the Mega-City Region as a whole.

The Greater Munich area as a localised system of value chains

The analyses so far have outlined the structural organisation and spatial impact of intra-firm networks within and beyond the Greater Munich area. In this section we now present the results of the *value chain* analysis that has been undertaken on the basis of the web survey (see Appendix C). Figure 53 highlights the spatial patterns of the business relations along the value chain for *APS firms* located in the Mega-City Region of Munich on the regional, national, European and global scale. It is important to note that this Figure is a diagram based on the number of interactions as stated by the firms who responded in the internet-based survey. The different shades of the colour in the legend illustrate the volume of interrelations along the value chain. The darker the colour, the greater the number of interactions reported by the responding APS firms. The proportion of business relations on the regional, national, European and global scale is mapped within each individual segment of the value chain. For example: within the value chain segment of financing, more than 50 per cent of business relations are concentrated on the regional scale.

Figure 53 shows that the largest proportion of the value-added relations of APS firms is concentrated at the regional scale, i.e. within the Mega-City Region of Munich. The most frequent interactions are in the fields of processing, financing, marketing and sales & distribution. These value chain elements provide important services for APS firms and assume an important role as entrepreneurial support network within the Mega-City Region of Munich. On the national scale, a relatively high number of business relations in R&D can be observed reflecting the fact that many APS firms in the Greater Munich area have to attract R&D services from all of Germany in order to compete successfully in the knowledge economy. Business relations on the European or global scale are clearly less pronounced. All in all, 54 per cent of all business relations of APS firms are concentrated on the regional scale; 40 per cent are focused on the national, and 6 per cent on the European scale – less than 1 per cent of the value-added relations mentioned in the web survey are globally oriented (see Table 38A in Appendix A).

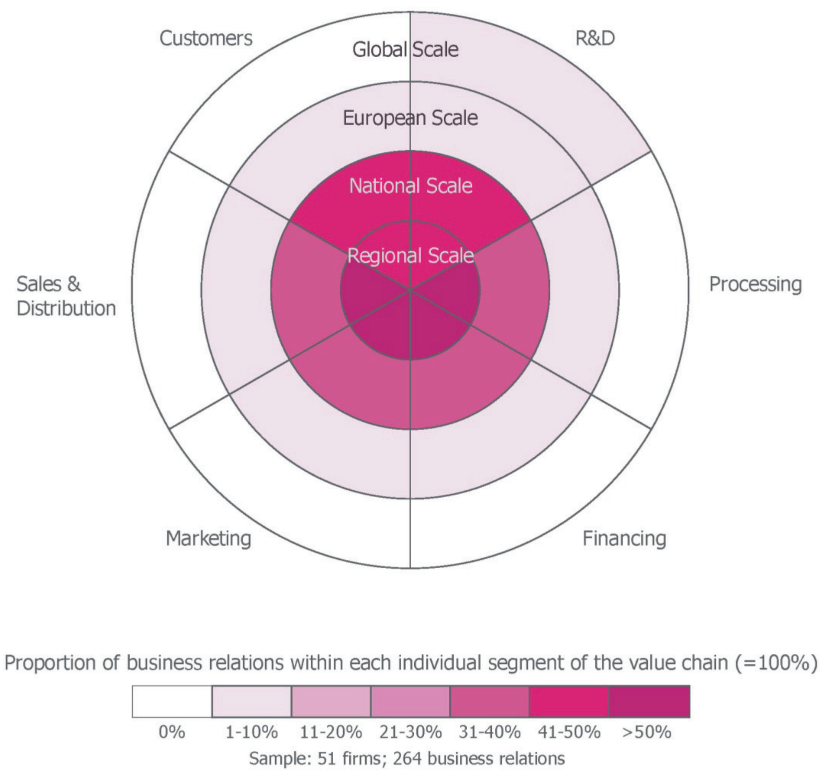


Figure 53: Value-adding relations of APS firms located in the MCR of Munich
(Author's calculation)

These findings show that proximity to customers and partners along the value chain plays a central role in the understanding of spatial development in Mega-City Regions. Companies faced with international competition choose their locations in the vicinity of 'knowledge poles' as well as in dense and diverse labour markets. A similar argument is put forward by Porter (1990), who emphasises the interdependence between high-level demand and a high-quality supply. This triggers a cumulative process that positively affects the competitiveness of regional economies. Companies establish a comparative advantage against other competitors throughout the world when they are stimulated by regional competitors, challenging suppliers and demanding customers. Quality production, permanent and rapid product and process innovation, a unique research and development capacity, specialised knowledge and the capacity for a rapid pooling of information is generated by companies that build their innovation on a continuous exchange with other companies and institutions on a regional scale (Porter 1990).

Another reason why a large proportion of the business relations of APS firms is focused on the national and regional scale lies in the different kinds of proximity provided within regions and nations. As we have already seen in Section 7.1, knowledge about national and cultural peculiarities, as well as language skills and trust are important determinants in the provision of services. Relations based on trust are regulated on the basis of reputation as well as social, institutional and spatial proximity. A study of Jähnke and Wolke (2005), for example, shows that for service providers, it is particularly difficult to establish and maintain extra-firm relations over long distances (Jähnke and Wolke 2005). But also specific national regulations – as confirmed in the interviews – provide strong incentives for APS firms to penetrate national markets rather than to expand into global business activities.

Figure 54 shows the findings of the web survey for *High-Tech enterprises* located in the Mega-City Region of Munich. As in the case of APS firms, the majority of value-added relations are concentrated on the regional and national scale. However, in contrast to APS networks, High-Tech firms within the greater Munich area are displaying a remarkable level of global relations. Overall, 35 per cent of all value-added relations in the High-Tech sector are focused on the regional and on the national scale. 18 per cent are directed towards the European, and 12 per cent towards the global scale (see Table 38A in Appendix A). Obviously, in order to compete successfully in the global economy, High-Tech firms rely on resources and expertise provided by firms on different spatial scales. Tödtling et al. (2006) confirm this finding arguing that information flows from clients, suppliers and competitors are highly internationalised in the High-Tech sector. High-Tech firms combine knowledge sources from the region with those of national and international origin in their innovation processes (Tödtling et al. 2006). Similarly, Chiarvesio et al. (2010) argue that leading High-Tech firms are increasingly expanding the boundaries of their supply base and investing in global networks in order to sustain a competitive advantage (Chiarvesio et al. 2010). In this sense, the greater Munich area cannot be regarded as a self-sustaining urban system. On the contrary, it is highly interconnected into a global relational space composed of flows of information, capital, goods and people, travelling along roads, railways, aviation routes and – increasingly – telecommunications.

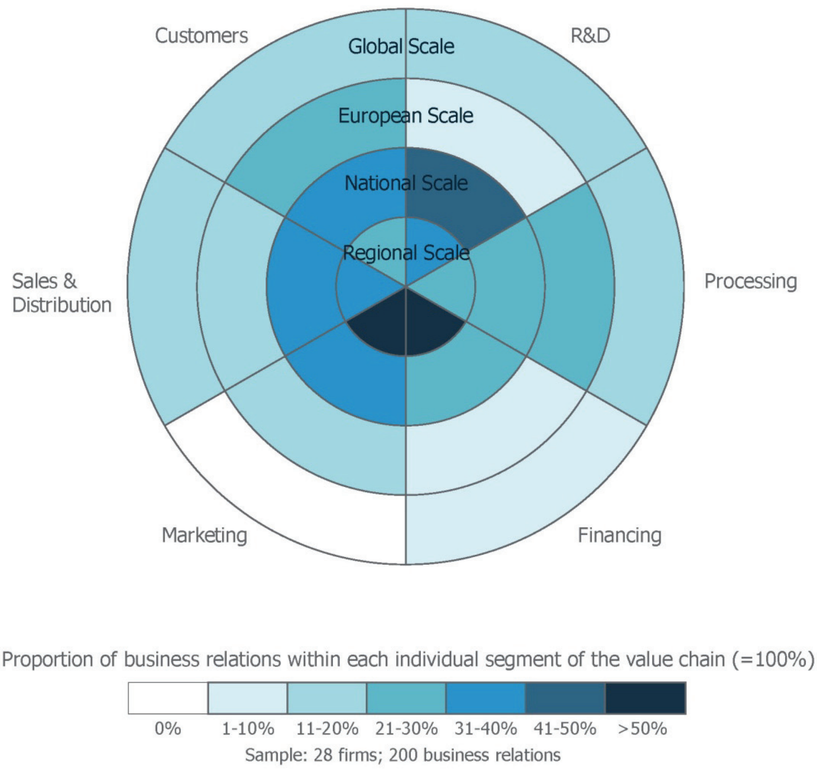


Figure 54: Value-adding relations of High-Tech firms located in the MCR of Munich
(Author's calculation)

To conclude, the interlocking networks of the knowledge economy in the Greater Munich area provide evidence that the latter can be understood as a functionally monocentric and hierarchically organised Mega-City Region, in which intra-firm and extra-firm linkages are concentrated to a considerable extent. The connectivity based on intra-firm networks of APS and High-Tech companies creates an urban core network – composed by the FUAs of Munich, Augsburg, Regensburg and Ulm – and an extended city network, which includes additional cities and towns depending on whether APS or High-Tech networks are considered. Similarly, the value chain analysis shows that knowledge-intensive firms in the Greater Munich area source the largest part of their value-added services on the regional scale. The most frequent regional business relations are in the fields of marketing and financing, which indicates the importance of these activities as entrepreneurial support network within the Mega-City Region of Munich. The regional patterns of the intra-firm and extra-firm business networks underline that it is the complementary combination of Munich and the surrounding secondary FUAs that lifts the entire Meg-City Region into a competitive position in the global economy. The combination of the urbanisation externalities of the FUA of Munich and the complementary integration of the secondary centres around Munich leads to an effective and economically powerful urban configuration. Secondary centres – such as Freising or Ingolstadt – are characterised by strong localisation economies: they provide local expertise and specialised skills that are highly beneficial for the Mega-City Region as a whole. Nevertheless, the rather monocentric pattern of the regional connectivity in the Greater Munich area indicates also a relatively *steep functional urban hierarchy*. This hierarchy proves to be different depending on whether global or regional business networks are considered. The larger the geographical scale of intra-firm networks, the higher the dominance of the FUA of Munich in comparison with its surrounding secondary agglomerations. Against this backdrop, Christaller's central place theory – which has had a huge influence on the German spatial development policy – can be criticised for its restricted focus on the regional scale. The functional urban hierarchy of today is profoundly affected by the globalisation of the economy and its progressive shift towards the handling of information, rather than by a city's capacity to supply retail services to a surrounding area (Taylor 2004b). It is exactly for this reason why hub airport locations – such as Freising – gain in importance. Relational proximity based on physical infrastructure, accessibility and the organisational ability of firms to facilitate interactions is a crucial driver of today's functional urban hierarchy.

7.3.2 The Rhine-Ruhr region

Our second example for analysing regional connectivity patterns is Rhine-Ruhr, a large polycentric city-region, embracing 30-40 towns and cities with a total population of some 10 million people. Rhine-Ruhr has been chosen because it is internationally known for its archetypical polycentric urban structure, and because – all FUAs taken together – it indicates the highest connectivity values of all Mega-City Regions in Germany by far (see Figure 35 and 36 in section 7.2.2). In morphological terms, Rhine-Ruhr has a classic polycentric structure comprising a set of strong medium-sized cities – Duisburg, Essen, Dortmund and Düsseldorf – with over half a million people and Cologne nearing 1 million people (see Hall and Pain 2006). These cities are very close together, especially in the Ruhr area in the northern half of the region. Towards the south – along the Rhine axis – the cities are more widely spaced. In terms of employment change, there is a clear distinction between the Ruhr agglomerations of Duisburg, Essen and Dortmund – which lost employment in the 1980s and 1990s – and the Rhine agglomerations of Bonn, Cologne and Düsseldorf – which gained from service industry growth. The service sector in general is more strongly represented in Düsseldorf, Cologne and Bonn. In terms of commuting patterns, Düsseldorf is very much the dominant commuter destination, receiving big flows from neighbouring FUAs such as Duisburg, Essen and Cologne. Major two-way flows can also be observed between Cologne and Bonn as well as between the major Ruhr agglomerations of Essen, Bochum and Dortmund (Hall and Pain 2006). Although Rhine-Ruhr still has a relatively strong industrial base, de-industrialisation is taking place all across the region. However, some agglomerations have been able to offset job losses in the industrial sector with new jobs in the emerging knowledge economy. Due to several agglomeration advantages, some FUAs – such as Düsseldorf – have done much better in this respect. In the second half of the 20th century, Düsseldorf profited enormously from the tertiary sector. Today it is one of the leading centres of the German advertising and fashion industry (Knapp et al. 2006a).

Regional connectivity patterns in the Rhine-Ruhr region

The importance of Düsseldorf is also expressed in Figure 55, which shows the spatial patterns of intra-firm connectivity between *APS firms* in the Rhine-Ruhr region. On the regional scale, a highly connected city triad emerges, bounded by the FUAs of Düsseldorf, Cologne and Dortmund. The axis between Düsseldorf and Cologne can be interpreted as the backbone of the region. It includes intra-firm networks of all the APS sub-sectors examined: 63 of the 270 APS companies studied have locations in both Düsseldorf and Cologne. This connection indicates the second largest city-interlock between two neighbouring FUAs in Germany, after the link between Hamburg and Bremen. The Dortmund-Düsseldorf and the Dortmund-Cologne link, on the other hand, are mainly based on banking and finance, logistics and insurance companies, i.e. economic sectors with a strong regional retail business. Overall, the strong connectivity in the Rhine-Ruhr region is the result of a distinctive functional and geographical specialisation. In Düsseldorf, for example, there is a concentration of companies in sectors such as law consulting or information and communication services. In Cologne, on the other hand, there is a clustering of companies in fields such as design, architecture & engineering, as well as insurance. As a consequence, the Rhine-Ruhr region has established a distinct functional polycentricity, based on spatial division of labour and driven by the networks of knowledge-intensive business services.

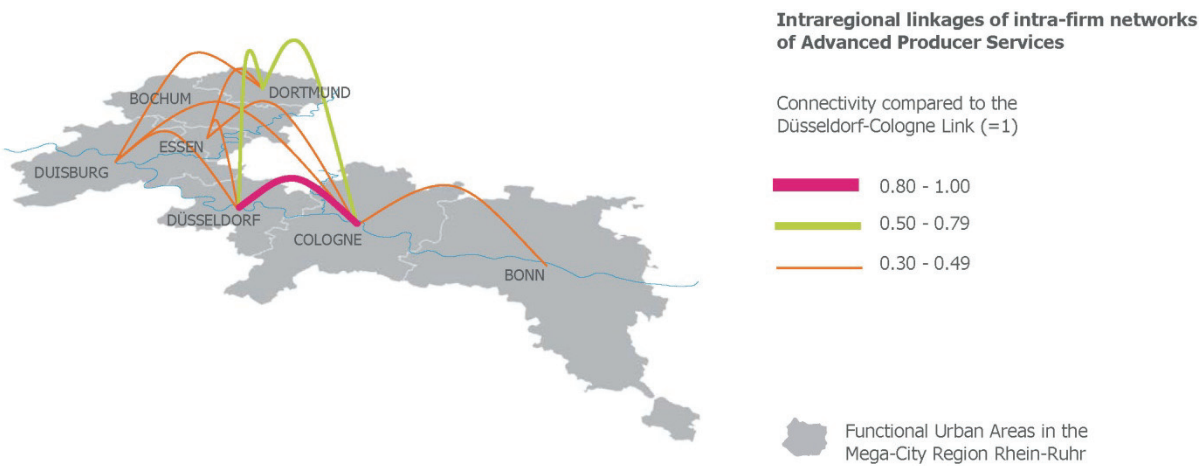


Figure 55: Regional connectivity of APS firms in the Rhine-Ruhr region
(Author's calculation; visualisation: Anne Wiese)

The regional linkages in the *High-Tech sector* (see Figure 56) are even more intense. Again, the strongest connection can be found between Düsseldorf and Cologne, followed by the connectivity between Düsseldorf and Bochum. The link between Düsseldorf and Bochum is mainly composed on companies in the fields of machinery, vehicle construction and medical & optical instruments. On the whole, the Ruhr area and the Rhine axis seem to be highly connected with each other in functional terms. In fact, these two apparently competing urban regions prove to be economically closely interrelated, with the connectivity between Düsseldorf and Bochum standing out as the most important High-Tech dyad connecting the FUAs in the Ruhr area to the agglomerations along the Rhine axis.

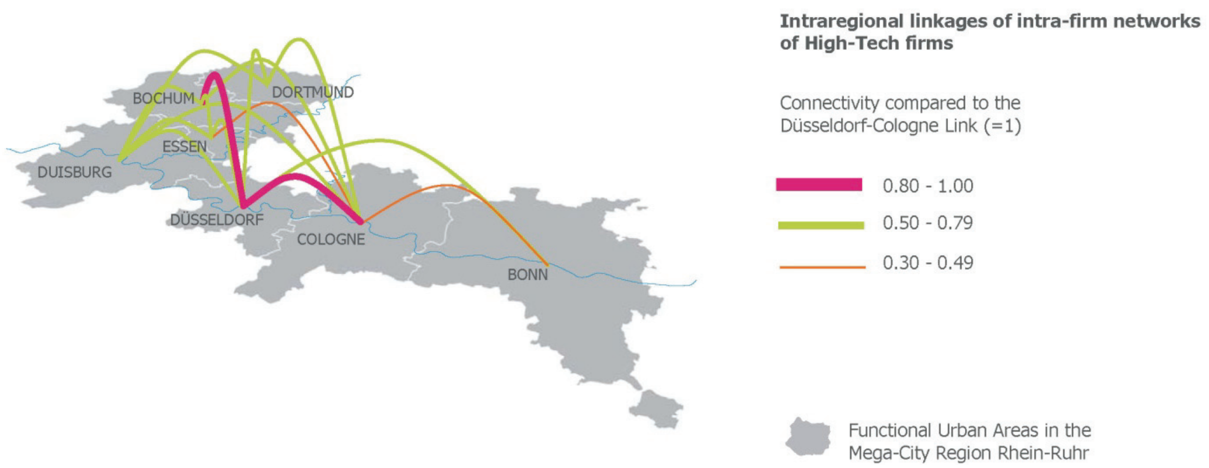


Figure 56: Regional connectivity of High-Tech firms in the Rhine-Ruhr region
(Author's calculation; visualisation: Anne Wiese)

Figure 57 shows the connectivity patterns of *APS firms* in the Rhine-Ruhr region on a slightly bigger spatial scale. All adjacent agglomerations of the Rhine-Ruhr region are now also integrated into the network analysis. On the left-hand side, the FUAs are localised in their exact geographical position. On the right-hand side, the relational position between the FUAs is displayed. As in the Munich case, the city-interlocks are measured as a ratio of the strongest link in the APS records (Munich-Hamburg = 100 per cent): they are only plotted if they reach a value greater than 2.5 per cent. FUAs lying inside the case study area (compare Figure 55 and 56) are shown in pink; FUAs lying outside this area are marked by purple points.

In general, the Figure shows a very strong regional connectivity within the Rhine-Ruhr region, especially in comparison to the Mega-City Region of Munich (compare Figure 46). These two cases are comparable because they are based on the same reference: the city-interlock between Munich and Hamburg. The central position within the relational map of Rhine-Ruhr is occupied by Düsseldorf, which is highly connected with the FUAs of Cologne, Dortmund and Essen (first ring around Düsseldorf). Again, the FUA triad of Düsseldorf, Dortmund and Cologne emerges as an important spatial pattern within the Rhine-Ruhr region. Bonn, Bochum and Duisburg, on the other hand, are less strongly integrated into the regional networks of APS firms (second ring).

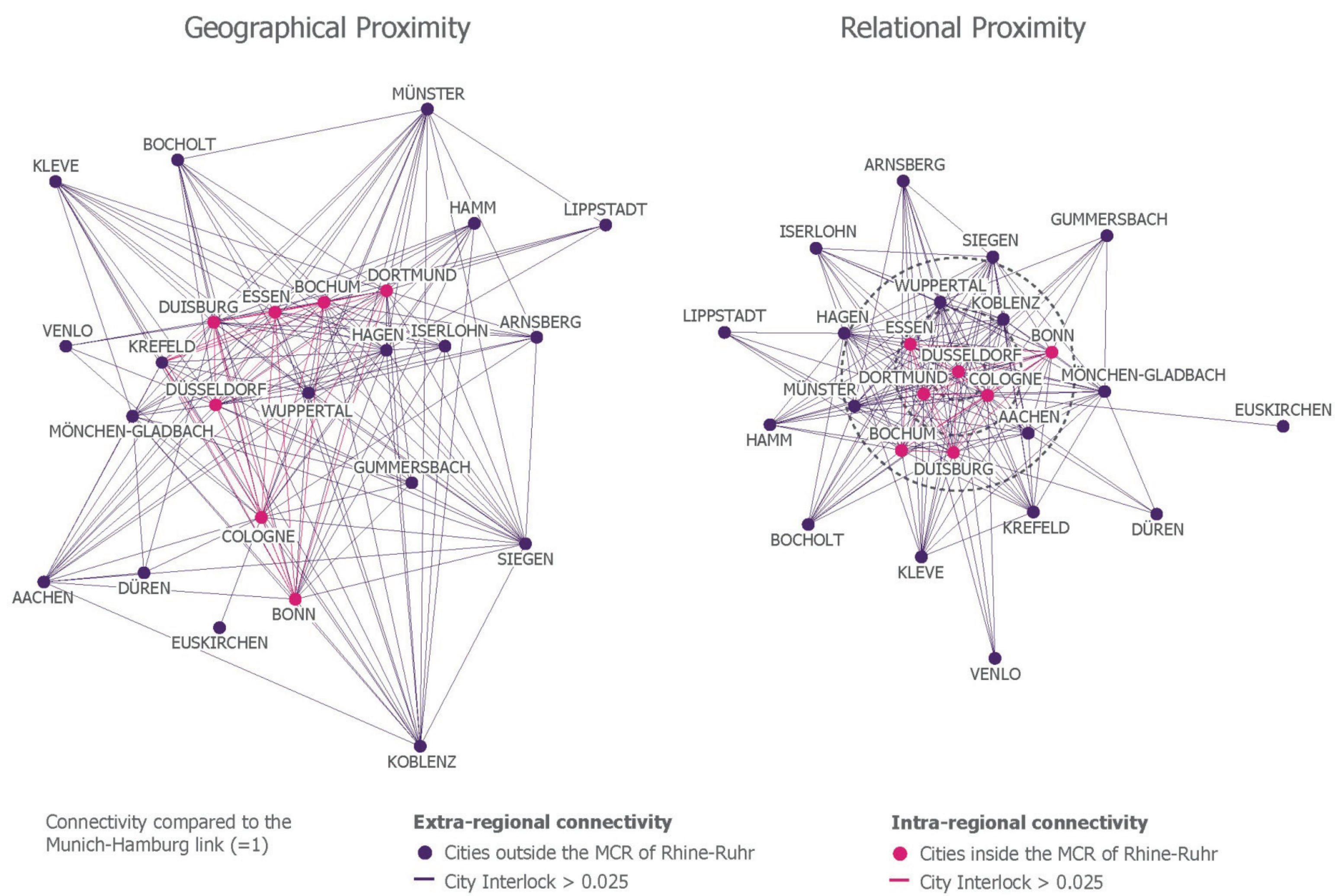


Figure 57: Geographical vs. relational proximity of APS firms in the Rhine-Ruhr region
(Author’s calculation; visualisation: Anne Wiese, Michael Bentlage)

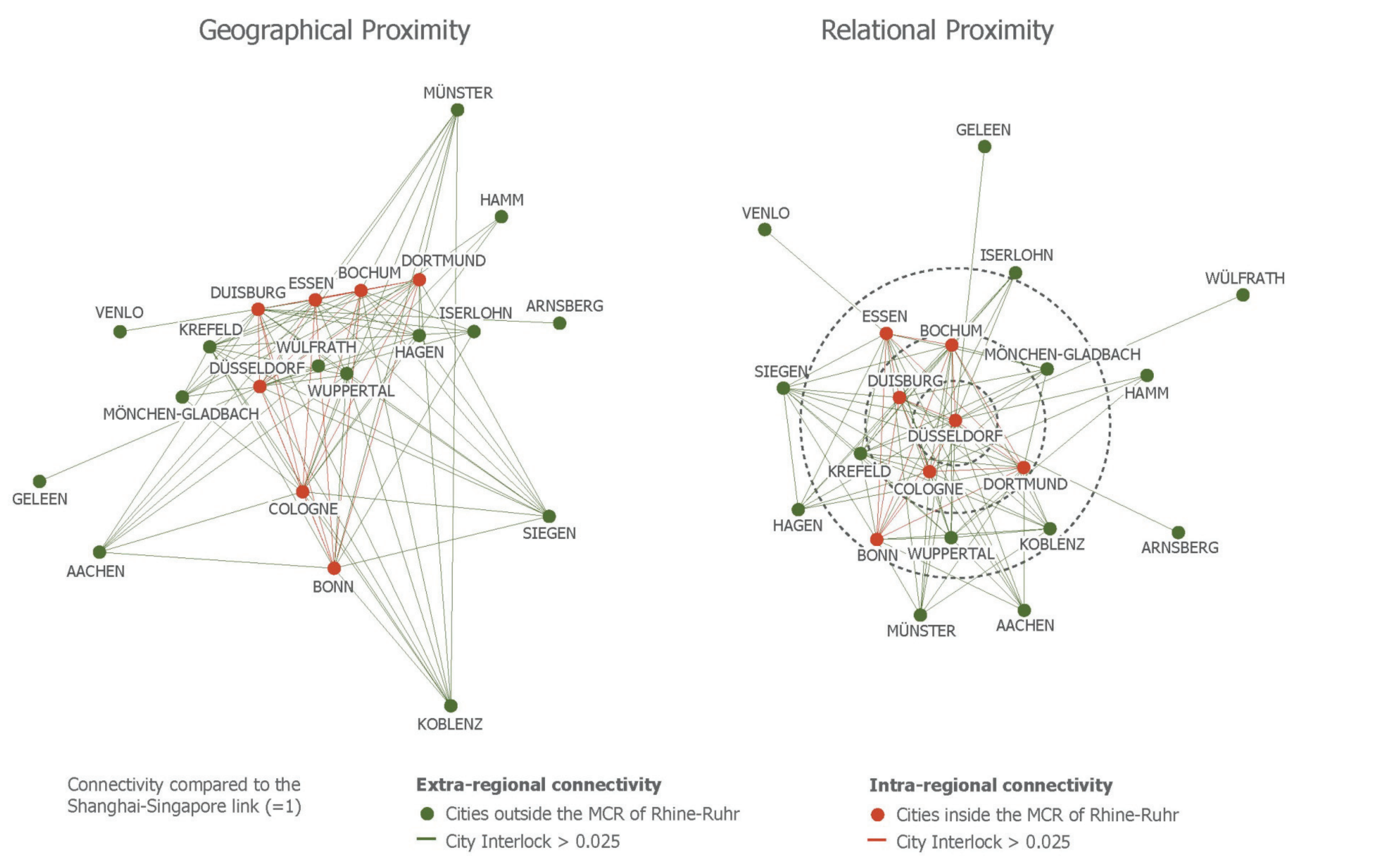


Figure 58: Geographical vs. relational proximity of High-Tech firms in the Rhine-Ruhr region
(Author's calculation; visualisation: Anne Wiese, Michael Bentlage)

Wuppertal, Koblenz, Münster and Aachen show a similar degree of regional connectivity to those of Bonn, Bochum and Duisburg. In the APS sector, they are primarily linked to the Rhine-Ruhr region by the retail business of large banks and insurance companies. The Bermenia Versicherungsgesellschaft, for example, has its headquarters in Wuppertal. Münster is the location of the headquarters of Provinzial NordWest, one of the biggest public insurance companies in Germany. In Aachen, there is an important Generali Group office (service value 4).

The connectivity between Aachen and the Rhine-Ruhr region is also strongly influenced by engineering companies. Many engineering firms such as Hochtief or Euro Engineering have a location both in Aachen and in several FUAs in the Rhine-Ruhr regions. These firms benefit from the importance of Aachen as a centre of the mechanical engineering and automotive industries. Aachen is a significant location for the German tyre manufacturer Continental and the U.S. car manufacturer Ford. Moreover, many institutes of the RWTH Aachen University – a German University of Excellence – are focused on automotive technology. RWTH Aachen has achieved an international reputation in several fields of engineering and science, especially mechanical engineering, electrical engineering, industrial engineering, computer science, physics and chemistry (RWTH Aachen 2010).

Figure 58 shows the same situation for the *High-Tech sector*. Again, city-interlocks are only plotted if they exceed 2.5 per cent of the strongest link in the High-Tech sample (Shangai-Singapore = 100 per cent). FUAs located within the case study area are coloured orange; FUAs outside the case study area are green. Once more, it becomes clear that Düsseldorf acts as an important gateway between the Ruhr area and the Rhine axis. Essen, Bochum and Duisburg are close together not only in geographical terms, but also in relational terms. Of all FUAs in the Ruhr area, Dortmund shows the highest functional connectivity – or relational proximity – to the agglomerations along the Rhine. Bonn, on the other hand, is relatively weakly involved in the regional intra-firm networks of High-Tech firms. However – similarly to the APS sector – the FUAs within the Rhine-Ruhr region demonstrate a very distinct High-Tech connectivity among one another, particularly in comparison to the connectivity pattern in the Mega-City Region of Munich.

Wuppertal, Koblenz, Mönchengladbach and Krefeld also emerge as quite strongly integrated into the High-Tech networks of the Rhine-Ruhr area. The High-Tech connectivity of Mönchengladbach, for example, is mainly established by mechanical engineering firms such as the Voith AG or the SMS group. The regional connectivity of Krefeld, by contrast, is generated primarily by the intra-firm networks of the chemical industry, which is traditionally located in the agglomeration of Krefeld. The chemical company Bayer, for example, operates a large plant in Uerdingen, a district of the city of Krefeld located directly on the Rhine.

Overall, the Rhine-Ruhr region shows a very intensive networking through the intra-firm activities of APS and High-Tech companies. Intra-regional connectivities between the FUAs of the Rhine-Ruhr region tend to be stronger than the connections to neighbouring FUAs. This provides evidence for the hypothesis proposed initially, that linkages of knowledge-intensive enterprises are increasingly concentrated on an extended regional scale, forming what might be characterised as functionally polycentric Mega-City Region (see Section 4.3). In other words, the FUAs in the Rhine-Ruhr region are very close to one another not only geographically, but also from a relational point of view. Düsseldorf emerges as the real heart of the Rhine-Ruhr region. Together with Dortmund and Cologne, it creates a highly connected FUA triad forming a kind of functional bridge between the Ruhr area and the Rhine axis.

Global connectivity patterns in the Rhine-Ruhr region

Let us now turn to the global connectivity patterns in the Rhine-Ruhr region. Figure 59 shows – for each agglomeration in Rhine-Ruhr – the five most intensively connected locations in the *APS sector*, as well as the position of the most networked location outside Germany. The size of the circle illustrates the total network connectivity for each FUA. As in the case of Munich (compare Figure 48), the dominance of the German FUAs Hamburg, Munich, Berlin, Frankfurt and Stuttgart stand out particularly in the connectivity ranking. Focusing on the specific networks on the international scale, the city of Vienna shows the highest connectivity to the FUAs of Dortmund, Bochum, Essen, Duisburg and Cologne – alongside the strong orientation of Düsseldorf to London. The connectivity between Düsseldorf and London is mainly composed of the intra-firm networks of financial services, law consulting as well as management- and IT-consulting enterprises. Firms such as Deutsche Bank, the ING Group, Freshfields Bruckhaus Deringer, Clifford Chance and the Boston Consulting Group have important offices in both Düsseldorf and London (Service Value at least 3). The connectivity between the Rhine-Ruhr region and Vienna, on the other hand, is established to a large extent by the logistics industry. Logistics companies such as the German Post, Schenker AG, Kuehne & Nagel or Logwin have important locations in Vienna and – at the same time – in several FUAs in the Rhine-Ruhr area. Logistics firms are well-distributed throughout the Rhine-Ruhr region, namely in Cologne in the south as well as in Dortmund (the eastern gateway to Rhine-Ruhr) and in Duisburg (the western gateway to Rhine-Ruhr). The Austrian capital also shows strong connectivities to Warsaw, Prague, Budapest and Moscow, which again underlines the importance of Vienna as gateway to the East European markets (see also Section 7.1).

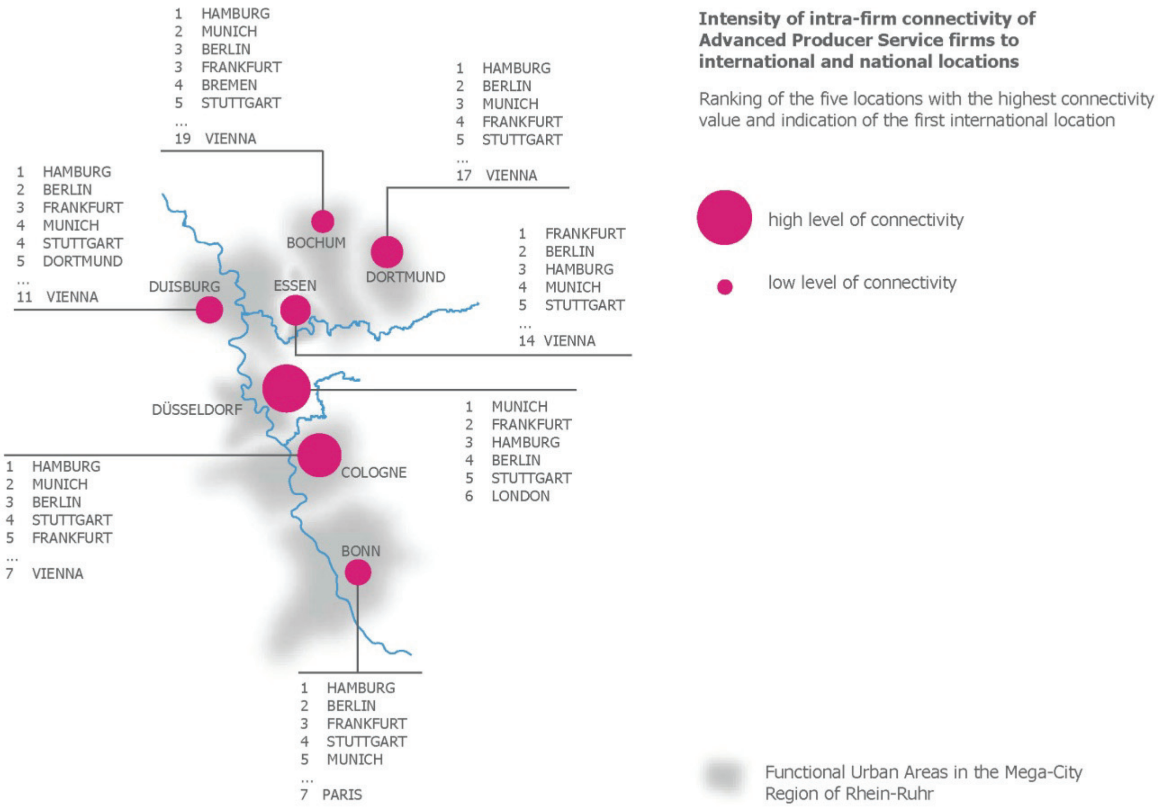


Figure 59: International connectivity of APS firms in the Rhine-Ruhr region
(Author's calculation)

As in the Mega-City Region of Munich, the *High-Tech sector* in the Rhine-Ruhr region also shows very high international connectivity patterns (see Figure 60). Düsseldorf and Cologne indicate the largest connectivity values, followed by the FUAs of Duisburg, Bochum and Essen (see size of the blue circles). Remarkably strong links exist with East Asian cities such as Shanghai and Singapore. In four FUAs – Düsseldorf, Cologne, Bochum and Bonn – Shanghai occupies the top position. The connection between Shanghai and the Rhine-Ruhr region is produced mainly by global mechanical engineering companies such as the Voith Group or the Freudenberg Group. But also automotive suppliers, such as Robert Bosch and Johnson Controls, and chemical companies, such as BASF and Lanxess, have important locations in both Shanghai and in the Rhine-Ruhr area.

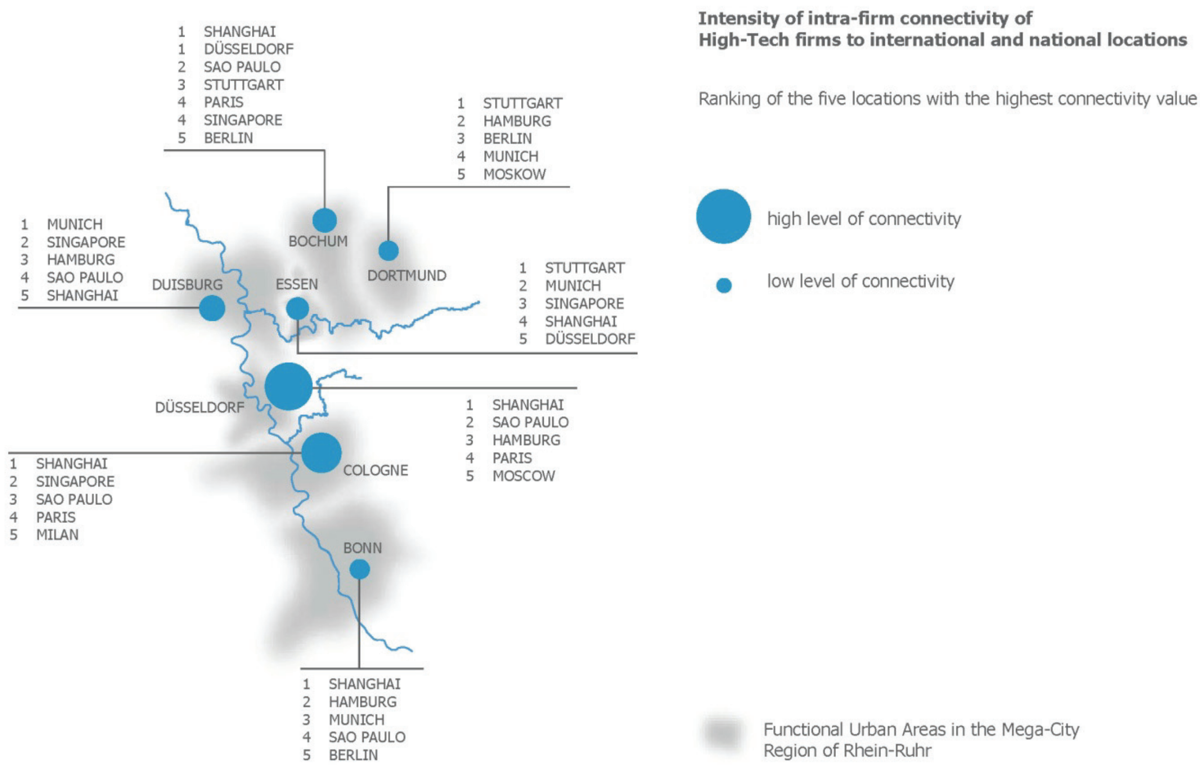


Figure 60: International connectivity of High-Tech firms in the Rhine-Ruhr region
(Author's calculation)

The Rhine-Ruhr region as a hierarchical urban system

If one analyses the functional urban hierarchy within the Rhine-Ruhr region on different spatial scales, significant differences can be identified in comparison to the Mega-City Region of Munich (compare Figure 50 and Figure 61). Rhine-Ruhr shows a much stronger functional polycentricity. In the functionally monocentric Mega-City Region of Munich, the dominance of the primary FUA increases with the geographical scale of connectivity. In the polycentric Mega-City Region of Rhine-Ruhr, by contrast, the connectivity patterns show a more complex structure depending on the functional specialisation of the corresponding secondary FUAs.

Among the FUAs along the Rhine axis, Düsseldorf and Cologne show the highest connectivity values by far. Düsseldorf shows the strongest integration into the intra-firm networks of APS and High-Tech companies, not only internationally but also on the regional scale. As already identified in previous studies (Knapp et al. 2006a; Taylor et al. 2008), Düsseldorf proves to be the central gateway of the

Rhine-Ruhr area connecting the whole region to a global ‘space of flows’ (Castells 2000). Cologne, on the other hand, shows a double specialisation. At the international level, it emerges as an important High-Tech centre with 93 per cent of Düsseldorf’s global network connectivity. At the regional level, on the other hand, it emerges as an important APS location with as much as 98 per cent of Düsseldorf’s network connectivity. In other words, Cologne is a global High-Tech centre, especially because of its globally-oriented engineering and chemical companies, and a regional APS centre, mainly because of its regionally and nationally-oriented insurance companies. Thus, a certain division of labour can be observed between the two FUAs on the Rhine. Whereas Cologne is the main location for nationally oriented insurance, design and media services, Düsseldorf constitutes the leading centre for global advertising, management consulting, law and accountancy firms.

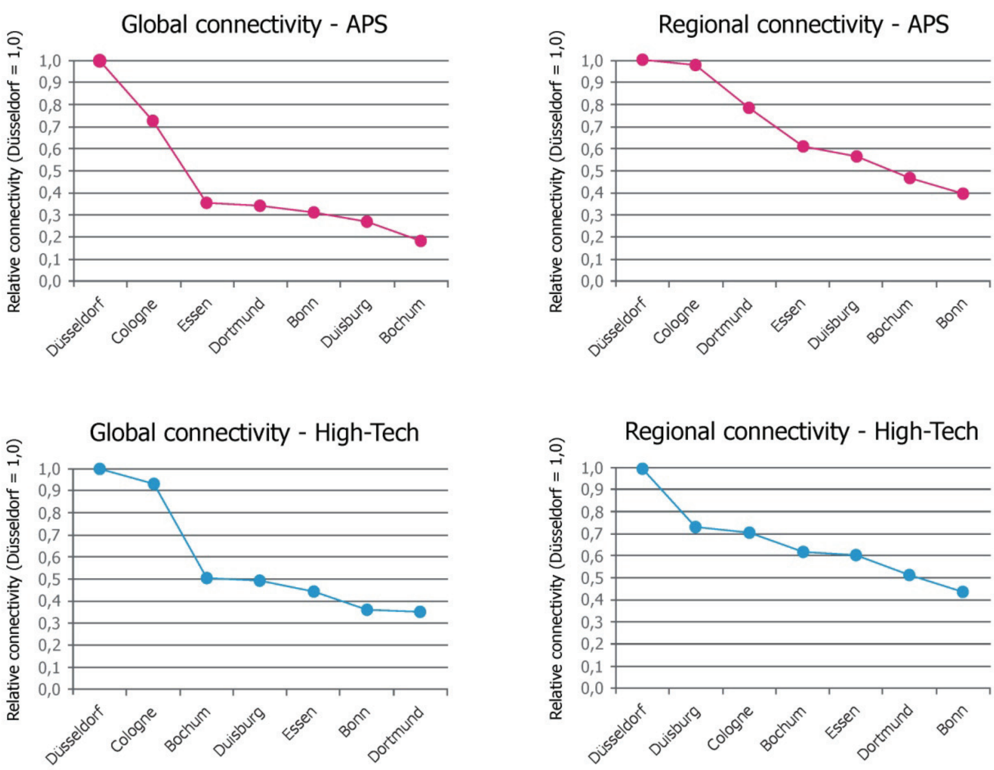


Figure 61: Global and regional connectivity in the MCR of Rhine-Ruhr (Author’s calculation)

Legend: Global Connectivity illustrates how well the nine FUAs are connected to extra-European destinations such as New York, Tokyo, Sydney etc. Regional Connectivity illustrates how well the nine FUAs are connected among one another. The connectivity values are related to the maximum value (=1).

In the Ruhr area, on the other hand, Essen and Dortmund are the most intensively involved in *APS networks*. Essen shows a relative concentration of management consulting firms, which explains its 3rd ranking in the global APS connectivity. In the *High-Tech sector*, Duisburg and Bochum show the highest connectivity values of all the Ruhr FUAs. The emergence of the High-Tech sector in these agglomerations might be stimulated by pre-existing skills and experiences that have been inherited from previous patterns of economic development. An interviewee from a High-Tech company in the Ruhr area, for example, underlined the importance of the regional industrial culture in order to transform new ideas and inventions into marketable products. In line with Martin’s (2010) argument, this finding suggests that path dependency need not necessarily end in a lock-in situation. Existing knowledge resources might well constitute an important basis for departure into new innovations and markets. Martin (2010) for example argues that local industrial evolution is about adaptation in response to ever-shifting markets and competitive environments (Martin 2010) (see Section 2.1.1).

The relatively high connectivity of Duisburg and Bochum is also the result of their sheer urban size. After Cologne, they indicate the highest number of inhabitants and jobs of all FUAs in the Rhine-Ruhr region. However, viewing the total connectivity of the Rhine-Ruhr agglomerations in perspective with the sum of their population and employment figures once again confirms our previous finding that the sheer size of a FUA does not necessarily increase its economic importance (see Figure 62). In the Rhine-Ruhr region, Düsseldorf proves to be the main economic gateway for *APS firms* – not Cologne, which is actually much bigger than Düsseldorf in terms of inhabitants and jobs. Furthermore, highly populated agglomerations such as Duisburg and Bochum show a clear deficiency of significance, at least in terms of their integration into the international intra-firm networks of knowledge-intensive companies. According to Hoyler (2011a), this indicates a certain limit to the number of cities in a region that can achieve critical importance as hubs for global service activities. Primary cities create a kind of “shadow effect” that hinders international APS firms from locating in secondary cities, for example Düsseldorf vs. Cologne, Essen and Dortmund; and Berlin vs. Leipzig and Dresden (Hoyler 2011a). For *High-Tech networks*, Düsseldorf and Essen are the only agglomerations with a clear surplus of significance (see Figure 63). Essen is home of the headquarters of some major German corporations such as REW, Hochtief, Evonik, Schenker and ThyssenKrupp. Moreover, some global mechanical engineering companies are sited there, for example MAN and the Voith Corporation. The networks of these international companies lead to Essen having surprisingly high total network connectivities in the High-Tech sector. A special case in the Rhine-Ruhr region is Bonn, the former capital of Germany. After the German reunification at the end of the 1990s, many ministries were relocated from Bonn to Berlin. Subsequently, despite many negative prognoses, Bonn has developed quite successfully in economic terms, not least because of the huge amount of subsidies being paid in compensation for the loss of its status as the capital of Germany (Knapp et al. 2005). For a long time, this led to a surplus of significance, as previous studies confirm (Thierstein et al. 2006; Knapp et al. 2006b). However, this advance seems to be slowing – Figure 62 and Figure 63 show that Bonn now indicates a slight deficiency of significance in both the APS and the High-Tech sectors.

All in all, the analysis of the functional urban hierarchy in the Rhine-Ruhr region confirms Düsseldorf’s position as an important hub for knowledge-intensive firms on the regional, national and global scales: on the regional scale, it emerges as an important gateway between the Ruhr area and the Rhine axis; on the national scale, it is one of those German FUAs that have long constituted the apex of a polycentric national configuration of cities and metropolitan regions, characterised by complementary functional and sectoral specialisations (Blotevogel 2000); and on the global scale, it clearly acts as ‘first city’ for internationally-oriented APS firms and therefore constitutes a key gateway to the other major FUAs in the Rhine-Ruhr region. At the same time, however, Düsseldorf is highly dependent on the functional division of labour within the whole metropolitan area of Rhine-Ruhr. The geographical scope of the business activities and the connectivities of the FUAs identified in the analysis of intra-firm networks show a high degree of functional polycentricity. Thus, in comparison to Munich, Rhine-Ruhr can be considered as a highly polycentric Mega-City Region with regard to the functional geography of its knowledge-intensive enterprises.

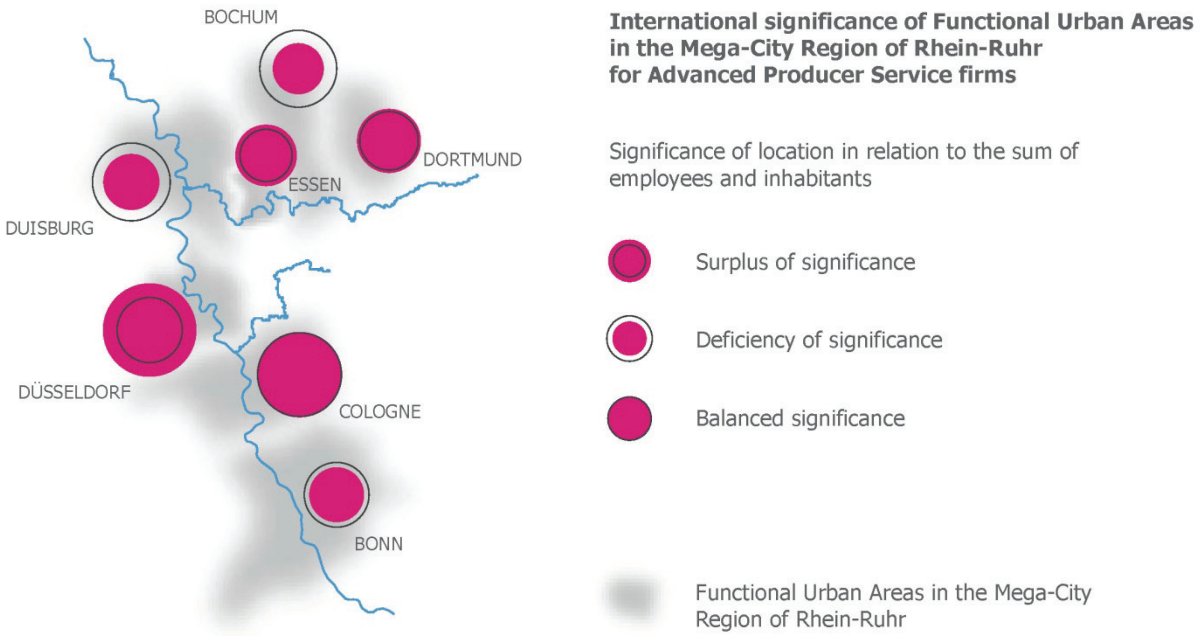


Figure 62: APS significance of FUAs in the MCR of Rhine-Ruhr in comparison to each other (Author's calculation)

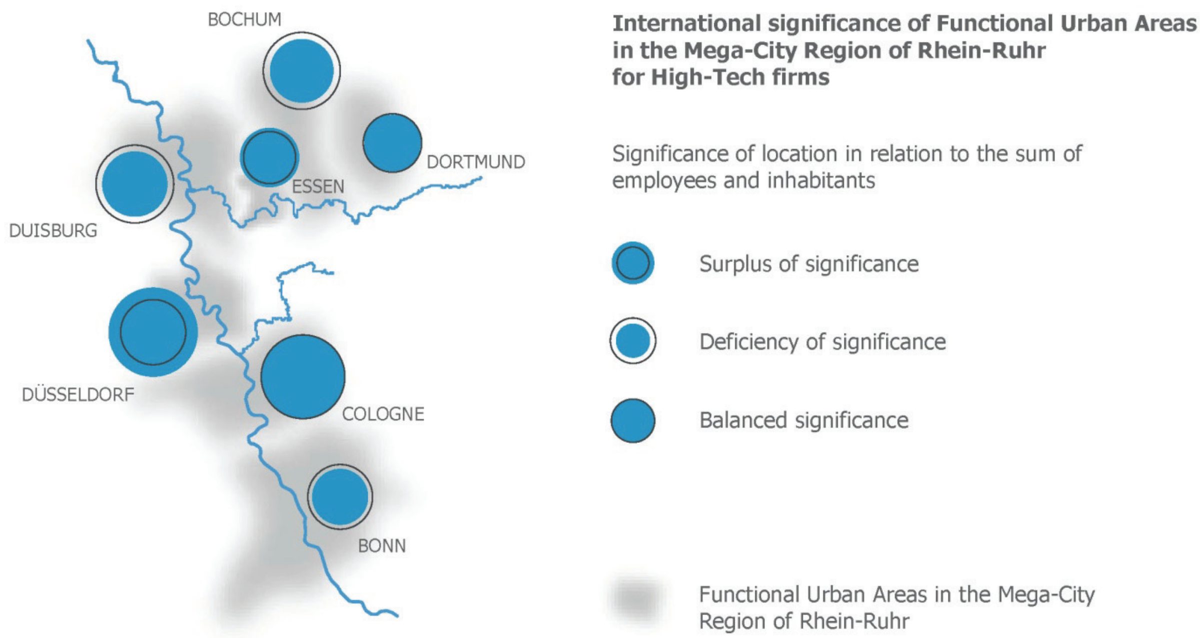


Figure 63: High-Tech significance of FUAs in the MCR of Rhine-Ruhr in comparison to each other (Author's calculation)

The Rhine-Ruhr region as a localised system of value chains

Looking at the results of the value chain analysis, a similar picture to that of the Mega-City Region of Munich is revealed, especially in the *APS sector*. The different shades in Figure 64 show the number of value-added relations mentioned in the web survey. Obviously, the majority of business relations of APS firms in the Rhine-Ruhr region are focused on the regional and national scale: marketing and financing are highly concentrated on the regional scale; relations in the field of R&D and processing occur particularly on the national scale. All in all, 49 per cent of all business relations have been indicated as regional in scope; 37 per cent are focused on the national scale, and 9 per cent on the European scale – only 5 per cent of the value-added relations are globally aligned (see Table 50A in Appendix A). Again, geographical proximity seems to be a major driver for face-to-face interaction along the value chain. This, in turn, leads to the creation of new ideas and new knowledge in a regional context. An interviewee from a High-Tech company, for example, explains the interdependence between face-to-face communication and knowledge creation as follows:

> *"Direct face-to-face interaction enables a common understanding in the problem-solving process to be developed (…). This is an interactive process based on people who can share and communicate their thoughts immediately (…). All those involved take something for themselves, transform it and, by so doing, generate new knowledge and skills." (High-Tech firm, Giessen, 05.10.2010).*

This statement shows that even though skills and experience are highly individual, knowledge creation is a collective process. Specialised activities along the value chain require an increase in information exchange. New knowledge is created through interaction among individuals and organisations and through interactive processes of interpreting and transforming existing knowledge within a specific context. Knowledge is not only an individual asset, but also a context-specific and collective resource (Nonaka et al. 2000).

In the *High-Tech sector*, the business relations along the value chain show a relatively strong national orientation (see Figure 65). Overall, 29 per cent of the value-added relations are focused on the regional, 41 per cent on the national, 17 per cent on the European and 13 per cent on the global scale (see Table 50A in Appendix A). The global orientation of sales & distribution is particularly striking. Sales and distribution units tend to be rather small and widely dispersed because they need to be as close as possible to the markets served by the firm. Dicken (2007), for example, argues that sales & distribution offices have an important function to prevent firms form making costly mistakes by misunderstanding the different consumer cultures in which they are doing business (Dicken 2007). Similarly, an interviewee from a High-Tech firm in Munich stated that sales & distribution was a key interface to consumer tastes providing important information for the innovation process. However, despite the strong global orientation of sales & distribution, nearly 70 per cent of the networking activities along the value chain still occur on the regional and national scale. Even though High-Tech production has a great industrialisation potential, the development of new High-Tech products – especially during the first innovative stage in a product's live cycle – cannot be broken down into individual modules from the beginning. The relevant information is difficult to codify and to communicate. The transmission of such product specifications within the corporate network creates increasing transaction costs. Therefore, both APS *and* High-Tech companies are forced to choose the right partners to ensure a continuous exchange of information and regular face-to-face contacts, which is only manageable through physical proximity or good international accessibility.

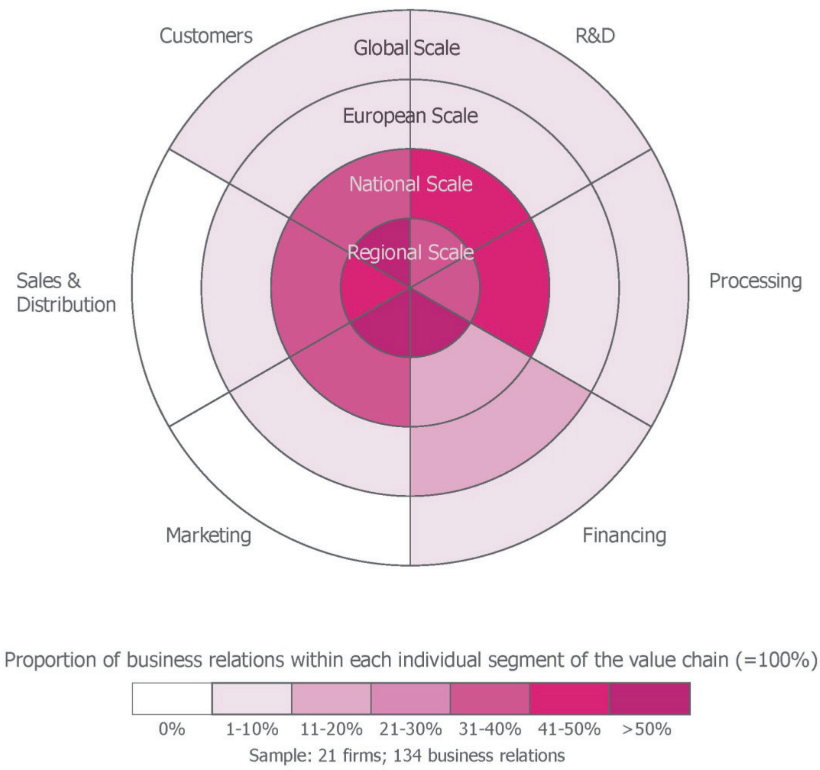


Figure 64: Value-adding relations of APS firms located in the MCR of Rhine-Ruhr (Author's calculation)

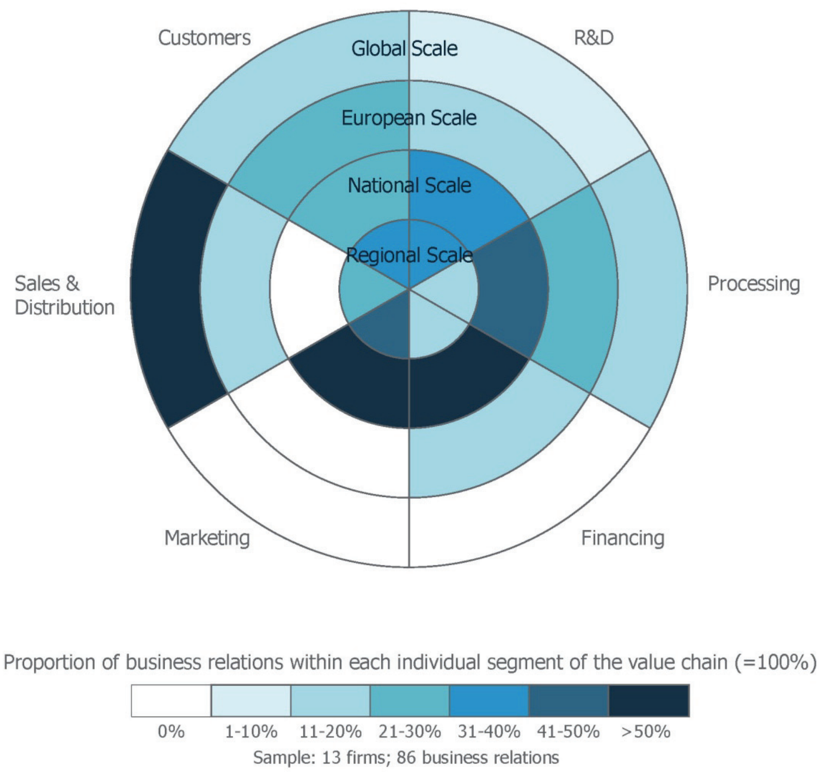


Figure 65: Value-adding relations of High-Tech firms located in the MCR of Rhine-Ruhr (Author's calculation)

To conclude, the Rhine-Ruhr region can be characterised as a highly interconnected system of value chains, which indicates strong connectivities especially on the regional and the national scales. This provides evidence for the hypothesis proposed initially, that linkages of knowledge-intensive enterprises are concentrated on an extended regional scale, leading to the emergence of polycentric Mega-City Regions in Germany (see Section 4.3). The interlocking network analysis based on intra-firm networks of multi-branch enterprises shows that Düsseldorf acts as the primary FUA in the Rhine-Ruhr region and constitutes a key gateway for global, national and regional networks of the knowledge economy. In contrast to the Mega-City Region of Munich, Rhine-Ruhr is a highly *polycentric* Mega-City Region, not only in morphological but also in relational terms: the functional relations within Rhine-Ruhr are not directed towards one specific centre; rather, they are tangential and criss-cross. Knapp et al. (2006a) confirm this picture of a remarkable functional polycentricity with respect to both commuting patterns and self-containment, at least in most parts of the Rhine-Ruhr region (Knapp et al. 2006a). In terms of business relations along the value chain, the majority of business activities of APS firms are also focused on the regional scale, especially those requiring high-level knowledge such as marketing or financing. In the High-Tech sector, however, most value-added activities are distributed over the national scale, which again shows the role of cultural and institutional proximity as important determinant for the locational strategies of knowledge-intensive firms. The geographical proximity of related APS and High-Tech companies in the Rhine-Ruhr region provides many opportunities for information flows and technical interchange (Boschma and Iammarino 2009). Sophisticated High-Tech companies in the Ruhr area need easy access to knowledge-intensive services in Düsseldorf and Cologne. At the same time, APS firms in Düsseldorf need proximity to their customers in the Ruhr area in order to be aware of the current problems of their industry partners. This functional interdependence suggests that the FUAs along the Rhine and the Ruhr should not be seen as two separate city-regions, but as one polycentric Mega-City Region with an enormous potential to develop economic strength from functional division of labour. The same conclusion is drawn by Blotevogel and Schulze (2010) arguing that – from an analytical point of view – there are many arguments for merging the Ruhr area and the Rhine axis into one polycentric Mega-City Regions (Blotevogel and Schulze 2010). Therefore, it will be important for policy-makers to support these functional linkages by providing high-quality physical infrastructures in order to ensure regional and international accessibility (see Chapter 10). The FUAs in the Rhine-Ruhr region will only be able to compete successfully for global investments, talents and attention if they overcome their notorious political rivalry.

7.3.4 The Upper Rhine region

The last example for analysing interlocking networks and functional urban hierarchies on a regional scale is the cross-border metropolitan region of the Upper Rhine. We chose the Upper Rhine region for two reasons: firstly, because we want to test how national borders affect the functional networks of the knowledge economy; and secondly, because the Upper Rhine region has an economic performance that is well above the overall West European average (BAK 2006), which makes it a particularly interesting case study. The Upper Rhine region – defined as the mandated territory of the Upper Rhine Conference – extends into the three countries of France, Germany and Switzerland. On the French side, it includes the whole of the Alsace region, which is divided into the Haut-Rhin and Bas-Rhin *départements.* On the German side, the region covers the western part of the Federal State of Baden-Württemberg and the southern part of Rhineland-Palatinate. On the Swiss side, the Upper

Rhine region includes the cantons of Basel-Stadt, Basel-Land, Solothurn, Jura and Aargau. In 2006 this region had a population of almost 5.9 million over a total area of 21,500 km^2 (Oberrheinkonferenz 2008).

Table 6: Facts and figures about the Upper Rhine region (Oberrheinkonferenz 2008)

	Area (km^2)	**Population Development 1990-2006 (%)**	**GDP Development 1992-2005 (1992=100)**	**Employment (in 1'000)**
Alsace	8,281	+11	145.2	728
Northwest Switzerland	3,588	+9	175.3	684
Southern Palatinate	1,512	+11	136.4	118
Baden	8,128	+11	136.9	1,226

Between 1990 and 2006, the population of the Upper Rhine region increased by more than 560,000, which corresponds to 10.6 per cent growth. This development was practically identical (+11%) in the French and German regions; it was somewhat lower in northern Switzerland (+9%) (see Table 6). The increase in population was mainly the result of immigration. According to current forecasts, the population of the Upper Rhine region is set to increase to around 6.1 million by 2020, an increase of a little more than 3 per cent on 2006. The most dynamic development is forecast to be in Alsace with a rise of around 10 per cent. In the other subregions, the population growth may fall dramatically or even turn out to be negative (Oberrheinkonferenz 2008). The economic affluence – measured in terms of the gross domestic product per head of population – differs widely between the individual subregions. In 2005, northern Switzerland had a national income of EUR 36,600 per head of population. The GDP of Baden was EUR 29,300, followed by Alsace with EUR 25,800 and Southern Palatinate with EUR 23,100 per head of population. In 2006 the Upper Rhine region had an economically active population of some 2.9 million, of whom around 2.8 million were in work. Around 90,000 workers commuted within the Upper Rhine region and to the neighbouring foreign countries. The largest flows of commuters are from Alsace to Northern Switzerland (approx. 35%), from Baden to Northern Switzerland (approx. 31%) and from Alsace to Baden (28%) (Oberrheinkonferenz 2008).

Connectivity patterns in the Upper Rhine region

Figure 66 shows the connectivity patterns in the Upper Rhine region as demonstrated by the intra-firm networks of *APS companies*. The area examined is defined by all the FUAs which have their centres within the area of the Upper Rhine Conference. In addition, the four large neighbouring agglomerations of Luxembourg, Frankfurt, Stuttgart and Zurich were included in the analysis. The connections with Zurich are counted as intra-regional, as the FUA is seamlessly connected to the Upper Rhine region. The connections with Luxembourg, Frankfurt and Stuttgart are counted as outward connectivities. These are shown in the form of curves, in order to show the differences between intra-regional and extra-regional connectivities more clearly. Only connectivities greater than 0.5 in comparison with the Zurich-Basel connection (=1.0) – the strongest intra-regional connection – are shown.

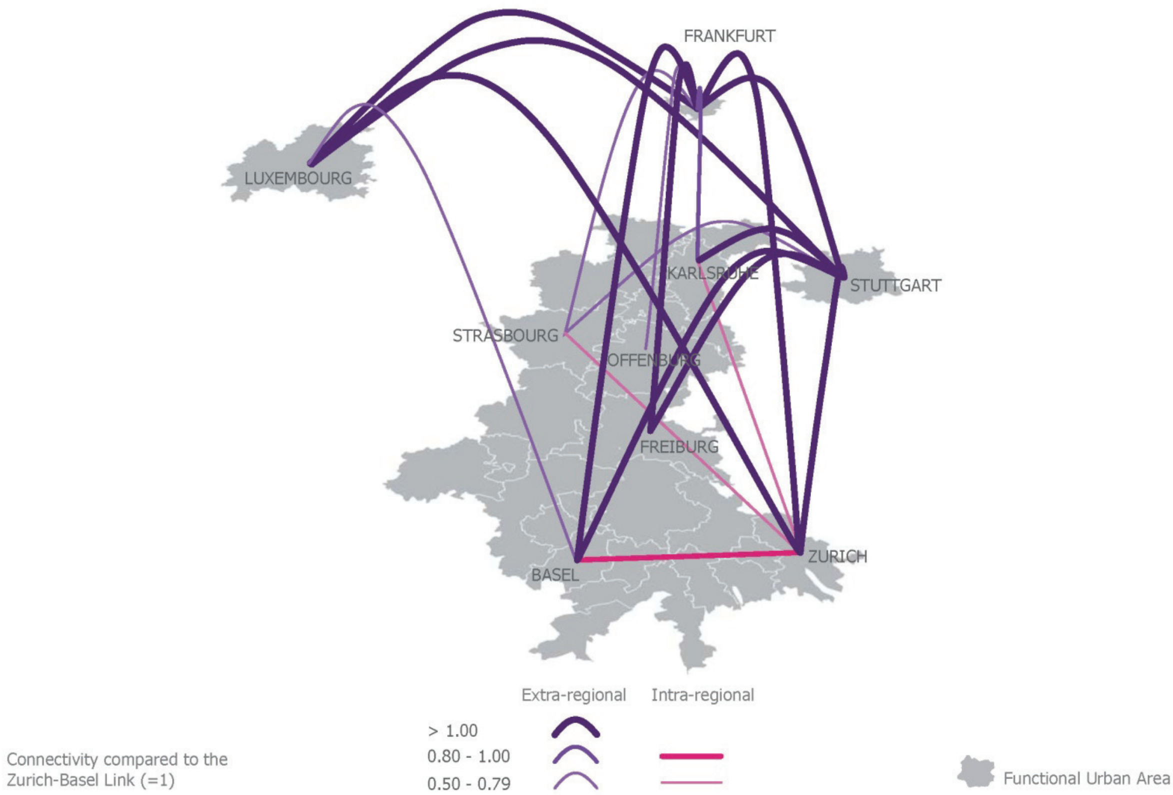


Figure 66: Intra-firm networks of APS firms in the Upper Rhine region
(Author's calculation; visualization: Anne Wiese)

It is striking that the majority of intra-firm networks of APS companies are with the large agglomerations of Luxembourg, Frankfurt, Stuttgart and Zurich. Basel, Karlsruhe, Freiburg and Strasbourg are, in particular, intensively linked with these neighbouring centres. The largest intra-regional connectivity is between Basel and Zurich. These two apparently competing agglomerations are seen in reality to be economically closely connected. Basel has an infrastructure for obtaining knowledge of similar quality to that of Zurich: for example, Basel is dominated by globally-operating pharmaceutical and chemicals companies. But this does not mean that Basel and Zurich are opposed. Rather, they work together to form the central economic backbone of the Mega-City Region of Northern Switzerland (Behrendt and Kruse 2001; Thierstein et al. 2006). The two German agglomerations of Karlsruhe and Freiburg, on the other hand, are relatively closely connected with Frankfurt and Stuttgart. These networks are formed above all by local branches of financial service providers and insurance companies with a retail presence in the Upper Rhine region. The connections between Karlsruhe and Zurich are for the most part formed by financial service providers. Strasbourg, finally, has a special role within the Upper Rhine region from a political perspective: as the seat of the European Parliament, the city is home to a central EU institution. It is also the seat of the Council of Europe and the location of the European Court of Human Rights, which means that its political influence as a European capital extends far beyond the borders of the EU. Strasbourg is well-linked by intra-firm networks of APS companies with Frankfurt, Stuttgart and Zurich. The connections with Frankfurt and Stuttgart, however, are less pronounced than those of the two German FUAs of Karlsruhe and Freiburg. Obviously, in the APS sector, the national borders within the Upper Rhine region still appear to have some inhibiting effects in doing cross-border business.

Our APS company records show that the Upper Rhine region has a particular strength in the logistics sector. The region's good accessibility and its central location in Europe have led over time to a dense locational network of high-performing logistics companies. Of a total of 30 logistics companies investigated, 20 have a location in the Upper Rhine region; most of these are relatively significant branches with a service value of 3 or more. Panalpina – a major transport and logistics service provider – has its headquarters in Basel. Hence, a large percentage of the global APS connectivity in the Upper Rhine region is formed by knowledge-intensive logistics service providers. Basel, for example, is ranked 15 in our global 'logistics network connectivity' ranking (see Table 62A in Appendix A). A major reason for this high performance in the logistics sector stems from the fact that the Upper Rhine region has a well-developed transport infrastructure (see BAK 2006). Firstly, it has excellent rail connections with the trans-European rail network, a central feature being north-south traffic, in particular the stretch of the Hamburg-Frankfurt-Basel-Milan railway. The expansion of the European west-east Paris-Munich-Vienna-Budapest route will ensure the future position of the Upper Rhine region as an important hub of the European rail network. Secondly, its location on the Rhine gives it a substantial role in inland waterways shipping. The harbours are centres for combined transport, linking the Upper Rhine region with the North Sea ports of Rotterdam and Antwerp. Last but not least, the Upper Rhine region has five airports, with the Basel-Mulhouse-Freiburg EuroAirport being the most important transport intersection. This airport may not be an international hub. But some of the individual sub-regions in the Upper Rhine benefit from geographical proximity to the international hub airports in Frankfurt, Paris and Zurich. The FUA of Karlsruhe's proximity to the Frankfurt airport, for example, gives it the best inter-continental accessibility in the Upper Rhine region – ahead of Basel, Strasbourg and Freiburg (BAK 2006).

Figure 67 shows the interconnections of the Upper Rhine region as demonstrated by the intra-firm networks of *High-Tech companies*. The chemical-pharmaceutical industry makes a strong contribution – about 6 per cent – to the GDP of the Upper Rhine region (see BAK 2006). Two important global pharmaceutical companies, Novartis and Roche, have their headquarters in Basel. Viewed historically, the economic structures of the region grew out of textile dyeing and later the chemical and pharmaceutical industries, which complemented each other very well. The chemical and pharmaceutical industry has a high productivity per man-hour and considerable net-product growth. In the Basel agglomeration in particular, it plays a key role in regional economic growth. In the French and German Upper Rhine region, on the other hand, the focus is more on the supply sector, for example in the mechanical engineering and automotive sectors as well as medical technology (BAK 2006). As our High-Tech company records show, a number of intra-firm networks allow potential positive effects of these sectors to reach the other areas of the Upper Rhine region. For example, mechanical engineering companies such as SEW Eurodrive and the Schäffler Group, and pharmaceutical companies such as BASF and Novartis have several locations distributed all over the Upper Rhine region.

Despite this spatial concentration of many complementary economic sectors, the strong intra-firm networking of the Upper Rhine region with Frankfurt, Stuttgart and Zurich shown in Figure 67 is striking. The most intensive intra-regional connections are between Basel and Zurich. This connection is established mainly through companies in the computer hardware and electronics sectors. This shows that these two FUAs complement one another well from a functional point of view.

Information and telecommunication is the most significant High-Tech sector in Zurich. Particular reference should be made to IBM, which operates a significant research laboratory in the Zurich agglomeration. Since 2004, Google has also had its European research centre in Zurich, one of the company's largest site after Mountain View (NZZ 2007). Of a total of 30 companies examined in the computer hardware sector, 13 have a site in Zurich. As an interdisciplinary technology, the IT sector in Zurich provides an important service for the Upper Rhine region's life science companies, which illustrates the complementary functions of Zurich and Basel as specialised agglomerations in Northern Switzerland.

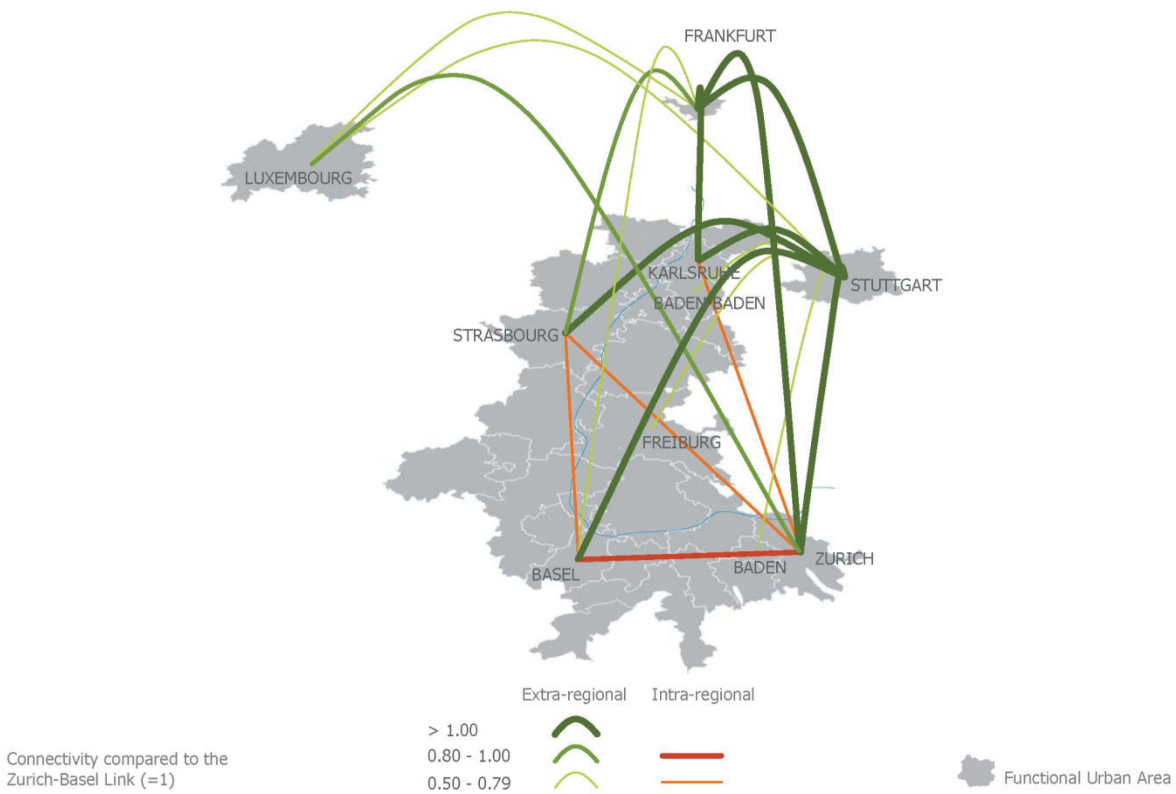


Figure 67: Intra-firm networks of High-Tech firms in the Upper Rhine region
(Author's calculation; visualization: Anne Wiese)

The connectivity pattern in the Upper Rhine region has also been examined by means of social network analysis. The following Figures show the networking structure in the Upper Rhine region and all adjacent FUAs. Here, too, large neighbouring centres were incorporated into the analysis – Frankfurt, Stuttgart, Zurich, Nancy, Metz and Luxembourg. As in the cases of Munich and Rhine-Ruhr, the Figures show two different types of graphs. On one side, the FUAs are positioned in their precise geographical location, so that the graph represents the geographical proximity between the individual agglomerations. The graph on the other side shows the relational proximity between the individual FUAs: the more closely connected the FUAs are to one another, the closer they are positioned in relation to one another. The Figures show only those connections which represent a city-interlock greater than 2.5 per cent of the strongest connection in the whole of the available records (Munich-Hamburg = 100 per cent). The major neighbouring agglomerations of the Upper

Rhine region – Frankfurt, Stuttgart, Zurich, Nancy, Metz and Luxembourg – are shown slightly larger to facilitate orientation when comparing geographical and relational proximity.

Regarding the *APS sector*, Figure 68 confirms that Zürich, Frankfurt and Stuttgart are very intensively networked with the Upper Rhine region through advanced activities of knowledge-intensive services firms. Together, they form the centre of the relational map. In a second ring around this centre are the FUAs of Basel, Luxembourg, Mannheim and Heilbronn. The remaining major centres of the Upper Rhine region – Strasbourg, Freiburg, Offenburg and Karlsruhe – only appear in the third ring. The relational map for the *High-Tech sector*, on the other hand, looks quite different (see Figure 69). Stuttgart can be seen here to be the central hub. A second ring contains Zurich, Frankfurt, Mannheim, Heilbronn, Villingen-Schwenningen and Karlsruhe, with Karlsruhe as the only FUA in the official Upper Rhine Conference region. Other major agglomerations of the Upper Rhine region – such as Basel, Strasbourg and Freiburg – do not appear until the third ring.

All in all, the interlocking network analysis shows that the Upper Rhine region is highly interconnected with its large neighbouring FUAs: Stuttgart, Frankfurt and Zurich. This finding is the result of the companies' internal locational choice. Globally-oriented APS firms choose their locations mostly within core agglomerations of Mega-City Regions. Thereby, they connect these places directly with other core agglomerations in the world, or vice versa: they disconnect core FUAs from their broader hinterlands. In this sense, Figure 68 and 69 can be interpreted as visual representations of what Sassen (2001b) calls a specific "form of centrality": "…we are seeing the formation of a transterritorial 'center' constituted, partly in digital space, via intense economic transactions in the network of global cities. These networks of major international business centers constitute new geographies of centrality. The most powerful of these new geographies at the global level binds the major international financial and business centers (…). The intensity of transactions among these cities, particularly through the financial markets, trade in services, and investment has increased sharply… At the same time, there has been a sharpening inequality in the concentration of strategic resources and activities between each of these cities and others in the same country, a condition that further underlines the extent to which this is a cross-border space of centrality" (Sassen 2001b:124p). This specific type of centrality, however, does not mean that there is no functional networking within the Upper Rhine region itself. Information exchange and business activities do not only arise through intra-firm office networks, but also from extra-firm networks along the value chain. To what extent such value-adding networks are concentrated in the Upper Rhine region still has to be clarified. Some studies provide evidence that the Upper Rhine region forms one of the largest life science units in Europe (BAK 2006). In any case, our interlocking network analysis provides evidence that intra-firm networks of the knowledge economy are overlapping at varying length and reach. Connectivities to higher-order FUAs in the functional urban hierarchy have to be understood as complementary relations to intra-regional activities along the value chain.

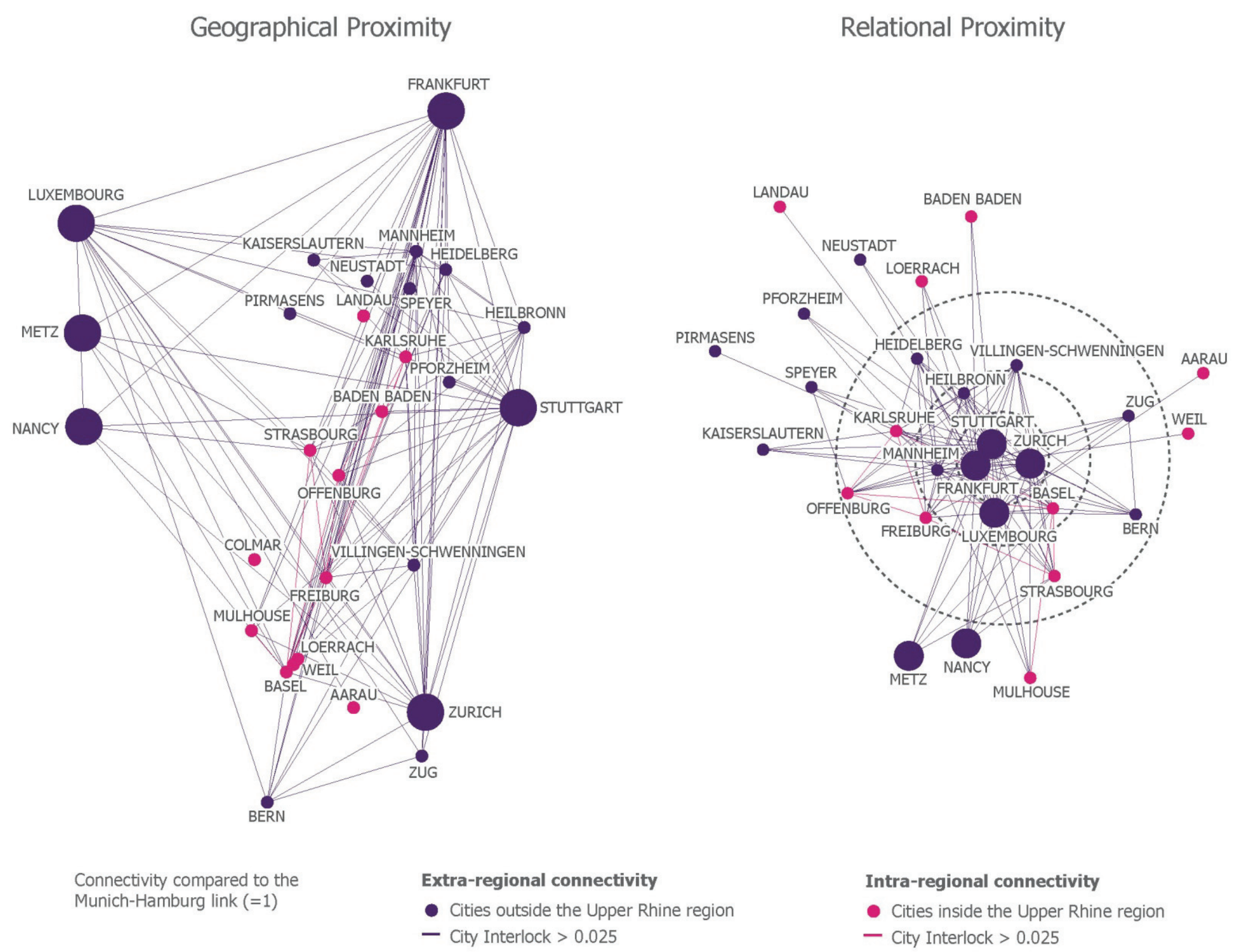


Figure 68: Geographical vs. relational proximity of APS firms in the Upper Rhine region
(Author's calculation; visualization: Anne Wiese, Michael Bentlage)

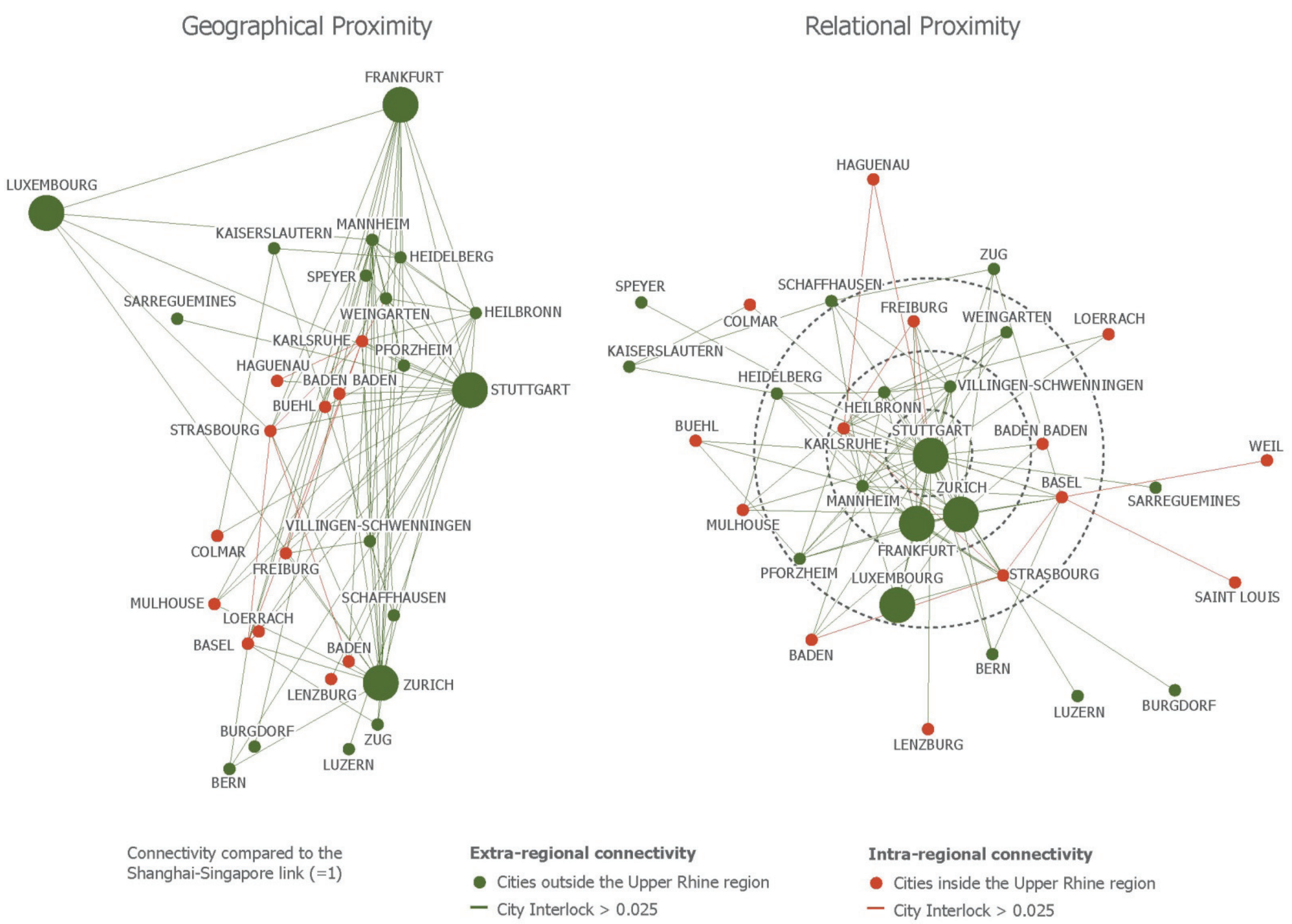


Figure 69: Geographical vs. relational proximity of High-Tech firms in the Upper Rhine region (Author’s calculation; visualization: Anne Wiese, Michael Bentlage)

Hierarchical spatial patterns in the Upper Rhine region

If the total interlock connectivity of the FUAs is viewed in perspective with their absolute sizes – as measured by the sum of the population and jobs – the significance of the FUAs with relation to their connectivity can be better assessed. At this point I should mention that the selection of the FUAs in the cross boarder metropolitan region around Basel can be brought into question. In fact, the selected FUAs – Basel, Saint Louis, Lörrach, Weil and Liestal – are functionally highly interdependent (Oberrheinkonferenz 2008). In this study, the selection of the FUAs corresponds to the definition applied in the ESPON research project 111 (see Section 5.3). This definition is based on the expertise of national experts leading to a certain national bias in the selection of FUAs: cross border metropolitan regions tend to have too many FUAs, because each expert selected them according to the statistical data available in the corresponding country without adaption to cross-border urban configurations. Nevertheless, keeping this restriction in mind, Figure 70 compares the significance between the 15 FUAs in the Upper Rhine Conference region, which are most strongly integrated into the intra-firm knowledge networks of *APS companies*. The black rings illustrate the total of population and employment. The FUA of Strasbourg has the most inhabitants and people in work, ahead of Freiburg, Karlsruhe and Basel. Basel has the top position with regard to the total interlock connectivity – shown by the pink circles – ahead of Strasbourg and Freiburg. If these two indicators are superimposed, it becomes clear that Basel records by far the greatest surplus of significance. Globally-networked, knowledge-intensive service providers appear in above-average concentration at the FUA of Basel. In addition to Basel, Aarau also shows a significantly large surplus of significance. Aarau's strategically favourable position between the intensively-networked centres of Zurich and Basel appears to have a positive effect on its global network connectivity. This shows that smaller sub-centres in Northern Switzerland – with its dense population and well-developed transport infrastructure – are in a good position to complement major centres such as Zurich and Basel. The outstanding transport infrastructure enables national and regional markets to be very well-supplied from smaller centres such as Aarau. Also, small agglomerations offer favourable conditions such as good availability of cheaper building land, low location costs and fast connections to the motorways (Thierstein et al. 2006). All these factors lead to the fact that Aarau indicates a considerable surplus of significance, although it is relatively small in terms of inhabitants and jobs.

Figure 71 shows the 15 FUAs in the Upper Rhine region, which are most strongly integrated into the intra-firm networks of *High-Tech companies*. In comparison with the APS sector, the agglomerations of Weingarten (roughly corresponding to the Landkreis of Karlsruhe), Haguenau, Saint-Louis and Baden have found their way into the top 15, taking the place of Offenburg, Liestal, Brugg and Aarau. In the High-Tech sector, significantly more FUAs have a surplus of significance than in the APS sector. This indicates that High-Tech companies are not necessarily concentrated in a few highly-urbanised centres, but are distributed over the whole polycentric city-region resulting from a process of "concentrated de-concentration" (Hall and Pain 2006). Saint-Louis has the largest surplus of significance, followed by Baden and Basel (see also Table 54A in Appendix A). Saint-Louis is immediately adjacent to the EuroAirport of Basel-Mulhouse-Freiburg. In fact, it is located along the axis between Basel city and the airport. Once more, an FUA in the immediate vicinity of an airport is shown to be a significant location for knowledge-intensive firms. The same phenomenon is apparent in the Mega-City Region of Munich with the FUA of Freising (see Section 7.3.1), and in the Rhine-Main metropolitan area with the FUA of Rüsselsheim (Lüthi et al. 2010a).

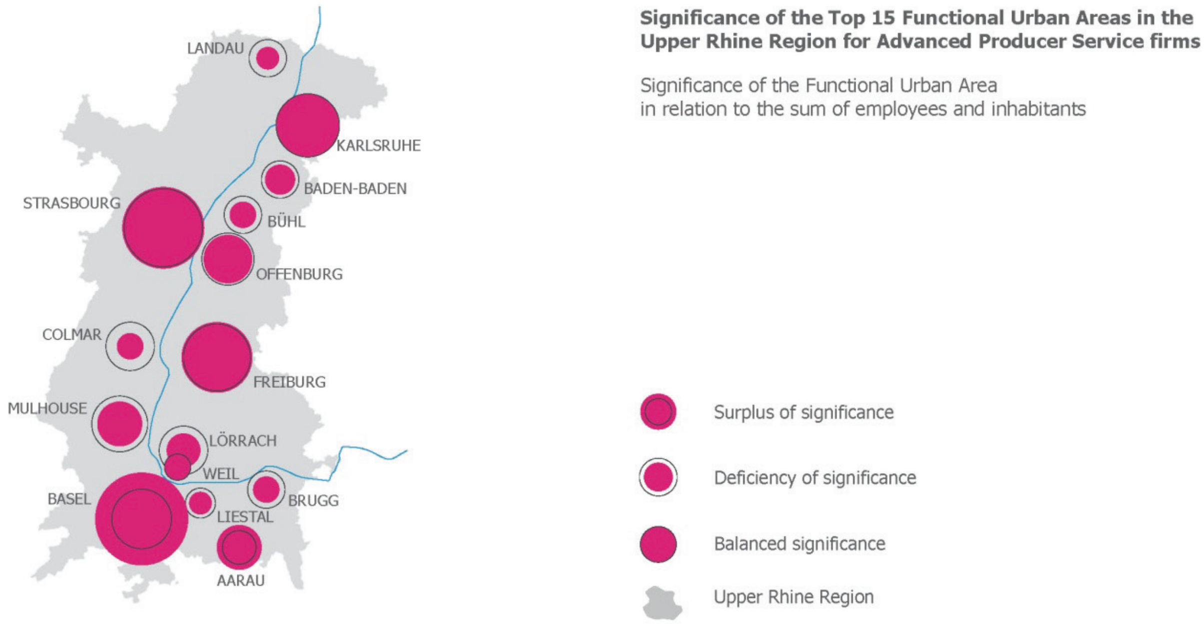


Figure 70: APS significance of FUAs in the Upper Rhine region in comparison to each other (Author's calculation)

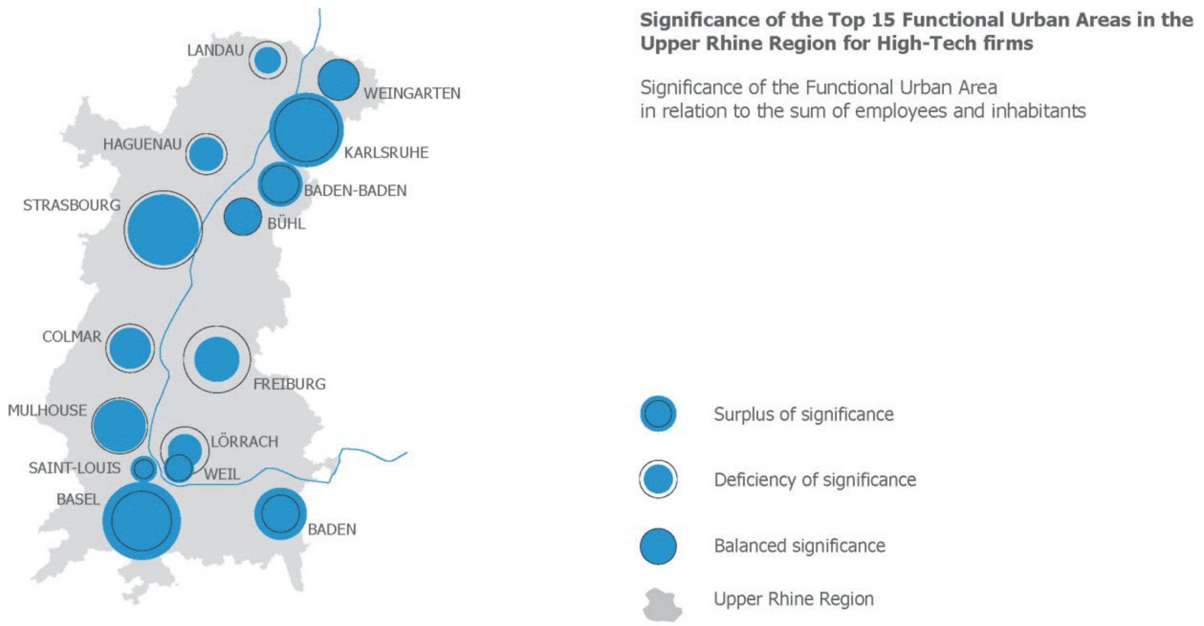


Figure 71: High-Tech significance of FUAs in the Upper Rhine region in comparison to each other (Author's calculation)

The situation of Baden can be assessed similarly to that of Aarau in the APS sector. Baden is located in a strategically good location between Basel and Zurich, the two most important economic centres of Northern Switzerland. This FUA is in the densely-populated Limmat valley, about 20 km to the north-west of Zurich. As the place where the company of Brown, Boveri & Cie. (now Asea Brown Boveri, ABB) was founded, Baden has an important industrial history. The headquarters of the Swiss-Swedish ABB electronics group is now located in Zurich, although the headquarters of ABB Schweiz AG is still located in Baden (ABB 2009). Since the sale of the ABB power plant division, the French Alstom now represents another international group based in Baden (Alstom 2010). With sites worldwide, Alstom and ABB make up a large percentage of the connectivity of the Baden FUA.

A second important High-Tech cluster in the Upper Rhine region is formed by the axis between Karlsruhe and Baden-Baden. The Siemens AG, for example, has one of its largest German sites at Karlsruhe (Siemens AG 2010). Further significant companies come from the IT sector (e.g. IBM) and the chemical and pharmaceutical industry. In this context, mention should also be made of the Karlsruhe Institute of Technology (KIT), which resulted from a merger of the University of Karlsruhe and the Karlsruhe Research Centre. The KIT enjoys an excellent reputation in subject areas such as physics, mechanical engineering, structural engineering, IT and electrical engineering and is one of Germany's Universities of Excellence (KIT 2009). This example shows that high-quality establishments for the creation of new knowledge are important centres of attraction for globally-active, knowledge-intensive firms, and therefore make a crucial contribution to the global connectivity of cities and agglomerations.

Overall, the Upper Rhine Region can be seen to be a strategically well-positioned economic area with clear strengths in value-added intensive sectors of industry such as chemicals and pharmaceuticals. The relatively modest number of headquarters in the APS sector is compensated for by intensive networking with FUAs such as Zurich and Frankfurt. The greatest intra-regional connectivity in both the APS and High-Tech sectors is between Basel and Zurich, which underlines the close functional networking between these two agglomerations in densely-populated Northern Switzerland. Regarding the functional urban hierarchy in the Upper Rhine region, Basel is shown to be the main centre for APS activities. High-Tech companies, on the other hand, are distributed more evenly over several parts of the region, especially in Northern Switzerland and Southern Palatinate. Viewing the total connectivity of the FUAs in perspective with the sum of their population and employment figures once again brings to light the major significance of strategic alternative locations such as Saint Louis, which is located in immediate vicinity to the Basel airport, or Aarau and Baden, which are located in the wider metropolitan orbit of Zurich and Basel, the two main economic centres in Northern Switzerland.

Part 4: Conclusion

8. Synthesis of the findings

The aim of this chapter is to produce a synthesis of the study and to sharpen the main research findings. To this end, we outline once again the main research perspective: the starting point of the approach was the functional logic of the knowledge economy. When looking at its value-creation activities, it becomes obvious that these processes follow a functional and networked logic between independent as well as interdependent institutions throughout the value chain. Through the analysis of the intra-firm and extra-firm locational networks of knowledge-intensive companies, we identified functional connectivity patterns, urban hierarchies and localised systems of value chains. These quantitative findings were supplemented by face-to-face interviews with the managing directors of knowledge-intensive firms. By using these research methods we did not consider geography first, but started with the locational behaviour of multi-branch, multi-location enterprises. Based on this information, the nature and geographical scope of intra-firm and extra-firm networks were evaluated with regard to the question of how these networks interconnect German agglomerations to the world city network. The analysis has been made from different angles. On the one hand, we explored the connectivity patterns on different spatial scales: global, national and regional. On the other hand, we distinguished between High-Tech and APS companies in order to reveal the functional and spatial differences between the two main pillars of the knowledge economy.

8.1 Answering the hypotheses

On the basis of the three hypotheses formulated initially and their empirical and theoretical elaboration, the following conclusions can be drawn.

Hypothesis 1: A multiplicity of high-grade APS and High-Tech locations creates interlinkages between cities and towns on an extended regional scale, leading to a new spatial phenomenon in Germany: polycentric Mega-City Regions.

The spatial pattern of intra-firm and extra-firm networks in the German space economy provides evidence that knowledge networks are particularly concentrated in the wider metropolitan orbit of the most internationally connected German agglomerations, forming what might be characterised as functional mergers of cities in polycentric Mega-City Regions (Hall and Pain 2006). This confirms Hall's (2009) assumption that "the more… central core cities succeed in the global economy, the more they will tend to irrigate the growth of other cities in their localities. Hence…, the development of polycentric Mega-City Regions around these principal cities" (Hall 2009:807). In this study, the Greater Munich area, the Rhine-Ruhr region and the cross-border metropolitan region of the Upper Rhine have been analysed in greater detail. In the following, we shall summarise the main findings of these three case studies and put them into the context of the knowledge economy.

Mega-City Region of Munich: The interlocking network analysis indicated that the Greater Munich area can be understood as a functionally-monocentric and hierarchically-organised Mega-City Region, in which intra-firm linkages of APS and High-Tech firms are concentrated to a considerable extent. In relational terms, the core of the Mega-City Region is clearly formed by the FUA of Munich. The axes between Munich and Augsburg as well as between Munich and Regensburg show the highest intra-firm connectivity. This confirms previous studies, showing that Regensburg is functionally more closely networked with Munich than with Nuremberg, although the latter is geographically closer to Regensburg (Thierstein et al. 2007; Lüthi et al. 2010b). In general, the intra-firm analysis reveals an urban core network – composed by the FUAs of Munich, Augsburg, Regensburg and Ulm – and an extended regional city network, which includes additional agglomerations depending on whether APS or High-Tech networks are analysed. In the APS sector, for example, the FUA of Kempten indicates surprisingly high regional city-interlocks, too. In the High-Tech sector, on the other hand, Heidenheim emerges as hidden centres rendering unexpected services to the High-Tech networks in the Mega-City Region of Munich.

Similarly, the analysis based on business relations along the value chain shows that knowledge-intensive firms in the Greater Munich area source the largest part of their value-added services on the regional scale, i.e. within the Mega-City Region of Munich. In the APS sector, 54 per cent of all business relations are concentrated on the regional scale; 40 per cent are focused on the national, and 6 per cent on the European scale – less than 1 per cent of the value-added relations mentioned in the web survey are globally oriented. In the High-Tech sector, on the other hand, 35 per cent of all value-added relations are focused on the regional and also on the national scale; 18 per cent are directed towards the European, and 12 per cent towards the global scale. The most frequent regional business relations in both the APS and the High-Tech sectors are in marketing and financing, which indicates that these services assume an important role as entrepreneurial support network within the Mega-City Region of Munich. These findings confirm Jähnke and Wolke's (2005) conclusion that – in Greater Munich – regional and national supplier relations dominate over international ones (Jähnke and Wolke 2005).

All in all, the regional patterns of the intra-firm and extra-firm business networks in the Mega-City Region of Munich underline that geographical proximity still tends to plays a central role in the locational strategies of knowledge-intensive firms. Companies faced with international competition choose their locations in dense and diverse labour markets, which brings together high-level demand with high-quality supply (Porter 1990). Knowledge about institutional and cultural peculiarities – for example about the existing regulative system – as well as language skills and trust facilitate this matching process and increases the efficiency of the localised system of value chains. In fact, it is the complementary combination of Munich and the surrounding secondary FUAs that lifts the entire Mega-City Region into a competitive position in the global economy. The combination of the urbanisation externalities of the Munich FUA – which provides critical mass in terms of economic density and diversity – and the complementary integration of the secondary centres around Munich – characterised by strong localisation economies – leads to an effective and economically powerful urban configuration. The airport FUA of Freising, for example, is emerging as a highly significant APS centre, whereas other secondary FUAs – such as Ingolstadt – provide specialised knowledge from the High-Tech sector. These agglomerations provide local expertise and specialised skills, which are highly beneficial for the Mega-City Region as a whole. However, as the considerable extent of *global* connectivity in the High-Tech sector shows, the Mega-City Region of Munich cannot be regarded as a self-sustaining urban system. It is the interplay between agglomeration economies and global network economies that define the Mega-City Region of Munich as an important node in the functional networks of the knowledge economy.

Mega-City Region of Rhine-Ruhr: In contrast to the Mega-City Region of Munich, the interlocking network analysis based on intra-firm networks shows that Rhine-Ruhr is a highly *polycentric* Mega-City Region, not only in morphological but also in relational terms: the functional relations within Rhine-Ruhr are not directed towards one specific centre; rather, they are tangential and criss-cross. This confirms the finding of Knapp et al. (2006a), which indicates a remarkable functional polycentricity in Rhine-Ruhr with respect to both commuting patterns and self-containment (Knapp et al. 2006a). This also provides clear evidence for the hypothesis proposed initially, that linkages of knowledge-intensive enterprises are strongly concentrated on an extended regional scale, forming what might be characterised as functionally polycentric Mega-City Region. The interlocking network analysis identifies Düsseldorf as the main gateway, not only for global and national networks, but also for regional networks of the knowledge economy. In the APS sector, Düsseldorf, Dortmund and Cologne create a highly connected city triad forming a kind of functional bridge between the Ruhr area and the Rhine axis. In the High-Tech sector, the connectivity between Düsseldorf and Bochum stands out as an important dyad connecting the FUAs in the Ruhr area with the agglomerations along the Rhine.

In terms of the business relations along the value chain, Rhine-Ruhr emerges as a highly interconnected value-added system with strong relations on the regional and the national scale. In the APS sector, the majority of business relations are focused on the regional scale, especially those requiring high-level knowledge such as marketing or financing. Overall, 49 per cent of all the value-added relations in the APS sector are focused on the regional, 37 per cent on the national, 9 per cent on the European and only 5 per cent on the global scale. In the High-Tech sector, by contrast, the business relations show a relatively strong national orientation: 29 per cent of the value-added relations stated in the web survey by Rhine-Ruhr-based companies are concentrated on the regional, 41 per cent on the national, 17 per cent on the European and 13 per cent on the global scale. The most part of the *global* relations is based on sales & distribution, reflecting the fact that these activities have an important function to prevent firms from making costly mistakes by misinterpreting different consumer cultures (Dicken 2007). However, despite the strong global orientation of sales & distribution, the most part of the networking activities along the value chain still occur on the regional and national scale. Obviously, the development of new High-Tech products still requires geographical and institutional proximity, which provides many opportunities for information flows and therefore facilitates technical interchange between the various business partners along the value chain (Boschma and Iammarino 2009).

All in all, the strong connectivity within the Rhine-Ruhr region is the result of a distinctive functional and geographical specialisation. Sophisticated High-Tech companies in the Ruhr area and knowledge-intensive services in Düsseldorf and Cologne are highly intertwined partners in a complex system of value chains, making the whole region a potential laboratory of knowledge creation and innovation. In fact, these two seemingly competing urban regions prove to be economically closely interrelated. Thus, the FUAs along the Rhine and the Ruhr should not be seen as two separate city-regions, but as one polycentric Mega-City Region with an enormous potential to develop economic strength from functional division of labor. From a political point of view, however, the merger of the Ruhr area and the Rhine axis is a difficult task, since this would require that the different sub-regions in Rhine-Ruhr have to overcome their notorious political rivalry (Blotevogel and Schulze 2010).

Upper Rhine region: The third example for analysing interlocking firm network on a regional scale was the cross-border metropolitan region of the Upper Rhine, defined as the mandated territory of the Upper Rhine Conference, which extends into the three countries of France, Germany and Switzerland. The Upper Rhine region indicates an economic performance that is well above the overall West European average. It is a strategically well-positioned economic area with clear strengths in intensively value-added sectors of industry such as chemicals and pharmaceuticals (BAK 2006).

The interlocking network analysis based on *intra-firm* networks of knowledge-intensive firms shows that the Upper Rhine region is highly interconnected with its large neighbouring FUAs: Stuttgart, Frankfurt and Zurich. A considerable city-interlock in both the APS and the High-Tech sector can be observed between Basel and Zurich, which underlines the close functional networking between these two agglomerations in densely-populated Northern Switzerland. This finding confirms previous evidence showing that Basel and Zurich are highly connected in functional terms, and therefore form the central economic backbone of the Mega-City Region of Northern Switzerland (Behrendt and Kruse 2001; Thierstein et al. 2006). However, the strong city-interlocks of the FUAs in the Upper Rhine region with Zurich, Stuttgart and Frankfurt do not mean that there is no networking within the Upper Rhine region itself. Information exchange and business activities do not only arise through intra-firm office networks, but also from extra-firm networks along the value chain. It can be assumed that the more global network economies – e.g. in the form of intra-firm networks – will concentrate in core FUAs, the more agglomeration economies – e.g. in the form of extra-firm networks – will pass on the growth to other agglomerations in their vicinity (Hall 2009).

In conclusion, although these three case studies – the Greater Munich area, the Rhine-Ruhr region and the Upper Rhine region – provide much evidence that the networks of the knowledge economy are concentrating on an increasingly extensive geographical scale, it remains difficult to determine the boundaries of an emerging polycentric Mega-City Region exactly. They prove difficult to delineate because markets, service networks and interactions overlap and shift in a local-global nexus (Pain 2008). Drawing boundaries requires an understanding of the linkages and complementarities across industries and institutions. There is an increasing recognition, however, that such relationships are dynamic and evolve over time, spanning multiple boundaries in a variable geometry of overlapping spaces with flexible and fuzzy contours (Dicken 2007). Indeed, some fifty years ago, Ducan (1960) was pointing out that "there is no such thing as a single, uniquely defined 'region' which manifests a full spectrum of city-regional relationships" (Duncan 1960:402). Rather, functional relations in Mega-City Regions constitute a complex web of physical and non-physical flows of socioeconomic interactions, each of these creating its own spatial and functional boundaries (Pain 2008). In the case of the Mega-City Region of Munich, for example, we saw that APS and High-Tech networks create quite different relational geographies, depending on the architecture and the reach of the corresponding functional relations. Furthermore, Mega-City Regions should not be interpreted as self-contained urban systems. The emergence of functionally polycentric spatial structures can not be solely explained by the intra-regional division of labour as they develop complementarily to national and international relations along the value chain. Especially the *intra-firm* analysis based on the interlocking network model of Taylor (2004b) shows that TNCs – particularly the big ones – do not necessarily establish more than one office in a Mega-City Region. If so, they complement the 'regional' headquarter with additional smaller retail subsidiaries handling more routine and standardised information in nearby cities. As Taylor's (2004b) model implies, the potential information flow for example between a 'regional' headquarter and a small subsidiary is never as big as the flow between two 'regional' headquarters. As a consequence, the city-interlocks between the primary cities in *different* Mega-City Regions are mostly higher than between the primary and the secondary cities within *one and the same* Mega-City Region. Hence, the intra-firm network analysis tends to underestimate regional networking activities. As we saw in the analysis based on business relations along the value chain, externalised transactions – organised either through the market or in collaboration with other firms – are highly concentrated on a regional scale. TNCs tend to entre into a regional market by establishing internal office locations. Afterwards, they develop extra-firm business relations along the value chain, not only to have access to low-cost labour but also to tap specialised regional knowledge resources. In other words: they use their global intra-firm structure to benefit from network economies and organisational proximity between their office locations worldwide; at the same time, they use their various office locations to benefit from agglomeration economies and geographical proximity to specific customers and partners along the value chain.

Hypothesis 2: Global network economies create a steep functional urban hierarchy in the German space economy, in which only few agglomerations establish substantial international connectivity; in terms of national and regional connectivity, this functional urban hierarchy is less pronounced.

Our empirical analysis of the German knowledge economy shows that knowledge-intensive activities bring about a spatial concentration of connectivity to only a few urban areas. APS and High-Tech networks have a very uneven and highly concentrated geography. This leads to quite a distinct functional urban hierarchy, which proves to be different depending on whether global, national or regional linkages are considered. At this point, I would like to mention again that this hierarchy is not defined as command-and-control hierarchy in the sense of a business command structure, but as a functional urban hierarchy based on the strategic locational choice of knowledge-intensive firms and their use of cities and regions as locations of value-adding activities (see also Section 4.3).

Global scale: On the global scale, only a minority of regions tend to have the capacity to acquire high degrees of network connectivity, because these are the locations of leading-edge knowledge in highly specialised activities. The development of an orientation towards the global market in the German knowledge economy seems to be creating a functional urban hierarchy, with East Asia, Central and South America, Eastern Europe, Western Europe and Germany itself being the most important destinations for Germany-based knowledge-intensive enterprises.

East Asia: East Asia emerges as an important destination for High-Tech firms located in Germany. The chemicals, mechanical engineering and electronics sectors in particular are strongly represented in East Asia. East Asian High-Tech producers have developed their own specialised knowledge so that firms in Europe and North America can effectively exploit not only cheap labour but also increased technical expertise in East Asian countries (Borrus 2000). In fact, East Asian cities clearly catch up with North American cities in terms of global network connectivity. According to Taylor et al. (2011b), this tends to be related to the high national demand in the US itself, which has resulted in a much more nationally-oriented connectivity pattern than in other countries (Taylor et al. 2011b). Similarly, Tokyo – the traditional global city – loses ground in comparison to cities like Shanghai, Hong Kong and Singapore.

Central and South America: Beyond East Asia, there are three Central and South American cities representing important *farshoring* destinations for Germany-based High-Tech companies: Sao Paulo, Mexico City and Buenos Aires. These cities clearly show the global spread of the world city network in the High-Tech sector, especially in comparison with APS, where no South American city appears in the top 20 of the connectivity ranking. A study of the OECD (2008), for example, confirms that High-

Tech and medium High-Tech industries are on average more internationalised than service sectors, because they have a greater industrialisation and modularisation potential, whereby the various stages of the production process can be located across different sites worldwide, depending on the knowledge and the technical expertise that is required (OECD 2008).

Eastern Europe: Eastern Europe is proving to be an important *nearshoring* destination for Germany-based High-Tech companies. The opening up of Eastern Europe created both a low-cost production location for sourcing components, and the potential of a growing consumer market (Dicken 2007). But also the organisational convenience, based on cultural, institutional and geographical proximity, seems to be encouraging many German High-Tech companies to locate their offshore subsidiaries in Eastern Europe. This puts pressure on the traditional gateway position of Vienna between Western and Eastern Europe. It can be assumed that, in the course of the economic development of Eastern Europe, many firms may re-locate their offices from Vienna to other East European cities such as Budapest, Prague or Warsaw.

Western Europe: Western European cities are important destinations for APS firms located in Germany. The European Union provides an important economic framework for trans-European business activities. Especially in an export-oriented economy – such as Germany – cross-border agreements and arrangements are particularly important. At the European level, some progress in harmonisation has already been achieved leading to more legal security in trans-European business transactions (Schneck 2006). However, more flexibility for firms means also more competition between cities for innovative enterprises and talented people. Thus, with the completion of the European single market, German agglomerations no longer compete among each other alone, but increasingly also with London, Paris, Milan and other European metropolises.

Germany: Even though the European single market provides many opportunities for trans-European business activities, the national scale still seems to play an important role for APS firms located in Germany. Six German FUAs rank in the top 20 in terms of APS connectivity: Hamburg, Frankfurt, Munich, Berlin, Stuttgart and Düsseldorf. These agglomerations can be regarded as a kind of 'urban circuit' that constitutes the top of the German functional urban hierarchy (Hoyler et al. 2008b). Especially cultural and linguistic requirements as well as specific national regulations seem to be the major reasons for this regional 'focus strategy' (Porter 1990), which enables APS firms to benefit from detailed knowledge of the existing regulative system. Especially in the APS sector, an export strategy is often waived in order to reduce complexity and therefore to increase the quality of the services being offered.

National scale: On the national scale, the empirical analysis based on intra-firm networks of the knowledge economy reveals a geography of APS and High-Tech connectivity that is quite polycentric in character, especially compared with countries such as the UK or France, where economic activities are strongly concentrated in London and Paris respectively. Nevertheless, the functional-urban hierarchy in Germany has proved to be steeper than is claimed by the federal structure and the political debate on German Mega-City Regions. A maximum of six FUAs – Munich, Frankfurt, Hamburg, Düsseldorf, Stuttgart and to a lesser extent Berlin – can be regarded as important strategic nodes in the organisational networks of the German knowledge economy.

Munich: Munich has proved to be the most important High-Tech hub in the German knowledge economy. It has by far the most headquarters in the High-Tech sector, showing its significance as the leading command-and-control centre in the German space economy. Furthermore, it shows the most intense global and national High-Tech connectivity, and the strongest networking with Beijing, Hong Kong and Shanghai. This connectivity arises mainly from the many High-Tech companies which have their headquarters in Munich, from where they proactively organise their expansion into East Asian markets.

Frankfurt: Frankfurt shows a particular dominance in the APS sector. It has by far the most headquarters in banking & finance, underlining its outstanding command-and-control function in this sector. Of all the agglomerations in Germany, Frankfurt is the most integrated into the *global* circuits of APS activities. Surprisingly, in the High-Tech sector, Frankfurt shows the strongest connection to New York and London, reflecting its close post-war economic ties with the USA and Western Europe (Hoyler 2011b). This connectivity, however, is mainly formed by standard subsidiaries of large foreign companies (service value 2). In this sense, Frankfurt seems to play a rather passive role when it comes to strategic decisions in the High-Tech sector.

Düsseldorf: Düsseldorf has proved to be the most important global service centre in the Rhine-Ruhr region. Together with Munich and Frankfurt, it shows the highest connectivity to London and New York as well as to the city triangle of Beijing, Hong Kong and Shanghai. Düsseldorf seems to be well equipped in its service connections to face the challenges posed by the growing East Asian economy. However, the real strength of Düsseldorf lies in its complementary combination with the surrounding FUAs in the *Rhine-Ruhr* region. Together, they form an enormous potential for developing economic strength from functional specialisation and the geographical division of labour. If all the FUAs in the Rhine-Ruhr region are combined to form one polycentric Mega-City Region, Rhine-Ruhr clearly ranks first in terms of critical mass and global network connectivity in both the APS and the High-Tech sectors.

Hamburg: Hamburg is confirmed in its role as the primary trade and service centre of northern Germany. In the APS sector, it ranks first in terms of national network connectivity and second in terms of global network connectivity. With 164 office locations, Hamburg also ranks second – after Munich – in terms of the number of APS office locations. In the High-Tech sector, it ranks third in terms of global and national connectivity. Overall, even though Hamburg is rarely found in the first position, it is often among the top three, which illustrates its established position in the functional urban hierarchy of the German space economy.

Stuttgart: Stuttgart shows a strong High-Tech profile. After Munich, it has the second highest number of High-Tech headquarters. It also ranks second in terms of global and national High-Tech connectivity. Compared to its sheer size, it shows a clear surplus of High-Tech significance. Furthermore, it indicates a clear surplus of globalism, which shows its strong integration in the global networks of High-Tech companies. Together with Munich, Stuttgart clearly forms the main node of High-Tech competence in the German space economy.

Berlin: Berlin's position in the German functional-urban hierarchy tends to be lower than expected. Even though Berlin is the biggest German agglomeration in terms of inhabitants and jobs, and even though it has gained significantly as a location of political decision-making after unification, it demonstrates a relatively low degree of global network connectivity. Obviously, the mere size of an agglomeration does not necessarily correlate with its position in the functional urban hierarchy. Urban size is an important condition, but not the only one, for achieving a top position with regards to economic connectivity. A similar conclusion is drawn by McCann and Acs (2011), who show in a longitudinal analysis that the size of a city is now far less important for its global networking than it was in the early 20th century (McCann and Acs 2011). The reason for this deficiency of significance is mainly structural. Many knowledge-intensive firms have office locations in Berlin, but the corresponding service values are rather low. In fact, Berlin indicates a lack of headquarters in the knowledge economy, which strongly affects the degree and the quality of its global network connectivity. The main opportunity for Berlin seems to be in its attractiveness as a place of residence for highly-skilled employees and in its role as complementary business location and 'strategic window' (Kriger and Rich 1987) to the established economic command-and-control centres in Germany.

The findings revealed in the empirical analysis based on intra-firm networks are also supported by the extra-firm analysis based on value-added relations in the German space economy: Munich and Rhine-Ruhr have proved to be the top Mega-City Regions in terms of density and variety of value-added expertise, followed by Stuttgart, Hamburg and Frankfurt. In these Mega-City Regions, many elements of the value chain are strongly represented, making them to sophisticated 'regional innovation and production systems' (Crevoisier et al. 2001). Companies located in these areas are potentially able to source many elements of their value-added activities on a regional scale, especially activities requiring up-to-date knowledge. Furthermore, these regions show an outstanding strength in highly value-added activities such as R&D, financing and marketing. Thereby, companies benefit from geographical proximity to other firms who produce key inputs for their products or services. These findings confirm that for knowledge-intensive enterprises urbanisation economies are crucial: thick and diversified markets reduce uncertainty in value-adding activities, for example by facilitating employees to find the right job or for employers to find the right talent (Gan and Li 2004).

Regional scale: On the regional scale, the functional urban hierarchy has proved to be different depending on what metropolitan region – Munich, Rhine-Ruhr or Upper Rhine – or which economic sectors – APS or High-Tech – are considered.

Mega-City Region of Munich: In the Mega-City Region of Munich, the FUA of Munich clearly acts as the central knowledge hub for the whole metropolitan region, which indicates a relatively steep functional urban hierarchy. The larger the geographical scale of intra-firm networks, the higher the dominance of the Munich FUA in comparison to its surrounding secondary cities. Basically, three types of FUAs can be distinguished. Firstly, FUAs like Munich and Regensburg, which – because of their relatively large urban size – provide enough diversity and urbanisation economies to create a minimum degree of APS and High-Tech connectivity. Secondly, there are agglomerations such as Freising and Ingolstadt, which show a strong functional specialisation and therefore high network connectivity in a particular sub-sector of the knowledge economy. The airport location at Freising, for example, shows a particular strength in the APS sector, which underlines the great importance of hub airports as competitive assets for international firms in the knowledge economy. And finally, there are agglomerations such as Landshut or Garmisch-Partenkirchen, which – because of their small urban size – show a clear deficiency of significance, at least in terms of their integration into international APS and High-Tech networks.

Mega-City Region of Rhine-Ruhr: The analysis of the functional urban hierarchy in the Rhine-Ruhr region confirms the findings of previous studies (e.g. Knapp et al. 2006a): Düsseldorf acts as the primary FUA in the Rhine-Ruhr region, and not Cologne that is actually much bigger than Düsseldorf in terms of inhabitants and jobs. This also supports our previous finding that the sheer size o a FUA does not necessarily increase its economic importance. For the APS sector, Hoyler (2011a) argues that primary cities – such as Düsseldorf – create a kind of 'shadow effect', which hinders international APS firms from locating in secondary cities (Hoyler 2011a). However, in contrast to the Mega-City Region of Munich, the functional urban hierarchy in the Rhine-Ruhr region shows a more complex spatial structure based on the economic specialisation of the corresponding FUAs. Cologne, for example, shows a double specialisation: at the global level, it emerges as an important High-Tech centre with 93 per cent of Düsseldorf's global network connectivity, especially because of its globally-oriented engineering and chemical companies. At the regional level, on the other hand, it emerges as an important APS location with as much as 98 per cent of Düsseldorf's network connectivity, mainly because of its many regionally and nationally-oriented insurance companies.

Upper Rhine region: Regarding the functional urban hierarchy in the Upper Rhine region, Basel is shown to be the main FUA for APS activities. Basel indicates a particular strength in the logistics sector. Its good accessibility and its central location in Europe have led to a dense locational network of high-performing logistics companies, which benefit from a well-developed transport infrastructure by road, rail, water and air; a central feature being the intersection of the north-south (Hamburg-Frankfurt-Basel-Milan) and the west-east (Paris-Munich-Vienna-Budapest) routs in the trans-European rail network (BAK 2006). High-Tech companies, on the other hand, are distributed more evenly over several parts of the Upper Rhine region, especially in Northern Switzerland and Southern Palatinate. Viewing the total connectivity of the FUAs in perspective with the sum of their inhabitants and jobs once again confirms the major significance of strategic alternative locations such as Saint Louis, which is located immediately next to the Basel airport, or Aarau and Baden, which are located along the axis between Zurich and Basel, the main economic backbone in the Mega-City Region of Northern Switzerland (Thierstein et al. 2006).

Hypothesis 3: Knowledge-intensive firms choose their locations in order to optimise their intra-firm and extra-firm relations along the value chain and to benefit from geographical and relational proximity to suppliers, customers and knowledge resources.

The third hypothesis focused on the strategic behaviour of knowledge-intensive firms, explaining the consequences that arise for their locational decision-making. Based on a series of face-to-face interviews, six strategic business activities have been identified as most relevant in terms of locational strategies in the knowledge economy.

Finding talent: Finding talent is one of the most important locational factors in the knowledge economy. Highly-educated and specialised personnel are an integral part of the innovation process. Talent is the main asset of knowledge-intensive firms, providing the fundamental basis for competitive advantage in the competition for leadership in innovation (Porter 1990). The interviews showed that the location of talent is a crucial aspect for both APS and High-Tech firms. Hence, the argument of Florida (2002) that 'jobs follow people' seems to have some justification, at least in the context of the knowledge economy (Florida 2002).

Acquiring innovative firms: Talent can also be brought into a company by acquiring innovative firms. The focus here is especially on companies that provide the optimum complement to the acquirer's portfolio, which is in line with the concept of 'related variety' (Boschma and Iammarino 2009). Furthermore, the purchase of a company also involves taking over the corresponding local business conditions such as the labour market or localised knowledge resources and technological culture. In other words, by acquiring innovative firms it is possible to build 'pipelines' in the form of organisational proximity between different agglomerations with a specific 'local buzz' (Bathelt et al. 2004).

Linking specialised knowledge: Knowledge creation has increasingly become integrated into various forms of business networks linking specialised knowledge from different parts of the world. The strength of such networks is that they combine the strategic advantage of global-scale operations with the ability to exploit local market opportunities. Clearly, this confirms Bartlett and Ghoshal's (2002) integrated network model, which is characterised by a high capacity to develop flexible coordination processes in international corporations (Bartlett and Ghoshal 2002). These corporations provide organisational proximity in the form of documented procedures, codified in manuals and blueprints, that facilitate communication between different parts of the organisation (Torre and Rallet 2005). The interviews showed that organisational proximity is particularly important where different cultures are working together, because conflicts often arise from language difficulties and cultural differences.

Speaking face-to-face: The role of face-to-face contacts in business networks depends on the people and their relationships to each other. In the area of R&D, communication is often organised electronically because it involves 'analytical knowledge' (Asheim et al. 2007b), which can be communicated relatively easily in standardised language. In the area of management, on the other hand, face-to-face communication is preferred, because it involves trust and 'synthetic knowledge' (Asheim et al. 2007b), which is created during the process of interaction with customers and suppliers. Basically, it can be said that the trend for intra-firm communication is moving towards virtualisation, while communication with customers and business partners along the value chain is still face-to-face.

Local clustering: The importance of face-to-face contacts in communication means that geographical proximity and local clustering still constitute a crucial factor in the innovation process, especially in the context of customer cooperation. Thus, agglomeration economies still tend to be a generic geographical process, which maps the logic of technological development and business organisation in space (Storper 1997). In Germany, customer relations appear to be particularly regional in nature. Some interviewees attributed this to Germany's federal government structure. Geographical proximity to competitors – as proposed by Porter (1990) – however, is not necessarily considered as an advantage, because informal contact with them is difficult to integrate in strategic decision-making processes.

Global sourcing: As well as local clustering, global sourcing is an important strategic business activity enabling knowledge-intensive firms to gain up-to-date information from specialised knowledge hubs all over the world. It means that firms not only have access to low-cost labour and materials, but can also tap into an international pool of technological and managerial resources. This finding is supported by various empirical studies indicating that relational learning networks are the key to understand the scale-sensitive process of local and non-local learning (Faulconbridge 2007). Together with the necessity of face-to-face contacts, this gives rise to intensive travel. International hub airports and high-speed train nodes are therefore frequently referred to as central gateway infrastructures, ensuring important inter-continental, European and sometimes also domestic connections.

All in all, the interviews have shown that the increasingly rich and diversified infrastructure of global travel and communication tends to qualify the assertion saying that firms have a strong tendency to locate close to one another because of frequent interactions requiring face-to-face contact. Indeed, geographical proximity helps, but it is neither a necessary nor a sufficient condition for knowledge creation to take place. The functional logic of the knowledge economy requires locations that facilitate the creation of new knowledge and ensure a smooth organisation of knowledge resources. The production and application of knowledge in the value creation process requires not only urbanisation economies in the form of dense and diversified regional markets, but also high-quality inter-continental and European accessibility to global knowledge hubs in the world economy. Mega-City Regions with well-developed international and regional accessibility tends to meet these requirements best.

8.2 The importance of the context in time and space

The different analyses in this case study have shed light on a number of details relating to the network structure and the functional urban hierarchy in the German urban system. The empirical results not only illustrate the locational strategies of APS and High-Tech companies on various spatial scales, but also identify a core process in the spatial development of cities and regions: the emergence of spatial hierarchies driven by the functional logic of the knowledge economy and its strategic location networks. This core process can only be understood through the simultaneous consideration of the context in which these network structures develop (see Figure 72). Or, as Sassen (2010) puts it: "Explaining the x requires a focus also on the non-x. Confining an analysis to description of the x that is the object of explanation provides a description, potentially enormously rich and revealing, but falls short of explaining. It also, thereby, falls short of theorising – and theorising is a way of seeing what the empirical details do not allow you to see" (Sassen 2010:151). In conclusion, therefore, the empirical results should once again be placed in a wider context, firstly with regard to the spatial core process of the knowledge economy and then in relation to the institutional context in which this process takes place. In the final section the results are reflected upon against the background of the relational economic geography as a scientific discipline.

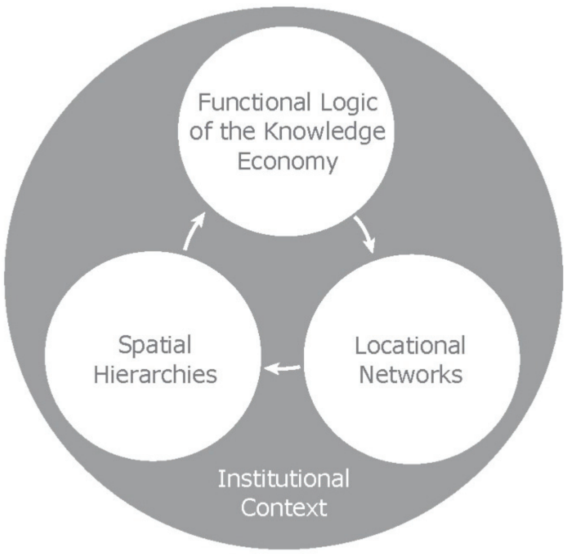


Figure 72: Interlocking firm networks and the institutional context
(Author's illustration)

Core process – from functional networks to spatial hierarchies

This study has shown that knowledge is used systematically in the value-added process of the knowledge economy, and that the company's location thereby plays an important role. The creation of knowledge is essentially an innovation-based value-added process concentrated in 'territorial production systems' (Maillat and Kebir 2001). This confirms Howells (2000) argument that the economy has its roots more strongly and more directly than ever before in the creation, distribution and the application of knowledge, which then becomes a strategic competitive factor for companies and regions (Howells 2000). What is important here is not ubiquitous information, but specific knowledge resources, created by interacting people that are organised in internal and external company networks. Thus, the functional logic of the knowledge economy asks for locations that facilitate the production of new knowledge and enable knowledge resources to be organised easily.

Often, the new possibilities offered by information and communication technologies are seen as the basis of the development and use of knowledge (Foray and Lundvall 1996). But in contrast to the assumption that these new technologies would mean 'the death of distance' (Cairncross 1997), our analyses support numerous other empirical studies which emphasise the complementary role of geographical and relational proximity in the knowledge creation process (Massard and Mehier 2009; Sturgeon et al. 2008). Geographical proximity is of great significance especially in the context of customer support and in joint projects with business partners along the value chain. The indispensable face-to-face contacts involved in these contacts, however, give also rise to a high level of travel. Therefore, relational proximity – in particular time proximity – is also a decisive factor for knowledge-intensive firms.

This leads to the development of widespread functional networks on different spatial scales. The various analyses in this study have shown that these networks tend to be concentrated in Mega-City Regions with a high level of international networking. The interdependence between international and intra-regional connectivity indicates that Mega-City Regions cannot be interpreted as self-sustaining urban systems. On the contrary, they always develop in interplay of intra-regional division of labour and international business relations along the value chain, resulting in high-performing locations with diversified and thick markets as well as with a high level of international and regional connectivity. This confirms our Mega-City Region model put forward in Chapter 4: the interplay between agglomeration economies and global network economies is strongly subject to increasing returns making Mega-City Regions to essential spatial nodes of today's global economy. These nodes have specific functions that are connected with particular urban qualities (Thierstein and Schein 2008). As the increase of such high-quality locations is limited, a functional urban hierarchy arises because of the clustering and concentrating of talented and creative people (Florida 2008). In Germany, for example, we are witnessing a relatively steep functional urban hierarchy despite of the federal government system.

Overall, it becomes clear that cities and towns are integrated simultaneously in national and international networks – and therefore also in national and international spatial hierarchies. In agglomerations with a large urban size – such as Munich or Berlin – national and international networks are overlapping relatively strongly. In smaller FUAs – for example in airport locations such as Freising or Rüsselsheim – the hidden geography of international firms of the knowledge economy is much more accentuated, i.e. with less superposition of national or regional knowledge-intensive networking. These locations illustrate that the functional urban hierarchy of today is profoundly affected by global network economies, rather than by a city's capacity to supply retail services to the surrounding area (Taylor 2004b). It is exactly for this reason why hub airport locations gain in importance.

Institutional context – the importance of political and socioeconomic conditions

The bottom-up character of this case study – i.e. the world city network from the perspective of the German space economy – has shown that the integration of German agglomerations into the world city network does not happen in isolation from the political context. According to Taylor (2011b) "globalisation does not mean the end of the state; rather it entails a spatial restructuring of economic activities in which the state continues to be implicated" (Taylor 2011b:197). Furthermore, he argues that "…relations between cities and states are very contingent, depending on history and contemporary development" (Taylor 2011b:199). In fact, spatial development in Germany stands between the conflicting priorities of the functional logic of the knowledge economy, which advances the spatial concentration of high-level economic functions, and the territorial logic of the government system. In this respect, Germany's federal government structure is a crucial underlying condition. In comparison to most countries in Europe, Germany is characterised by a dense network of small and medium-sized towns, augmented by a dozen larger centres with a population over half a million (Blotevogel and Schmitt 2006). Since the approval of the Spatial Planning Law in 1965, the Federal Government sought to achieve a balanced geographical development in order to provide equivalent living conditions throughout the German territory. In order to avoid excessive urbanisation a system of 'central places' – based on Christaller's central palace theory – was used as a directive planning instrument. For a long time, this led to the economic function of German cities being limited on a regional level. Until the end of the 1980s, there was no political will to ascribe a higher-level national or even international strategic role to bigger cities, as there was a fear of regional disparities and geographical injustice. Although a certain paradigm shift towards metropolitan development can be observed in recent years, the aim of a balanced spatial development is still very strongly anchored in the minds of the political decision-makers (see Blotevogel and Schmitt 2006).

This is also apparent in the political debate surrounding German Mega-City Regions. German regional planning policies ignored the strategic importance of metropolises for a long time. It was not until 1995 that the Standing Conference of Ministers Responsible for Spatial Planning decided to determine six Mega-City Regions – Berlin-Brandenburg, Hamburg, Munich, Rhine-Main, Rhine-Ruhr and Stuttgart – as "engines of social, economic and cultural development", whose "eminent functions… extend well beyond national borders" (MKRO 1995:27). Later, five further Mega-City Regions were added: the Saxony Triangle, Nuremberg, Bremen-Oldenburg, Hanover-Braunschweig-Göttingen-Wolfsburg and Rhine-Neckar. This increase to eleven politically-designated Mega-City Regions, however, tends to be the result of a political process, rather than the consequence of analytical evidence. From the point of view of the regional stakeholders, for example, the possibility of benefitting from the potential subsidies that have been expected in the train of the political paradigm shift towards metropolitan development is an important incentive to position themselves as political Mega-City Region (Blotevogel and Schmitt 2006).

But it is not only the federal political system that has a decisive influence on the development of German Mega-City Regions, but also the socioeconomic context. As many interviewees from global APS and High-Tech companies confirmed, specific institutional and cultural requirements as well as national regulations affect knowledge-intensive business activities to a considerable extent. The economic and financial crisis, which began in spring 2007, for example, revealed certain structural weaknesses in the German economic system. The combination of a high demand from abroad with a weak home demand during the years prior to the crisis was reflected in a large trade balance surplus. As a consequence, the German economy experienced an extraordinary export boom. This boom, however, came to an abrupt end when in the last quarter of 2008 world trade collapsed under the effect of the financial crisis (OECD 2010; Mamadouh and Wusten 2011).

The crisis had a particularly serious effect on the economically prosperous regions in south Germany. This is shown by the regional distribution of businesses and workforces hit by short-time working and the unemployment trends from June 2008 to June 2009 (Schwengler and Loibl 2010). The most recent studies indicate, however, that the same regions have survived the economic crisis largely unscathed (Berube et al. 2010; Prognos 2010a; Schwengler and Loibl 2010; URBACT 2010; BBSR 2009). After the economic crisis, they were affected for a brief period of time by serious economic slumps due to their close involvement in the international exchange of goods. But at the same time, their good structural economic conditions enabled them create above-average benefits from the subsequent increase in economic activity once global demand began to grow again. There is also the interesting observation that cities with significant economic connections with East Asia – such as the Australian cities of Melbourne, Brisbane and Sydney – enjoyed a relatively good economic performance during the crisis (Berube et al. 2010).

Thus, the economic crisis has shown that regions with a high international connectivity as well as a critical mass in terms of density and variety of value-added expertise are better able to use new market opportunities because they are better placed to constantly reinvent themselves. Leading innovative companies, strong research institutions and a highly-qualified workforce are among the central factors behind this success. However, these factors are far from assured for the future. Already today, Germany shows a lack of a highly-qualified workforce (Preuß 2008). Since knowledge resources have to be spatially concentrated in order to sustain economic diversity and thickness, it can be assumed that the functional urban hierarchy in Germany will become even steeper (Thierstein and Wiese 2011). The most serious long-term risks are the ones facing those automotive industry locations in Germany which have not succeeded in making the adaptations required by the structural changes in order to open up new market opportunities (BBSR 2009).

Relational economic geography – future priorities

What do the empirical results and conceptual considerations in this work mean for relational economic geography as a scientific discipline? Finally, I would like to address this question. Attention has already been drawn in Section 5.1 to the specific features of a relational research perspective. Relational approaches have gained in popularity in economic geography. Some authors speak of a “relational turn” (Storper 1997; Yeung 2005) or of a “transition towards a relational economic geography” (Bathelt and Glückler 2002:31). Others place the emphasis above all on the methodical enrichment of a relational perspective, but question the way it is built up to form a new theoretical paradigm (Dicken et al. 2001; Sunley 2008). Sunley (2008), for example, scrutinises whether the relational approach in economic geography is really enough to provide a new theoretical paradigm in economic geography; even though it provides new research topics and useful empirical tools for analysing economic activities in space (Sunley 2008). Bathelt and Glückler (2003) suggest that relational economic geography should not be misinterpreted as a new economic theory of space, but more as a way of seeing economic activity from a spatial perspective (Bathelt and Glückler 2003).

Similarly, Dicken et al. (2001) argue that rather than being a new research paradigm, networks provide a starting point for empirical work, as they "produce observable patterns in the global economy" (Dicken et al. 2001:91). My assessment corresponds to the latter arguments: relational economic geography as a methodological approach and starting point for empirical research.

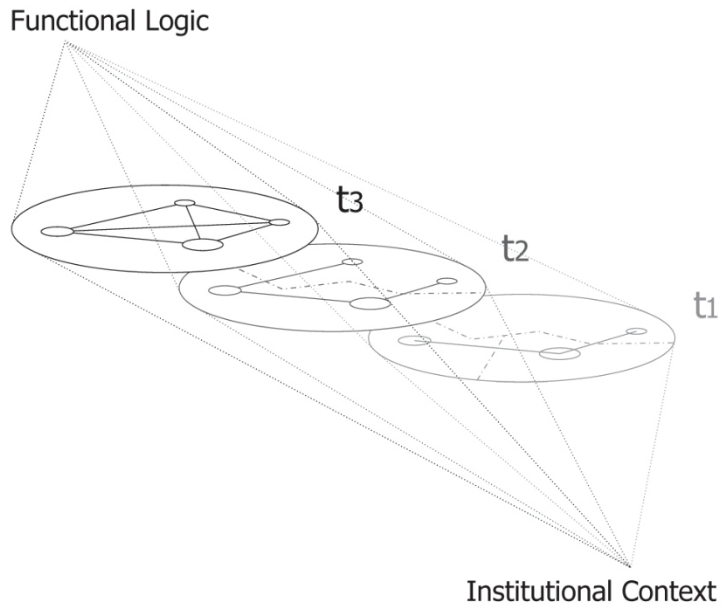


Figure 73: Relational economic geography: the importance of the context in time and space
(Visualisation: Anne Wiese)

My assessment is justified above all by the significance of the *context*, in which socioeconomic network structures are established (see Figure 73). Important conditions for the relational economic geography of the knowledge economy in Germany are the federal government structure and the strong orientation of the German economy towards exports. As explained above, these conditions have a considerable effect on the functional networks of the knowledge economy and thus on the spatial hierarchy in the German urban system. A relational perspective alone is not sufficient to cover this context adequately; in particular when it is a matter not only of investigating network structures, but also of identifying the underlying strategies of the actors involved, in order to better explain the effects and dynamics of the German space economy.

As well as the context, the principle of *contingency* also plays an important part. The principle of contingency means that the occurrence of an event does not always imply the occurrence of another event, so that identical starting conditions do not necessarily lead to the same outcome (Sayer 1985). This principle is closely connected to the concept of path dependency. Decisions and interactions in the past affect activities in the present, and they therefore direct strategic decisions along a historical development path (Bathelt and Glückler 2002). Therefore, in order to better understand the functional logic of the knowledge economy and its consequences for regional development, future research activities and network analyses must, among other things, focus more closely on the context and the temporal dimension of company networks. Similarly, Sunley (2008) argues that "economic geography's analysis of connections and relations would be better set within an evolutionary and historical institutionalism that understands economic relations as forms of institutional rules and practices and does not privilege ties and networks over nodes and agents" (Sunley 2008:1). Only in this way, it is possible to bridge the "debilitating binary division between territorial and relational geography" (Morgan 2007:1248) in regional studies. In this sense, Figure 73 illustrates a kind of 'road map' for the future research agenda, which should integrate the relational economic geography approach more closely into the broader institutional context of time and space.

9. Future research

In this work a large amount of material has been put forward for debate with regard to the position of German agglomerations in the broader world city network and its national urban system. Nevertheless, in concluding this study, it is useful to review the research findings once more and to answer one final question: what questions remain at least partially unanswered and therefore open for further research?

Knowledge-creating institutions: This analysis left out a third pillar of the knowledge economy – universities and higher education institutions. Most of these institutions were not included in the empirical surveys, even though some of them are highly active in international research. Still, we are perfectly aware that the debate on Mega-City Regions should include those institutions that create and diffuse knowledge and that in many ways they are thoroughly intertwined with the business sector and the political realm. An important next step for future research will be to bring the interlinkages of scientific institutions into the picture and cast light on their connectivity patterns with knowledge-intensive firms in polycentric Mega-City Regions.

Time: It has to be acknowledged that the empirical study in this thesis is static, even though the functional logic of the knowledge economy is framed in a dynamic context. The current picture of the knowledge economy in Germany, however, cannot be isolated in time and space. By including the time dimension into the analysis of the spatial strategies of firms, further information on changing spatial patterns and the drivers of change can be revealed. For example, how is the current financial and economic crisis articulated in spatial terms? Is there a slow structural change towards more knowledge-intensive economic activities, encouraging a further concentration of value-added activities in major cities? Or has the financial crisis resulted in a structural brake, giving smaller cities and towns new opportunities to catch up with the leading urban centres in the world? What part does the historical evolution of cities and regions play in the contemporary functional-urban hierarchy in the German space economy? This thesis provides an ideal starting point for carrying out comparative 'before and after crisis' analyses on the relational geography of the knowledge economy in Germany. Some steps in this direction have already been done using a longitudinal approach from a global perspective (Hoyler 2011b; Derudder et al. 2011; Engelen and Grote 2009; Alderson et al. 2010; Derudder et al. 2010). Derudder et al. (2011) for example show that German cities experience a relative decline in global network connectivity, particularly Frankfurt, Düsseldorf and Cologne (Derudder et al. 2011). These changes, however, took place before the financial crisis, so that its impact on the German space economy remains to be seen.

Visualisation: In the course of this research, innovative methods of visualising network data have been developed. Visualisation plays a significant role as it is able to transform abstract mathematical methods into network diagrams that are much easier to understand and more intuitively interpreted.

The simultaneous integration of analysis and visualisation creates an indispensable added value for understanding network activities in the knowledge economy. Nevertheless, new methods of analysing and visualising polycentric development need to be established in order to show and understand the potential contradictions of polycentricity between different geographical levels. Obtaining a picture of Mega-City Regions is crucial for comprehension, identification, motivation and commitment (Thierstein and Förster 2008). Raising awareness of this nascent spatial scale is a prerequisite for the establishment of large-scale metropolitan governance.

Accessibility: In order to obtain a more comprehensive picture of the spatial patterns of knowledge networks in Mega-City Regions, future research must focus especially on international gateway infrastructures, such as airports, seaports and high-speed train nodes. Little is known about the role of accessibility in promoting regional economic development. What are the long-term consequences of expanding international hub airports for the connectivity of airport cities and regions? How important is investment in regional and international transport infrastructure? And what should be the role of regional and national governments?

Economic and non-economic sectors: In order to understand spatial development processes thoroughly, more knowledge has to be acquired about both economic and non-economic sectors. For example, what would have been the outcome if creative industries or new media had been analysed in greater detail, or the locational strategies and organisational networks of logistics, distribution and wholesale activities? It is safe to assume that such third- and fourth-party logistics providers will play an important role in the increasingly globalised knowledge economy. But non-economic actors should also be part of a comprehensive research plan. All non-economic actors – such as nation-states, civil and social organisations, labour organisations and consumers – have very different spatialities from those of firms (Coe et al. 2008a).

Qualitative evidence: And finally, there is a need to extend and deepen the qualitative analysis, in order to inform policies on functional specialisation and complementarities within and between polycentric Mega-City Regions. Like most social processes, network activities are based on people's perceptions, their strategic choices and their willingness to act. What locational strategies are being developed in response to the financial and economic crisis? What is the relevance of national and regional contexts? The best way to capture these subjective motivations is by using qualitative research methods. These add significant originality and knowledge to understanding the dynamics of the German city network from a bottom-up perspective (Beaverstock 2011).

These questions and issues represent an important research agenda for policy on European, national and regional scales. Although many aspects of Mega-City Region development in Germany have been partially disentangled in this thesis, more work remains to be done to further the understanding of the evolving relational geographies of the German space economy. I look forward to reading critiques and further ideas.

10. Policy implications

In the course of this research work the Mega-City Regions of Germany have been examined from an analytical-functional perspective, and the hidden contexts and driving forces behind spatial development were revealed and examined. Political activity should – in addition to morphological tasks in the design of the built environment – also be oriented towards functionally defined Mega-

City Regions. In so doing it is important to understand the consequences of political activity on different spatial scales, and how this affects the localised system of value chains in Mega-City Regions. An essential task for cooperation between political and private actors in Mega-City Regions is to identify the areas that generate size and grouping benefits on the newly emerging large spatial scale, which cannot be implemented by individual cities, municipalities or administrative districts alone. At a strategic level this means cross-border cooperation in a broader sense. On the one hand, an improvement should be sought in the cooperation over content between public administration departments and economic sectors, while on the other, spatial cooperation should also be established – horizontally, by bringing different subregions of the Mega-City Regions together, and vertically, by improving the cooperation between municipalities, cities, planning regions and federal states, for example with regard to synergies in university and medicine sectors, when dealing with transport infrastructures or in the management of locations (Thierstein et al. 2007).

If the results of this research are converted into recommendations for political action, three strategic factors emerge which must be taken into account when implementing a spatial strategy in Mega-City Regions: Knowledge, Accessibility and Complementarities (see also Thierstein et al. 2007).

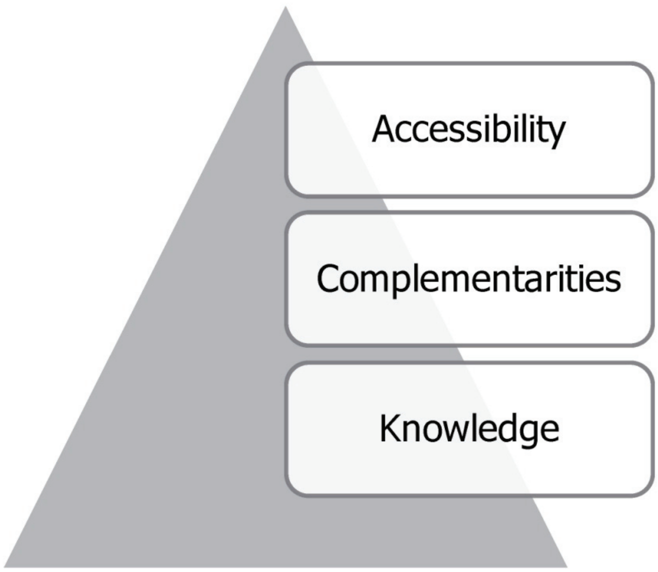


Figure 74: Strategic pillars of polycentric Mega-City Regions (Author's illustration)

Knowledge

The availability of knowledge is a key factor for economic success, both at company level and at the level of Mega-City Regions. Multi-sector clustering and co-location in dense urban areas is still vital for high-value knowledge transfer and innovation in global firms. In order to gain a faster, more efficient access to knowledge, knowledge-intensive enterprises organise themselves into various kinds of network. This research has shown that the availability of knowledge resources is an important argument in favour of knowledge-intensive firms locating in Mega-City Regions. In these areas there is also a higher networking intensity, both with other intra-firm sites and with extra-firm locations. The geographical distribution of companies is in line with the availability of the necessary sources of knowledge, for example universities and research institutions. Cooperation based on division of labour between suppliers and customers gives rise to connections along value added chains. A governance strategy in Mega-City Regions should understand this networking logic of knowledge-intensive firms and support it by providing the relevant infrastructures for generating knowledge and exchanging information or bringing together existing key players. An appropriate degree of specialisation should be considered, for example by giving preference to expanding existing core competences. In order to ensure that specialist research institutions can make the best possible contribution, the choice of location for these must provide top-quality physical accessibility and an efficient information and telecommunication technologies infrastructure. High-quality tacit knowledge is particularly linked to people; innovative, successful companies are therefore dependent to a great extent on a qualified workforce. Our interviews have shown that these groups of people value a high quality of life and attractive living environment. Thus the maintenance of soft location factors, such as access to attractive landscapes and cultural and tourist attractions, is also an indirect instrument for obtaining knowledge resources.

Accessibility

The processes for generating and expanding new knowledge are closely linked to the extent and quality of physical and non-physical accessibility. APS and High-Tech flows are becoming increasingly dependent on physical infrastructures even in the most digitised economic sectors. Different spatial scales have to be taken into account. On the one hand, accessibility *within* the Mega-City Region is significant, as it means that local tacit knowledge can be better shared in direct face-to-face exchanges. In this context the frequently-neglected aspect of tangential transport in Mega-City Regions is of eminent significance. Criss-cross patterns of commuting and business travel in polycentric urban regions is part of the everyday business of knowledge-intensive enterprises. Hence, investment in the public transport which supports these commuting patterns is essential for knowledge creation and diffusion. On the other hand, ensuring good *international* accessibility is also of central importance, as this is how new markets can be opened up, and also enables information which is not available locally to be made accessible quickly. Therefore, physical flow infrastructures such as international hub airports or inter-modal transportation systems are becoming more important. The connection of airports to the European high-speed rail networks also has high priority. And it is also important to pay attention to the ongoing development of the European logistics corridors, thereby ensuring the long-term trans-regional accessibility of Mega-City Regions.

Complementarities

The starting point for a successful spatial strategy is the identification of potential synergies within Mega-City Regions. The different subregions – high-density urban centres, urban landscapes, smaller and medium-sized centres, international airports, rural spaces between built-up areas – all have specific profiles. Taken together, these profiles have the potential – if appropriately combined and networked – to have a positive outward effect, thereby improving the quality of the whole region. In this way, Mega-City Regions can reach a sufficient critical mass and achieve greater success in the global competition between locations. The aim of a spatial strategy should be to bring together in a targeted way the strengths of the various sub-regions which may not appear to have much in common.

A potentially successful spatial strategy will superimpose and combine functional and spatial complementarities. *Functional complementarities* relate to the enterprise logic of interdependent processes along the value added chain. These value chains develop both within companies and between companies in different sectors. *Spatial complementarities*, on the other hand, arise from locating these functional value chains within Mega-City Regions. Different subregions have specific functions and comparative strengths, which go together with specific spatial qualities and territorial characteristics. It is the combination of functional and spatial complementarities which generates added value that could not be achieved individually.

As shown in Figure 74, the possible actions identified here are based on one another. Networked thinking is required. The new large scale of Mega-City Regions in Germany tears apart previous preconceptions. This research provides a starting point in the understanding of the spatial organisation of corporate locations in the German knowledge economy and the way they function in a global context. A central challenge for German policy-makers lies in finding a way out of the conflict between territorial cohesion and economic competitiveness. The politically-designated Mega-City Regions in Germany have come to cover around half of German territory. However, the current trends in the knowledge economy show that the majority of value added relationships are concentrated in a maximum of five German competence areas: Rhine-Ruhr, Munich, Rhine-Main, Hamburg and Stuttgart. The central idea of the Mega-City Region concept – i.e. the concentration of value added relationships, economic force and global resonance in large-scale polycentric Mega-City Regions – is by definition not suited to pursuing a comprehensive spatial strategy. It is therefore recommended that we look back to the analytical roots of the Mega-City Region concept. For Germany, this requires a reinterpretation of the basic principle of 'equivalent living conditions throughout the federal territory'. Or how Thierstein (2009) puts it: the emergence of a steep functional urban hierarchy must actively be managed and shaped (Thierstein 2009). Therefore, it seems to be reasonable that the hierarchical perspective should be reintroduced in the political debate on German Mega-City Regions again. This certainly would be more mind-opening than to strive for a balanced urban system of several more or less equivalent and almost evenly distributed Mega-City Regions in the Germany territory. Future strategies for territorial governance on a large scale must be based above all on a more in-depth analysis of spatial interconnections in the knowledge economy. This perspective contributes to the necessary understanding of Mega-City Regions as a relational spatial category, and lays an important foundation for establishing adequate governance strategies.

Appendices

Appendix A: Empirical Data

Data to the Figures

Table 7A: Global connectivity based on APS interlocking networks (See Figure 27; author's calculation)

Rank	FUA	Country	Gross Connectivity	Proportionate Connectivity (1,00 = New York)
1	New York NY	USA	73.553	1,00
2	London	UK	70.810	0,96
3	Hamburg	Germany	68.819	0,94
4	Paris	France	68.455	0,93
5	Frankfurt am Main	Germany	67.631	0,92
6	Munich	Germany	62.882	0,85
7	Hong Kong	China	60.898	0,83
8	Wien	Austria	60.071	0,82
9	Singapore	Singapore	59.428	0,81
10	Berlin	Germany	59.399	0,81
11	Milan	Italy	58.577	0,80
12	Stuttgart	Germany	57.864	0,79
13	Warsaw	Poland	57.298	0,78
14	Shanghai	China	55.601	0,76
15	Madrid	Spain	55.545	0,76
16	Tokyo	Japan	54.405	0,74
17	Düsseldorf	Germany	54.063	0,74
18	Prague	Czech Republic	53.133	0,72
19	Moscow	Russia	52.708	0,72
20	Sydney	Australia	52.523	0,71

Table 8A: Global connectivity based on High-Tech interlocking networks (See Figure 28; author's calculation)

Rank	FUA	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Shanghai)
1	Shanghai	China	66.115	1,00
2	Singapore	Singapore	64.769	0,98
3	Paris	France	59.058	0,89
4	Sao Paulo	Brazil	59.005	0,89
5	Moscow	Russia	52.096	0,79
6	Tokyo	Japan	51.923	0,79
7	Seoul	South Korea	50.099	0,76
8	Munich	Germany	47.853	0,72
9	Milan	Italy	47.421	0,72
10	Mexico City	Mexico	47.293	0,72
11	Buenos Aires	Argentina	47.095	0,71
12	Wien	Austria	46.797	0,71
13	Peking	China	46.316	0,70
14	Bangkok	Thailand	46.312	0,70

Rank	FUA	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Shanghai)
15	Madrid	Spain	45.770	0,69
16	Johannesburg	South Africa	45.513	0,69
17	Hong Kong	China	45.432	0,69
18	Istanbul	Turkey	45.318	0,69
19	Budapest	Hungary	45.018	0,68
20	Prague	Czech Republic	44.532	0,67

Table 9A: Office locations of APS firms in Germany and adjacent agglomerations
(See Figure 29; author's calculation)

Rank	FUA	Country	Total office locations	Service Value 5	Service Value 4	Service Value 3	Service Value 2	Service Value 1
1	Munich	Germany	180	23	12	37	99	9
2	Hamburg	Germany	164	14	20	31	87	12
3	Berlin	Germany	158	10	10	40	87	11
4	Frankfurt	Germany	151	18	13	30	86	4
5	Stuttgart	Germany	128	16	7	23	77	5
6	Düsseldorf	Germany	125	9	8	23	76	9
7	Cologne	Germany	115	15	5	22	64	9
8	Prague	Czech Republic	91	0	0	20	59	12
9	Zurich	Switzerland	86	1	4	17	59	5
10	Hanover	Germany	82	9	2	13	52	6
11	Leipzig	Germany	76	1	0	7	60	8
12	Dresden	Germany	73	0	1	9	57	6

Table 10A: Office locations of High-Tech firms in Germany and adjacent agglomerations
(See Figure 30; author's calculation)

Rank	FUA	Country	Total office locations	Service Value 5	Service Value 4	Service Value 3	Service Value 2	Service Value 1
1	Munich	Germany	93	20	4	13	50	6
2	Prague	Czech Republic	92	0	2	9	68	13
3	Berlin	Germany	81	3	5	10	55	8
4	Stuttgart	Germany	75	13	3	5	44	10
5	Hamburg	Germany	71	4	4	10	46	7
6	Zurich	Switzerland	57	2	2	11	33	9
7	Düsseldorf	Germany	49	7	4	5	30	3
8	Hanover	Germany	45	3	1	4	31	6
9	Frankfurt	Germany	40	1	1	6	29	3
10	Cologne	Germany	39	2	1	4	24	8
11	Dresden	Germany	38	0	0	5	28	5
12	Nuremberg	Germany	33	4	0	5	20	4

Table 11A: Functional urban hierarchy based on extra-European connectivity – APS
(See Figure 31; author's calculation)

Rank	FUA	Gross Connectivity	Proportionate Connectivity (1,00 = Frankfurt am Main)	Sum of employees and inhabitants
1	Frankfurt am Main	25.599	1,00	1.178.650
2	Hamburg	23.810	0,93	4.126.432
3	Munich	22.055	0,86	3.386.791
4	Düsseldorf	20.632	0,81	1.510.755
5	Stuttgart	20.100	0,79	2.541.339
6	Berlin	19.802	0,77	5.374.510
7	Nuremberg	16.388	0,64	950.245
8	Cologne	15.001	0,59	2.533.031
9	Hanover	14.349	0,56	643.149
10	Bremen	13.418	0,52	1.823.822
11	Leipzig	13.227	0,52	1.093.539
12	Dresden	11.470	0,45	1.152.796
13	Mannheim	10.225	0,40	984.379
14	Saarbrücken	8.416	0,33	1.361.882
15	Erfurt	7.324	0,29	459.595
16	Kassel	7.219	0,28	760.937
17	Essen	7.183	0,28	978.850
18	Dortmund	7.134	0,28	1.243.046
19	Bielefeld	7.014	0,27	848.866
20	Freiburg im Breisgau	5.969	0,23	746.070

Table 12A: Functional urban hierarchy based extra-European connectivity – High-Tech
(See Figure 31; author's calculation)

Rank	FUA	Gross Connectivity	Proportionate Connectivity (1,00 = Munich)	Sum of employees and inhabitants
1	Munich	22.596	1,00	3.386.791
2	Stuttgart	19.169	0,85	2.541.339
3	Hamburg	17.128	0,76	4.126.432
4	Berlin	16.122	0,71	5.374.510
5	Hanover	12.717	0,56	643.149
6	Düsseldorf	11.684	0,52	1.510.755
7	Frankfurt am Main	11.095	0,49	1.178.650
8	Cologne	10.871	0,48	2.533.031
9	Nuremberg	8.772	0,39	950.245
10	Saarbrücken	8.092	0,36	1.361.882
11	Mannheim	7.889	0,35	984.379
12	Bremen	7.371	0,33	1.823.822
13	Leipzig	7.085	0,31	1.093.539
14	Ulm	7.077	0,31	600.188
15	Dresden	6.829	0,30	1.152.796
16	Karlsruhe	5.895	0,26	640.142
17	Bochum	5.888	0,26	2.067.019

Rank	FUA	Gross Connectivity	Proportionate Connectivity (1,00 = Munich)	Sum of employees and inhabitants
18	Duisburg	5.807	0,26	2.147.270
19	Heilbronn	5.253	0,23	1.197.313
20	Kassel	5.170	0,23	760.937

Table 13A: Functional urban hierarchy based on national connectivity – APS
(See Figure 32; author's calculation)

Rank	FUA	Gross Connectivity	Proportionate Connectivity (Hamburg = 1,00)	Sum of employees and inhabitants
1	Hamburg	19.614	1,00	4.126.432
2	Munich	17.991	0,92	3.386.791
3	Berlin	17.614	0,90	5.374.510
4	Frankfurt am Main	16.405	0,84	1.178.650
5	Stuttgart	15.104	0,77	2.541.339
6	Düsseldorf	13.326	0,68	1.510.755
7	Cologne	13.127	0,67	2.533.031
8	Hanover	12.526	0,64	643.149
9	Nuremberg	11.451	0,58	950.245
10	Dresden	11.015	0,56	1.152.796
11	Bremen	10.722	0,55	1.823.822
12	Dortmund	10.356	0,53	1.243.046
13	Mannheim	10.146	0,52	984.379
14	Leipzig	9.768	0,50	1.093.539
15	Essen	8.034	0,41	978.850
16	Erfurt	7.802	0,40	459.595
17	Bielefeld	7.589	0,39	848.866
18	Kassel	7.023	0,36	760.937
19	Saarbrücken	6.321	0,32	1.361.882
20	Freiburg im Breisgau	6.283	0,32	746.070

Table 14A: Functional urban hierarchy based on national connectivity – High-Tech
(See Figure 32; author's calculation)

Rank	FUA	Gross Connectivity	Proportionate Connectivity (Munich = 1,00)	Sum of employees and inhabitants
1	Munich	7.594	1,00	3.386.791
2	Stuttgart	6.625	0,87	2.541.339
3	Hamburg	6.321	0,83	4.126.432
4	Berlin	6.311	0,83	5.374.510
5	Düsseldorf	4.511	0,59	1.510.755
6	Nuremberg	4.216	0,56	950.245
7	Hanover	4.039	0,53	643.149
8	Frankfurt am Main	3.941	0,52	1.178.650
9	Dresden	3.642	0,48	1.152.796
10	Leipzig	3.539	0,47	1.093.539

Rank	FUA	Gross Connectivity	Proportionate Connectivity (Munich = 1,00)	Sum of employees and inhabitants
11	Saarbrücken	3.268	0,43	1.361.882
12	Cologne	3.198	0,42	2.533.031
13	Bremen	3.092	0,41	1.823.822
14	Duisburg	2.995	0,39	2.147.270
15	Mannheim	2.885	0,38	984.379
16	Heilbronn	2.881	0,38	1.197.313
17	Karlsruhe	2.762	0,36	640.142
18	Ulm	2.584	0,34	600.188
19	Kassel	2.562	0,34	760.937
20	Bochum	2.474	0,33	2.067.019

Table 15A: APS significance of German FUAs in comparison to each other (See Figure 33; author's calculation)

Rank	FUA	Gross Connectivity	Sum of employees and inhabitants	Significance Index
1	Hanover	42.115	643.149	2,73
2	Frankfurt am Main	67.631	1.178.650	2,40
3	Erfurt	23.344	459.595	2,12
4	Nuremberg	45.145	950.245	1,98
5	Düsseldorf	54.063	1.510.755	1,49
6	Leipzig	36.249	1.093.539	1,38
7	Mannheim	32.061	984.379	1,36
8	Dresden	35.091	1.152.796	1,27
9	Kassel	22.705	760.937	1,25
10	Bielefeld	23.052	848.866	1,13
11	Freiburg im	19.658	746.070	1,10
12	Essen	23.920	978.850	1,02
13	Stuttgart	57.864	2.541.339	0,95
14	Dortmund	26.273	1.243.046	0,88
15	Bremen	38.098	1.823.822	0,87
16	Munich	62.882	3.386.791	0,78
17	Cologne	45.108	2.533.031	0,74
18	Saarbrücken	23.535	1.361.882	0,72
19	Hamburg	68.819	4.126.432	0,70
20	Berlin	59.399	5.374.510	0,46

Table 16A: High-Tech significance of German FUAs in comparison to each other (See Figure 34; author's calculation)

Rank	FUA	Gross Connectivity	Sum of employees and inhabitants	Significance Index
1	Hanover	25.732	643.149	3,28
2	Ulm	14.714	600.188	2,01
3	Nuremberg	19.943	950.245	1,72
4	Karlsruhe	13.310	640.142	1,71
5	Frankfurt am Main	23.766	1.178.650	1,66

Rank	FUA	Gross Connectivity	Sum of employees and inhabitants	Significance Index
6	Düsseldorf	26.004	1.510.755	1,41
7	Mannheim	15.942	984.379	1,33
8	Stuttgart	41.013	2.541.339	1,32
9	Kassel	12.077	760.937	1,30
10	Leipzig	15.850	1.093.539	1,19
11	Dresden	16.394	1.152.796	1,17
12	Munich	47.853	3.386.791	1,16
13	Saarbrücken	17.529	1.361.882	1,06
14	Heilbronn	12.649	1.197.313	0,87
15	Hamburg	36.643	4.126.432	0,73
16	Bremen	15.937	1.823.822	0,72
17	Cologne	21.921	2.533.031	0,71
18	Berlin	35.463	5.374.510	0,54
19	Duisburg	13.758	2.147.270	0,53
20	Bochum	12.907	2.067.019	0,51

Table 17A: APS connectivity and critical mass in German MCRs (See Figure 35; author’s calculation)

Mega-City Regions	Number of FUAs	Gross Connectivity	Connectivity per FUA	Connectivity per FUA in relation to the mean score (=1)	Sum of employees and inhabitants	Sum of employees and inhabitants in relation to the mean score (=1)
Rhine-Ruhr	7	203.021	29.003	1,99	11.996.550	1,73
Hamburg	3	73.571	24.524	1,68	4.837.915	0,70
Rhine-Main	8	140.971	17.621	1,21	5.621.961	0,81
Munich	9	136.061	15.118	1,04	8.745.842	1,26
Bremen-Oldenburg	6	86.093	14.349	0,99	5.197.683	0,75
Stuttgart	8	103.052	12.882	0,89	7.538.176	1,09
Berlin-Brandenburg	7	85.992	12.285	0,84	8.356.004	1,20
Rhine-Neckar	6	61.664	10.277	0,71	3.126.817	0,45
H-B-G-W*	10	81.388	8.139	0,56	4.354.353	0,63
Saxony-Triangle	25	201.500	8.060	0,55	10.155.343	1,46
Nuremberg	14	109.827	7.845	0,54	6.387.884	0,92

*H-B-G-W = Hanover-Braunschweig-Göttingen-Wolfsburg

Table 18A: High-Tech connectivity and critical mass in German MCRs (See Figure 36; author’s calculation)

Mega-City Regions	Number of FUAs	Gross Connectivity	Connectivity per FUA	Connectivity per FUA in relation to the mean score (=1)	Sum of employees and inhabitants	Sum of employees and inhabitants in relation to the mean score (=1)
Rhine-Ruhr	7	107.396	15.342	1,86	11.996.550	1,73
Hamburg	3	40.673	13.558	1,64	4.837.915	0,70
Stuttgart	8	87.803	10.975	1,33	7.538.176	1,09
Munich	9	94.247	10.472	1,27	8.745.842	1,26
Berlin-Brandenburg	7	53.080	7.583	0,92	8.356.004	1,20
Rhine-Main	8	59.744	7.468	0,90	5.621.961	0,81

Mega-City Regions	Number of FUAs	Gross Connectivity	Connectivity per FUA	Connectivity per FUA in relation to the mean score (=1)	Sum of employees and inhabitants	Sum of employees and inhabitants in relation to the mean score (=1)
Rhine-Neckar	6	40.313	6.719	0,81	3.126.817	0,45
H-B-G-W*	10	55.974	5.597	0,68	4.354.353	0,63
Bremen-Oldenburg	6	28.746	4.791	0,58	5.197.683	0,75
Nuremberg	14	62.358	4.454	0,54	6.387.884	0,92
Saxony-Triangle	25	100.080	4.003	0,48	10.155.343	1,46

*H-B-G-W = Hanover-Braunschweig-Göttingen-Wolfsburg

Table 19A: Globalism and localism for APS firms (See Figure 37; author's calculation)

Rank	FUA	Gross Connectivity	Connectivity to all FUAs inside Germany	Connectivity to all FUAs outside Germany	Globalism Index
1	Frankfurt am Main	67.631	16.405	51.226	1,26
2	Düsseldorf	54.063	13.326	40.737	1,24
3	Nuremberg	45.145	11.451	33.694	1,19
4	Stuttgart	57.864	15.104	42.760	1,14
5=	Saarbrücken	23.535	6.321	17.214	1,10
5=	Leipzig	36.249	9.768	26.481	1,10
7	Bremen	38.098	10.722	27.376	1,03
8=	Hamburg	68.819	19.614	49.205	1,01
8=	Munich	62.882	17.991	44.891	1,01
10	Cologne	45.108	13.127	31.981	0,98
11	Berlin	59.399	17.614	41.785	0,96
12	Hanover	42.115	12.526	29.589	0,95
13	Kassel	22.705	7.023	15.682	0,90
14	Dresden	35.091	11.015	24.076	0,88
15	Mannheim	32.061	10.146	21.915	0,87
16	Freiburg im Breisgau	19.658	6.283	13.375	0,86
17	Bielefeld	23.052	7.589	15.463	0,82
18=	Erfurt	23.344	7.802	15.542	0,80
18=	Essen	23.920	8.034	15.886	0,80
20	Dortmund	26.273	10.356	15.917	0,62

Table 20A: Globalism and localism for High-Tech firms (See Figure 37; author's calculation)

Rank	FUA	Gross Connectivity	Connectivity to all FUAs inside Germany	Connectivity to all FUAs outside Germany	Globalism Index
1	Cologne	21.921	3.198	18.723	1,29
2	Hanover	25.732	4.039	21.693	1,19
3	Munich	47.853	7.594	40.259	1,17
4	Stuttgart	41.013	6.625	34.388	1,15
5	Frankfurt am Main	23.766	3.941	19.825	1,11
6	Hamburg	36.643	6.321	30.322	1,06
7	Düsseldorf	26.004	4.511	21.493	1,05
8	Ulm	14.714	2.584	12.130	1,04

Rank	FUA	Gross Connectivity	Connectivity to all FUAs inside Germany	Connectivity to all FUAs outside Germany	Globalism Index
9	Berlin	35.463	6.311	29.152	1,02
10	Mannheim	15.942	2.885	13.057	1,00
11	Saarbrücken	17.529	3.268	14.261	0,96
12	Bochum	12.907	2.474	10.433	0,93
13	Bremen	15.937	3.092	12.845	0,92
14	Karlsruhe	13.310	2.762	10.548	0,84
15=	Nuremberg	19.943	4.216	15.727	0,82
15=	Kassel	12.077	2.562	9.515	0,82
17	Duisburg	13.758	2.995	10.763	0,79
18=	Dresden	16.394	3.642	12.752	0,77
18=	Leipzig	15.850	3.539	12.311	0,77
20	Heilbronn	12.649	2.881	9.768	0,75

Table 21A: Traditional globalism through NYLON based on APS networks (relative concentration of connections to New York and London) (See Figure 39; author's calculation)

Rank	FUA	Traditional Globalism
1	Munich	0,0094
2	Frankfurt am Main	0,0086
3	Düsseldorf	0,0076
4	Berlin	0,0051
5	Hamburg	0,0049
6	Cologne	0,0033
7	Stuttgart	0,0018
8	Nuremberg	-0,0003
9	Hanover	-0,0004
10	Bremen	-0,0016

Table 22A: New globalism through the Chinese cities triad based on APS networks (relative concentration of connections to Beijing, Hong Kong and Shanghai) (See Figure 39; author's calculation)

Rank	FUA	New Globalism
1	Munich	0,0075
2	Frankfurt am Main	0,0067
3	Düsseldorf	0,0059
4	Cologne	0,0038
5	Hamburg	0,0036
6	Berlin	0,0034
7	Stuttgart	0,0023
8	Nuremberg	0,0017
9	Hanover	-0,0006
10	Bremen	-0,0011

Table 23A: Traditional globalism through NYLON based on High-Tech networks (relative concentration of connections to New York and London) (See Figure 40; author's calculation)

Rank	FUA	Traditional Globalism
1	Frankfurt am Main	0,0022
2	Munich	0,0021
3	Düsseldorf	0,0019
4	Hamburg	0,0018
5	Cologne	0,0017
6	Berlin	0,0010
7	Nuremberg	0,0008
8	Stuttgart	0,0003
9	Hanover	-0,0001
10	Saarbrücken	-0,0022

Table 24A: New globalism through the Chinese cities triad based on High-Tech networks (relative concentration of connections to Beijing, Hong Kong and Shanghai) (See Figure 40; author's calculation)

Rank	FUA	New Globalism
1	Munich	0,0050
2	Cologne	0,0025
3	Düsseldorf	0,0022
4	Berlin	0,0017
5	Hamburg	0,0010
6	Stuttgart	0,0000
7	Saarbrücken	-0,0007
8	Frankfurt am Main	-0,0017
9	Hanover	-0,0034
10	Nuremberg	-0,0057

Table 25A: Value-adding activities in German Mega-City Regions (See Figure 41; author's calculation)

	Number of value added relations					
Mega-City Regions	R&D	Processing	Financing	Marketing	Sales & Distribution	Customers
Munich	62	49	42	44	31	76
Rhine-Ruhr	34	25	21	26	16	62
Stuttgart	34	26	12	18	13	36
Rhine-Main	29	24	37	25	16	45
Berlin-Brandenburg	24	23	16	15	13	38
Saxony Triangle	15	19	8	7	3	9
HBGW*	14	13	10	10	6	26
Nuremberg	13	9	6	4	3	14
Hamburg	12	16	29	30	15	45
Bremen-Oldenburg	9	12	6	10	8	10
Rhine-Neckar	5	4	1	2	3	8

*HBGW=Hannover-Braunschweig-Göttingen-Wolfsburg

Table 26A: Map of value-adding activities in the German space economy (See Figure 42; author's calculation)

FUA	Value added relation with the highest Localization Quotient	Localization Quotient	Number of value added relations
Aachen	R&D	2,51	8
Augsburg	Sales & Distribution	1,47	11
Berlin	Customers	1,14	32
Bochum	Marketing	1,68	4
Bonn	Customers	1,46	14
Braunschweig	Customers	1,38	5
Bremen	Sales & Distribution	1,71	6
Dortmund	R&D	1,67	4
Dresden	Processing	1,92	4
Düsseldorf	Customers	1,87	16
Essen	Marketing	1,80	5
Frankfurt am Main	Financing	1,84	27
Hamburg	Marketing	1,58	30
Hanover	Financing	1,91	6
Ingolstadt	Customers	2,20	4
Cologne	Marketing	1,37	10
Krefeld	Customers	2,57	4
Ludwigshafen am Rhein	Customers	2,20	4
Lübeck	Financing	2,95	8
Mainz	Processing	1,77	4
Munich	R&D	1,10	43
Münster	Financing	2,33	4
Nuremberg	Processing	1,92	8
Regensburg	Customers	1,71	4
Rüsselheim	R&D	4,01	4
Saarbrücken	Customers	1,10	4
Stuttgart	R&D	1,12	24
Wiesbaden	Marketing	3,35	4
Wolfsburg	Customers	1,85	12

Sample: 203 firms; 313 value added relations.

Table 27A: Regional connectivity of APS firms in the MCR of Munich (See Figure 44; author's calculation)

	Augsburg	Freising	Garmisch	Ingolstadt	Kaufbeuren	Landshut	Munich	Regensburg	Rosenheim
Augsburg		0,18	0,11	0,21	0,11	0,16	1,00	0,46	0,20
Freising			0,07	0,07	0,07	0,09	0,32	0,19	0,08
Garmisch				0,05	0,04	0,09	0,19	0,11	0,07
Ingolstadt					0,05	0,10	0,49	0,18	0,06
Kaufbeuren						0,04	0,15	0,10	0,04
Landshut							0,32	0,16	0,08
Munich								0,77	0,41
Regensburg									0,20
Rosenheim									

Table 28A: Regional connectivity of High-Tech firms in the MCR of Munich (See Figure 45; author's calculation)

	Augsburg	Freising	Garmisch	Ingolstadt	Kaufbeuren	Landshut	Munich	Regensburg	Rosenheim
Augsburg		0,15	0,05	0,17	0,05	0,12	1,00	0,25	0,11
Freising			0,00	0,19	0,10	0,05	0,30	0,20	0,12
Garmisch				0,03	0,00	0,05	0,11	0,03	0,06
Ingolstadt					0,02	0,18	0,56	0,12	0,03
Kaufbeuren						0,02	0,03	0,05	0,00
Landshut							0,41	0,06	0,12
Munich								0,88	0,60
Regensburg									0,18
Rosenheim									

Table 29A: Geographical vs. relational proximity of APS firms in the MCR of Munich (See Figure 46; author's calculation)

	Aalen	**Amberg**	**Ansbach**	**Augsburg**	**Deggendorf**	**Freising**	**Garmisch**	**Heidenheim**	**Ingolstadt**	**Kaufbeuren**	**Kempten**	**Landshut**	**Memmingen**	**Munich**	**Neumarkt**	**Passau**	**Regensburg**	**Rosenheim**	**Schwabach**	**Straubing**	**Ulm**	**Innsbruck**	**Salzburg**
Aalen		0,008	0,006	0,019	0,010	0,008	0,008	0,007	0,016	0,007	0,016	0,008	0,008	0,029	0,005	0,008	0,020	0,009	0,006	0,006	0,017	0,000	0,002
Amberg			0,011	0,027	0,014	0,018	0,017	0,011	0,010	0,008	0,026	0,023	0,013	0,048	0,010	0,013	0,027	0,014	0,007	0,011	0,018	0,004	0,009
Ansbach				0,034	0,011	0,017	0,011	0,010	0,013	0,015	0,024	0,011	0,016	0,049	0,010	0,014	0,034	0,008	0,007	0,015	0,025	0,010	0,010
Augsburg					0,021	0,037	0,023	0,026	0,044	0,022	0,076	0,033	0,026	0,208	0,015	0,030	0,095	0,041	0,013	0,028	0,084	0,035	0,056
Deggendorf						0,019	0,014	0,013	0,013	0,009	0,018	0,014	0,014	0,032	0,010	0,014	0,021	0,010	0,007	0,018	0,016	0,000	0,006
Freising							0,014	0,013	0,014	0,015	0,037	0,018	0,023	0,066	0,011	0,032	0,039	0,016	0,008	0,026	0,025	0,020	0,038
Garmisch								0,011	0,010	0,008	0,020	0,019	0,013	0,040	0,010	0,008	0,023	0,014	0,007	0,011	0,014	0,000	0,001
Heidenheim									0,009	0,007	0,023	0,011	0,011	0,035	0,009	0,007	0,023	0,015	0,006	0,010	0,025	0,000	0,001
Ingolstadt										0,009	0,019	0,020	0,015	0,102	0,006	0,015	0,038	0,013	0,008	0,009	0,029	0,000	0,006
Kaufbeuren											0,023	0,008	0,013	0,031	0,007	0,010	0,020	0,008	0,007	0,008	0,013	0,006	0,007
Kempten												0,028	0,026	0,101	0,013	0,019	0,056	0,023	0,009	0,015	0,044	0,024	0,032
Landshut													0,013	0,066	0,010	0,013	0,033	0,016	0,007	0,011	0,022	0,004	0,009
Memmingen														0,064	0,010	0,008	0,027	0,013	0,007	0,015	0,014	0,007	0,008
Munich															0,023	0,071	0,161	0,085	0,020	0,035	0,124	0,051	0,109
Neumarkt																0,006	0,014	0,006	0,006	0,010	0,010	0,000	0,000
Passau																	0,032	0,015	0,007	0,021	0,029	0,014	0,027
Regensburg																		0,041	0,013	0,025	0,067	0,024	0,032
Rosenheim																			0,008	0,009	0,027	0,001	0,013
Schwabach																				0,007	0,007	0,000	0,000
Straubing																					0,020	0,008	0,015
Ulm																						0,016	0,026
Innsbruck																							0,040
Salzburg																							

Table 30A: Geographical vs. relational proximity of High-Tech firms in the MCR of Munich (See Figure 47; author's calculation)

	Aalen	**Amberg**	**Ansbach**	**Augsburg**	**Deggendorf**	**Freising**	**Garmsich**	**Heidenheim**	**Ingolstadt**	**Kaufbeuren**	**Kempten**	**Landshut**	**Memmingen**	**Munich**	**Neumarkt**	**Passau**	**Regensburg**	**Rosenheim**	**Schwabach**	**Straubing**	**Ulm**	**Innsbruck**	**Salzburg**
Aalen		0,000	0,006	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,031	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Amberg			0,006	0,013	0,000	0,015	0,006	0,006	0,013	0,000	0,013	0,010	0,008	0,081	0,000	0,010	0,076	0,023	0,002	0,006	0,019	0,006	0,006
Ansbach				0,018	0,000	0,000	0,006	0,045	0,027	0,010	0,019	0,015	0,013	0,053	0,000	0,010	0,021	0,029	0,000	0,016	0,015	0,011	0,027
Augsburg					0,006	0,031	0,010	0,037	0,036	0,010	0,010	0,024	0,008	0,204	0,000	0,010	0,050	0,023	0,000	0,019	0,036	0,015	0,031
Deggendorf						0,016	0,000	0,000	0,006	0,006	0,000	0,000	0,000	0,019	0,000	0,010	0,016	0,000	0,013	0,000	0,006	0,000	0,000
Freising							0,000	0,005	0,039	0,019	0,000	0,010	0,000	0,061	0,000	0,000	0,040	0,024	0,000	0,000	0,015	0,000	0,000
Garmsich								0,006	0,006	0,000	0,000	0,010	0,006	0,023	0,000	0,010	0,006	0,011	0,000	0,006	0,006	0,006	0,011
Heidenheim									0,032	0,016	0,026	0,018	0,015	0,094	0,000	0,010	0,044	0,042	0,000	0,016	0,053	0,021	0,024
Ingolstadt										0,003	0,003	0,037	0,008	0,113	0,000	0,016	0,024	0,006	0,013	0,016	0,045	0,015	0,018
Kaufbeuren											0,006	0,003	0,003	0,006	0,000	0,000	0,010	0,000	0,000	0,000	0,003	0,003	0,003
Kempten												0,003	0,010	0,061	0,000	0,000	0,019	0,006	0,000	0,006	0,010	0,003	0,029
Landshut													0,011	0,084	0,000	0,031	0,011	0,024	0,000	0,034	0,021	0,011	0,029
Memmingen														0,036	0,000	0,010	0,008	0,006	0,002	0,006	0,008	0,008	0,008
Munich															0,000	0,069	0,179	0,123	0,015	0,058	0,176	0,057	0,152
Neumarkt																0,026	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Passau																	0,016	0,010	0,000	0,019	0,010	0,010	0,010
Regensburg																		0,037	0,000	0,013	0,065	0,008	0,015
Rosenheim																			0,000	0,013	0,023	0,023	0,048
Schwabach																				0,000	0,013	0,000	0,000
Straubing																					0,013	0,006	0,013
Ulm																						0,024	0,021
Innsbruck																							0,032
Salzburg																							

Table 31A: International connectivity of APS firms in the MCR of Munich (See Figure 48; author's calculation)

Munich

R	FUA	CI
1	Hamburg	958
2	Berlin	912
3	Frankfurt	870
4	Düsseldorf	719
5	Stuttgart	696
6	London	600
7	Cologne	579
8	Paris	564
9	New York	552
10	Vienna	491
etc.	…	…
Interlock Connectivity = 62882		

Augsburg

R	FUA	CI
1	Hamburg	219
2	Munich	199
3	Cologne	173
4	Bremen	163
5	Berlin	160
6	Stuttgart	159
7	Frankfurt	153
8	Düsseldorf	144
9	Nuremberg	125
10	Mannheim	124
etc.	…	…
Interlock Connectivity = 18750		

Regensburg

R	FUA	CI
1	Berlin	168
2	Hamburg	162
3	Stuttgart	157
4	Munich	154
5	Frankfurt	142
6	Cologne	139
7	Nuremberg	123
8=	Hanover	117
8=	Dresden	117
10	Mannheim	116
etc.	…	…
Interlock Connectivity = 18203		

Freising

R	FUA	CI
1	Hamburg	102
2	Berlin	79
3	Frankfurt	74
4	Stuttgart	73
5	Nuremberg	71
6=	Düsseldorf	66
6=	Warsaw	66
8	Munich	63
9=	Hanover	61
9=	Milan	61
etc.	…	…
Interlock Connectivity = 14796		

Ingolstadt

R	FUA	CI
1	Munich	98
2	Hamburg	85
3	Stuttgart	82
4	Berlin	62
5	Bremen	59
6	Cologne	57
7	Frankfurt	56
8	Manheim	52
9=	Augsburg	42
9=	Kassel	42
etc.	…	…
Interlock Connectivity = 5275		

Rosenheim

R	FUA	CI
1	Munich	81
2	Hamburg	75
3	Frankfurt	63
4	Düsseldorf	60
5	Berlin	59
6	Stuttgart	56
7	Mannheim	47
8	Dortmund	46
9	Cologne	45
10	Hanover	44
etc.	…	…
Interlock Connectivity = 4807		

Landshut

R	FUA	CI
1	Hamburg	64
2=	Berlin	63
2=	Munich	63
4	Stuttgart	59
5	Hanover	58
6	Frankfurt	57
7	Nuremberg	47
8	Düsseldorf	46
9=	Cologne	44
9=	Dortmund	44
etc.	…	…
Interlock Connectivity = 4496		

Kaufbeuren

R	FUA	CI
1	Hamburg	34
2	Munich	30
3	Berlin	29
4	Nuremberg	27
5	Frankfurt	25
6=	Stuttgart	24
6=	Düsseldorf	24
6=	Hanover	24
9	Dresden	23
10	Mannheim	22
etc.	…	…
Interlock Connectivity = 3947		

Garmisch-Partenkirchen

R	FUA	CI
1	Munich	38
2	Hamburg	36
3	Berlin	35
4	Frankfurt	29
5	Dresden	26
6=	Düsseldorf	25
6=	Hanover	25
8=	Dortmund	24
8=	Kiel	24
10	Nuremberg	23
etc.	…	…
Interlock Connectivity = 2905		

(R=Rank; CI=City Interlock; FUA=Functional Urban Area)

Table 32A: International connectivity of High-Tech firms in the MCR of Munich
(See Figure 49; author's calculation)

Munich

R	FUA	CI
1	Shanghai	430
2	Singapore	427
3	Paris	348
4	Berlin	342
5	Sao Paulo	340
6	Tokyo	334
7	Peking	332
8=	Vienna	328
8=	Seoul	328
8=	Moscow	328
etc.	…	…
Interlock Connectivity = 47853		

Augsburg

R	FUA	CI
1	Munich	126
2	Shanghai	117
3	Paris	111
4	Kuala Lumpur	89
5=	Singapore	86
5=	Milan	86
7	Hong Kong	85
8	Sao Paulo	83
9	Seoul	81
10	Prague	79
etc.	…	…
Interlock Connectivity = 11942		

Regensburg

R	FUA	CI
1	Munich	111
2	Shanghai	82
3	Berlin	76
4	Sao Paulo	73
5	Peking	64
6	Singapore	63
7	Moscow	60
8	Seoul	59
9	Melbourne	57
10	Hong Kong	55
etc.	…	…
Interlock Connectivity = 9064		

Rosenheim

R	FUA	CI
1	Shanghai	80
2	Paris	78
3=	Munich	76
3=	Sao Paulo	76
5=	Bangkok	75
5=	Singapore	75
7	Seoul	68
8	Hong Kong	66
9=	Jakarta	61
9=	Milan	61
etc.	…	…
Interlock Connectivity = 8307		

Ingolstadt

R	FUA	CI
1	Shanghai	71
2=	Munich	70
2=	Berlin	70
4	Wolfsburg	56
5	Sao Paulo	54
6	Singapore	43
7=	Madrid	42
7=	Hamburg	42
7=	Dubai	42
10	Moscow	41
etc.	…	…
Interlock Connectivity = 8260		

Landshut

R	FUA	CI
1	Munich	52
2	Stuttgart	43
3	Shanghai	37
4	Paris	36
5	Barcelona	30
6	Detroit	26
7=	Singapore	25
7=	Koblenz	25
9=	Moscow	23
9=	Kassel	23
etc.	…	…
Interlock Connectivity = 3465		

Freising

R	FUA	CI
1	Munich	38
2	Peking	27
3=	Shanghai	26
3=	Moscow	26
5=	Warsaw	25
5=	Regensburg	25
7=	Ingolstadt	24
7=	Hamburg	24
7=	Kuala Lumpur	24
10	Berlin	23
etc.	…	…
Interlock Connectivity = 2777		

Garmisch-Partenkirchen

R	FUA	CI
1=	Mannheim	15
1=	Basel	15
3	Munich	14
4=	Shanghai	13
4=	Graz	13
6=	Paris	12
6=	Wien	12
6=	San Francisco	12
6=	Madison	12
10	Zug	11
etc.	…	…
Interlock Connectivity = 1487		

Kaufbeuren

R	FUA	CI
1=	Shanghai	12
1=	Freising	12
3=	Sao Paulo	10
3=	Seoul	10
3=	Madrid	10
3=	Istanbul	10
3=	Stuttgart	10
3=	Tokyo	10
3=	Hamburg	10
3=	Heidenheim	10
etc.	…	…
Interlock Connectivity = 1092		

(R=Rank; CI=City Interlock; FUA=Functional Urban Area)

Table 33A: Global and regional connectivity in the MCR of Munich (See Figure 50; author's calculation)

Global connectivity - APS

R	FUA	Gross Connectivity	Proportionaate Connectivity (1,00 = Munich)
1	Munich	22.055	1,00
2	Freising	5.310	0,24
3	Augsburg	4.846	0,22
4	Regensburg	4.598	0,21
5	Rosenheim	799	0,04
6	Kaufbeuren	750	0,03
7	Ingolstadt	605	0,03
8	Landshut	445	0,02
9	Garmisch	229	0,01

Regional connectivity - APS

R	FUA	Gross Connectivity	Proportionaate Connectivity (1,00 = Munich)
1	Munich	726	1,00
2	Augsburg	481	0,66
3	Regensburg	430	0,59
4	Ingolstadt	239	0,33
5	Rosenheim	222	0,31
6	Freising	207	0,29
7	Landshut	204	0,28
8	Garmisch	144	0,20
9	Kaufbeuren	117	0,16

Global connectivity - High-Tech

R	FUA	Gross Connectivity	Proportionaate Connectivity (1,00 = Munich)
1	Munich	22.596	1,00
2	Augsburg	5.223	0,23
3	Regensburg	4.114	0,18
4	Rosenheim	3.898	0,17
5	Ingolstadt	3.462	0,15
6	Landshut	1.290	0,06
7	Freising	1.112	0,05
8	Garmisch	689	0,03
9	Kaufbeuren	346	0,02

Regional connectivity - High-Tech

R	FUA	Gross Connectivity	Proportionaate Connectivity (1,00 = Munich)
1	Munich	491	1,00
2	Augsburg	239	0,49
3	Regensburg	222	0,45
4	Ingolstadt	164	0,33
5	Rosenheim	154	0,31
6	Freising	139	0,28
7	Landshut	126	0,26
8	Garmisch	41	0,08
9	Kaufbeuren	32	0,07

(R = Rank)

Table 34A: APS significance of FUAs in the MCR of Munich in comparison to each other
(See Figure 51; author's calculation)

Rank	**FUA**	**Gross Connectivity**	**Sum of employees and inhabitants**	**Significance Index**
1	Freising	14.796	424.748	2,23
2	Regensburg	18.203	635.080	1,83
3	Munich	62.882	3.386.791	1,19
4	Kaufbeuren	3.947	253.349	1,00
5	Augsburg	18.750	1.265.085	0,95
6	Garmisch	2.905	301.556	0,62
7	Ingolstadt	5.275	680.083	0,50
8	Landshut	4.496	737.629	0,39
9	Rosenheim	4.807	1.022.303	0,30

Table 35A: High-Tech significance of FUAs in the MCR of Munich in comparison to each other
(See Figure 52; author's calculation)

Rank	FUA	Gross Connectivity	Sum of employees and inhabitants	Significance Index
1	Regensburg	9.064	635.080	1,32
2	Munich	47.853	3.386.791	1,31
3	Ingolstadt	8.260	680.083	1,12
4	Augsburg	11.942	1.265.085	0,87
5	Rosenheim	8.307	1.022.303	0,75
6	Freising	2.777	424.748	0,60
7	Garmisch	1.487	301.556	0,46
8	Landshut	3.465	737.629	0,43
9	Kaufbeuren	1.092	253.349	0,40

Table 36A: Value-adding relations of APS firms located in the MCR of Munich
(See Figure 53; author's calculation)

	Number of relations along the value chain			
Value chain elements	Regional Scale	National Scale	European Scale	Global Scale
R&D	26	22	5	1
Processing	28	16	4	0
Financing	23	13	2	0
Marketing	22	12	1	0
Sales & Distribution	12	8	1	0
Customers	32	34	2	0

Table 37A: Value-adding relations of High-Tech firms located in the MCR of Munich
(See Figure 54; author's calculation)

	Number of relations along the value chain			
Value chain elements	Regional Scale	National Scale	European Scale	Global Scale
R&D	14	17	4	7
Processing	10	11	11	5
Financing	11	6	2	1
Marketing	12	7	3	0
Sales & Distribution	9	9	3	5
Customers	15	21	11	6

Table 38A: Business relations along the value chain in the MCR of Munich – Summary
(See Figure 53 and 54; author's calculation)

	Regional Scale	National Scale	European Scale	Global Scale
APS	54%	40%	6%	<1%
High-Tech	35%	35%	18%	12%

Table 39A: Regional connectivity of APS firms in the Rhine-Ruhr region
(See Figure 55; author's calculation)

	Bochum	Bonn	Dortmund	Düsseldorf	Duisburg	Essen	Cologne
Bochum		0,13	0,27	0,28	0,25	0,19	0,28
Bonn			0,17	0,26	0,18	0,13	0,31
Dortmund				0,63	0,37	0,35	0,57
Düsseldorf					0,34	0,48	1,00
Duisburg						0,24	0,33
Essen							0,45
Cologne							

Table 40A: Regional connectivity of High-Tech firms in the Rhine-Ruhr region
(See Figure 56; author's calculation)

	Bochum	Bonn	Dortmund	Düsseldorf	Duisburg	Essen	Cologne
Bochum		0,19	0,21	0,83	0,54	0,57	0,50
Bonn			0,28	0,71	0,27	0,19	0,36
Dortmund				0,53	0,57	0,27	0,51
Düsseldorf					0,79	0,71	1,00
Duisburg						0,67	0,51
Essen							0,36
Cologne							

Table 41A: Geographical vs. relational proximity of APS firms in the Rhine-Ruhr region (See Figure 57; author's calculation)

	Aachen	Arnsberg	Bocholt	Boschum	Bonn	Dortmund	Dueren	Düsseldorf	Duisburg	Essen	Euskirchen	Gummers-bach	Hagen	Hamm	Iserlohn	Kleve	Koblenz	Cologne	Krefeld	Lippstadt	Mönchen-Gladbach	Münster	Siegen	Wülfrath	Wuppertal	Geleen	Venlo
Aachen		0,020	0,018	0,068	0,046	0,093	0,040	0,144	0,076	0,091	0,011	0,022	0,043	0,024	0,019	0,022	0,064	0,140	0,037	0,020	0,051	0,054	0,051	0,004	0,057	0,000	0,018
Arnsberg			0,019	0,029	0,023	0,038	0,008	0,033	0,031	0,038	0,002	0,013	0,023	0,015	0,020	0,015	0,018	0,028	0,017	0,017	0,019	0,029	0,025	0,005	0,029	0,000	0,000
Bocholt				0,043	0,025	0,047	0,011	0,034	0,044	0,028	0,006	0,009	0,028	0,019	0,020	0,019	0,022	0,031	0,017	0,019	0,023	0,044	0,028	0,003	0,034	0,010	0,010
Boschum					0,050	0,106	0,017	0,111	0,100	0,075	0,013	0,038	0,052	0,031	0,037	0,031	0,051	0,112	0,037	0,029	0,046	0,061	0,057	0,011	0,071	0,004	0,021
Bonn						0,069	0,021	0,104	0,070	0,053	0,023	0,029	0,045	0,031	0,025	0,032	0,076	0,121	0,041	0,023	0,039	0,034	0,051	0,004	0,052	0,000	0,014
Dortmund							0,020	0,251	0,144	0,137	0,010	0,040	0,076	0,052	0,042	0,039	0,111	0,227	0,043	0,029	0,057	0,120	0,065	0,015	0,108	0,000	0,026
Dueren								0,018	0,027	0,019	0,010	0,013	0,017	0,013	0,013	0,013	0,014	0,035	0,017	0,013	0,032	0,008	0,020	0,002	0,019	0,000	0,000
Düsseldorf									0,134	0,189	0,013	0,042	0,072	0,052	0,040	0,042	0,121	0,395	0,061	0,021	0,059	0,143	0,070	0,017	0,109	0,004	0,032
Duisburg										0,093	0,013	0,020	0,068	0,046	0,040	0,040	0,061	0,132	0,052	0,029	0,038	0,073	0,048	0,008	0,090	0,004	0,029
Essen											0,010	0,024	0,071	0,042	0,040	0,032	0,077	0,176	0,037	0,021	0,039	0,071	0,052	0,010	0,087	0,000	0,017
Euskirchen												0,010	0,010	0,006	0,007	0,010	0,006	0,027	0,017	0,006	0,019	0,002	0,011	0,001	0,015	0,000	0,006
Gummersbach													0,016	0,013	0,013	0,013	0,019	0,057	0,013	0,010	0,029	0,010	0,024	0,010	0,038	0,000	0,006
Hagen														0,042	0,043	0,034	0,049	0,054	0,027	0,025	0,028	0,032	0,039	0,007	0,045	0,000	0,018
Hamm															0,024	0,023	0,029	0,030	0,019	0,015	0,021	0,020	0,022	0,005	0,031	0,000	0,004
Iserlohn																0,022	0,025	0,024	0,023	0,020	0,021	0,020	0,026	0,005	0,030	0,000	0,004
Kleve																	0,024	0,029	0,025	0,015	0,025	0,010	0,028	0,005	0,035	0,000	0,013
Koblenz																		0,128	0,030	0,017	0,033	0,057	0,049	0,008	0,062	0,000	0,016
Cologne																			0,059	0,017	0,061	0,154	0,070	0,014	0,109	0,004	0,039
Krefeld																				0,023	0,034	0,029	0,028	0,004	0,043	0,000	0,009
Lippstadt																					0,021	0,030	0,022	0,003	0,021	0,000	0,000
Mönchen-Gladbach																						0,019	0,038	0,010	0,049	0,000	0,013
Münster																							0,041	0,003	0,058	0,004	0,009
Siegen																								0,005	0,056	0,000	0,008
Wülfrath																									0,014	0,000	0,004
Wuppertal																										0,000	0,015
Geleen																											0,008
Venlo																											

Table 42A: Geographical vs. relational proximity of High-Tech firms in the Rhine-Ruhr region (See Figure 58; author's calculation)

	Aachen	Arnsberg	Bocholt	Bochum	Bonn	Dortmund	Dueren	Düsseldorf	Duisburg	Essen	Euskirchen	Gummers-bach	Hagen	Hamm	Iserlohn	Kleve	Koblenz	Cologne	Krefeld	Lippstadt	Mönchen-Gladbach	Münster	Siegen	Wülfrath	Wuppertal	Geleen	Venlo
Aachen		0,013	0,006	0,019	0,057	0,048	0,006	0,045	0,029	0,029	0,006	0,000	0,013	0,010	0,010	0,000	0,019	0,026	0,023	0,006	0,016	0,019	0,006	0,006	0,034	0,016	0,000
Arnsberg			0,006	0,016	0,013	0,023	0,002	0,019	0,029	0,016	0,000	0,002	0,016	0,006	0,006	0,000	0,016	0,015	0,013	0,000	0,011	0,015	0,010	0,006	0,015	0,000	0,000
Bocholt				0,006	0,006	0,006	0,000	0,006	0,010	0,006	0,000	0,003	0,006	0,000	0,000	0,000	0,006	0,006	0,006	0,000	0,024	0,006	0,006	0,000	0,006	0,000	0,003
Bochum					0,029	0,032	0,010	0,126	0,082	0,087	0,006	0,003	0,026	0,016	0,027	0,000	0,029	0,076	0,058	0,016	0,048	0,029	0,044	0,006	0,039	0,006	0,016
Bonn						0,042	0,006	0,108	0,040	0,029	0,021	0,000	0,023	0,006	0,027	0,000	0,048	0,055	0,048	0,006	0,023	0,029	0,026	0,006	0,032	0,013	0,000
Dortmund							0,003	0,081	0,087	0,040	0,003	0,000	0,045	0,023	0,016	0,000	0,048	0,078	0,034	0,006	0,034	0,058	0,026	0,016	0,031	0,006	0,006
Dueren								0,006	0,006	0,006	0,006	0,002	0,003	0,000	0,000	0,000	0,003	0,008	0,006	0,000	0,008	0,002	0,003	0,000	0,008	0,000	0,000
Düsseldorf									0,120	0,108	0,019	0,003	0,090	0,029	0,068	0,000	0,071	0,152	0,103	0,006	0,102	0,058	0,068	0,026	0,058	0,036	0,016
Duisburg										0,102	0,023	0,000	0,045	0,019	0,032	0,000	0,047	0,078	0,053	0,000	0,053	0,019	0,078	0,010	0,031	0,013	0,023
Essen											0,006	0,000	0,029	0,016	0,023	0,000	0,024	0,055	0,048	0,023	0,047	0,032	0,032	0,010	0,048	0,019	0,036
Euskirchen												0,000	0,000	0,000	0,002	0,000	0,013	0,006	0,006	0,000	0,006	0,000	0,016	0,000	0,010	0,000	0,000
Gummersbach													0,003	0,000	0,000	0,000	0,000	0,011	0,000	0,000	0,002	0,002	0,013	0,000	0,002	0,000	0,006
Hagen														0,006	0,013	0,000	0,023	0,026	0,019	0,000	0,019	0,023	0,045	0,006	0,024	0,006	0,000
Hamm															0,013	0,000	0,016	0,037	0,021	0,016	0,016	0,006	0,006	0,006	0,026	0,000	0,000
Iserlohn																0,000	0,013	0,013	0,029	0,000	0,023	0,006	0,018	0,006	0,019	0,006	0,000
Kleve																	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Koblenz																		0,036	0,029	0,000	0,024	0,042	0,013	0,010	0,026	0,000	0,006
Cologne																			0,081	0,000	0,039	0,057	0,053	0,006	0,055	0,003	0,010
Krefeld																				0,000	0,029	0,019	0,026	0,006	0,071	0,006	0,010
Lippstadt																					0,000	0,000	0,000	0,000	0,000	0,006	0,000
Mönchen-Gladbach																						0,018	0,019	0,010	0,024	0,006	0,000
Münster																							0,016	0,006	0,024	0,000	0,016
Siegen																								0,000	0,029	0,003	0,010
Wülfrath																									0,006	0,016	0,000
Wuppertal																										0,000	0,015
Geleen																											0,000
Venlo																											

Table 43A: International connectivity of APS firms in the Rhine-Ruhr region
(See Figure 59; author's calculation)

Düsseldorf

R	FUA	CI
1	Munich	719
2	Frankfurt	704
3	Hamburg	610
4	Berlin	605
5	Stuttgart	478
6	London	454
7	New York	439
8	Paris	432
9	Cologne	378
10	Vienna	356
etc.	…	…
Interlock Connectivity = 54063		

Cologne

R	FUA	CI
1	Hamburg	639
2	Munich	579
3	Berlin	552
4	Stuttgart	527
5	Frankfurt	521
6	Düsseldorf	378
7	Vienna	314
8	Hanover	313
9	Nuremberg	297
10	London	292
etc.	…	…
Interlock Connectivity = 45108		

Dortmund

R	FUA	CI
1	Hamburg	316
2	Berlin	300
3	Munich	295
4	Frankfurt	260
5	Stuttgart	252
6	Düsseldorf	240
7	Hanover	220
8	Cologne	217
9	Bremen	196
10	Dresden	192
etc.	…	…
Interlock Connectivity = 26273		

Essen

R	FUA	CI
1	Frankfurt	241
2	Berlin	228
3	Hamburg	226
4	Munich	222
5	Stuttgart	203
6	Düsseldorf	181
7	Cologne	169
8	Hanover	159
9	Dresden	146
10	Nuremberg	141
etc.	…	…
Interlock Connectivity = 23920		

Duisburg

R	FUA	CI
1	Hamburg	198
2	Berlin	166
3	Frankfurt	149
4=	Munich	148
4=	Stuttgart	148
6	Dortmund	138
7	Düsseldorf	128
8	Cologne	126
9	Bremen	121
10	Hanover	116
etc.	…	…
Interlock Connectivity = 19435		

Bonn

R	FUA	CI
1	Hamburg	157
2	Berlin	147
3	Frankfurt	140
4	Stuttgart	132
5	Munich	121
6	Cologne	116
7	Paris	109
8	Hanover	104
9	Düsseldorf	100
10	Bremen	88
etc.	…	…
Interlock Connectivity = 18756		

Bochum

R	FUA	CI
1	Hamburg	166
2	Munich	138
3=	Berlin	129
3=	Frankfurt	129
5	Bremen	123
6	Stuttgart	118
7	Mannheim	113
8	Cologne	107
9	Düsseldorf	106
10	Dortmund	102
etc.	…	…
Interlock Connectivity = 15466		

(R=Rank; CI=City Interlock; FUA=Functional Urban Area)

Table 44A: International connectivity of High-Tech firms in the Rhine-Ruhr region
(See Figure 60; author’s calculation)

Düsseldorf

R	FUA	CI
1	Shanghai	230
2	Sao Paulo	220
3	Hamburg	198
4	Paris	186
5	Moscow	183
6	Tokyo	178
7=	Stuttgart	168
7=	Singapore	168
9	Vienna	167
10	Munich	162
etc.	…	…
Interlock Connectivity = 26004		

Cologne

R	FUA	CI
1	Shanghai	184
2	Singapore	180
3	Sao Paulo	170
4	Paris	152
5	Milan	145
6	Mexico City	142
7	Moscow	140
8	Buenos Aires	135
9	Johannesburg	134
10	Tokyo	133
etc.	…	…
Interlcok Connectivity = 21921		

Duisburg

R	FUA	CI
1	Munich	144
2	Singapore	111
3	Hamburg	98
4	Sao Paulo	95
5	Shanghai	94
6	Tokyo	93
7	Paris	91
8	Berlin	90
9	Vienna	89
10	Milan	88
etc.	…	…
Interlock Connectivity = 13758		

Bochum

R	FUA	CI
1=	Shanghai	78
1=	Düsseldorf	78
3	Sao Paulo	77
4	Stuttgart	76
5=	Paris	72
5=	Singapore	72
7	Berlin	68
8	Munich	66
9	Vienna	65
10	Madrid	63
etc.	…	…
Interlock Connectivity = 12907		

Essen

R	FUA	CI
1	Stuttgart	83
2	Munich	80
3	Singapore	70
4	Shanghai	68
5	Düsseldorf	67
6	Berlin	66
7	Sao Paulo	65
8=	Hamburg	63
8=	Duisburg	63
10	Budapest	62
etc.	…	…
Interloch Connectivity = 11795		

Dortmund

R	FUA	CI
1	Stuttgart	100
2	Hamburg	92
3	Berlin	84
4	Munich	83
5	Moscow	78
6	Singapore	74
7	Prague	69
8	Istanbul	68
9=	Sao Paulo	65
9=	Mannheim	65
etc.	…	…
Interlock Connectivity = 10586		

Bonn

R	FUA	CI
1	Shanghai	96
2	Hamburg	95
3	Munich	86
4	Sao Paulo	83
5	Berlin	76
6	Paris	74
7	Prague	71
8=	Singapore	68
8=	Milan	68
8=	Tokyo	68
etc.	…	…
Interlock Connectivity = 10425		

(R=Rank; CI=City Interlock; FUA=Functional Urban Area)

Table 45A: Global and regional connectivity in the MCR of Rhine-Ruhr (See Figure 61; author's calculation)

Global connectivity - APS

R	FUA	Gross Connectivity	Proportionate Connectivity (1,00 = Düsseldorf)
1	Düsseldorf	20.632	1,00
2	Cologne	15.001	0,73
3	Essen	7.183	0,35
4	Dortmund	7.134	0,35
5	Bonn	6.418	0,31
6	Duisburg	5.627	0,27
7	Bochum	3.790	0,18

Regional connectivity - APS

R	FUA	Gross Connectivity	Proportionate Connectivity (1,00 = Düsseldorf)
1	Düsseldorf	1.133	1,00
2	Cologne	1.113	0,98
3	Dortmund	894	0,79
4	Essen	693	0,61
5	Duisburg	644	0,57
6	Bochum	531	0,47
7	Bonn	448	0,40

Global connectivity - High-Tech

R	FUA	Gross Connectivity	Proportionate Connectivity (1,00 = Düsseldorf)
1	Düsseldorf	11.684	1,00
2	Cologne	10.871	0,93
3	Bochum	5.888	0,50
4	Duisburg	5.807	0,50
5	Essen	5.200	0,45
6	Bonn	4.255	0,36
7	Dortmund	4.105	0,35

Regional connectivity - High-Tech

R	FUA	Gross Connectivity	Proportionate Connectivity (1,00 = Düsseldorf)
1	Düsseldorf	430	1,00
2	Duisburg	315	0,73
3	Cologne	305	0,71
4	Bochum	268	0,62
5	Essen	261	0,61
6	Dortmund	223	0,52
7	Bonn	188	0,44

(R = Rank)

Table 46A: APS significance of FUAs in the MCR of Rhine-Ruhr in comparison to each other (See Figure 62; author's calculation)

Rank	**FUA**	**Gross Connectivity**	**Sum of employees and inhabitants**	**Significance Index**
1	Düsseldorf	54.063	1.510.755	2,11
2	Essen	23.920	978.850	1,44
3	Dortmund	26.273	1.243.046	1,25
4	Cologne	45.108	2.533.031	1,05
5	Bonn	18.756	1.516.577	0,73
6	Duisburg	19.435	2.147.270	0,53
7	Bochum	15.466	2.067.019	0,44

Table 47A: High-Tech significance of FUAs in the MCR of Rhine-Ruhr in comparison to each other
(See Figure 63; author's calculation)

Rank	**FUA**	**Gross Connectivity**	**Sum of employees and inhabitants**	**Significance Index**
1	Düsseldorf	26.004	1.510.755	1,92
2	Essen	11.795	978.850	1,35
3	Cologne	21.921	2.533.031	0,97
4	Dortmund	10.586	1.243.046	0,95
5	Bonn	10.425	1.516.577	0,77
6	Duisburg	13.758	2.147.270	0,72
7	Bochum	12.907	2.067.019	0,70

Table 48A: Value-adding relations of APS firms located in the MCR of Rhine-Ruhr
(See Figure 64; author's calculation)

	Number of relations along the value chain			
Value chain elements	Regional Scale	National Scale	European Scale	Global Scale
R&D	10	10	2	1
Processing	7	11	2	2
Financing	10	3	2	1
Marketing	11	8	1	0
Sales & Distribution	5	4	1	0
Customers	23	14	4	2

Table 49A: Value-adding relations of High-Tech firms located in the MCR of Rhine-Ruhr
(See Figure 65; author's calculation)

	Number of relations along the value chain			
Value chain elements	Regional Scale	National Scale	European Scale	Global Scale
R&D	8	9	4	2
Processing	3	8	5	3
Financing	2	8	2	0
Marketing	5	6	0	0
Sales & Distribution	2	0	1	4
Customers	5	4	3	2

Table 50A: Business relations along the value chain in the MCR of Rhine-Ruhr – Summary
(See Figure 64 and 65; author's calculation)

	Regional Scale	**National Scale**	**European Scale**	**Global Scale**
APS	49%	37%	9%	5%
High-Tech	29%	41%	17%	13%

Table 51A: Intra-firm networks of APS firms in the Upper Rhine region (See Figure 66; author's calculation)

	BBA	BUE	FRA	FREI	KAR	LAN	LÖR	OFF	STU	WEIL	WEIN	COL	BUE	HAG	MUL	STL	STR	THA	LUX	AAR	BAD	BAS	BRU	LENZ	LIES	OLT	SOL	ZUR
Baden Baden (BBA)		0,02	0,21	0,10	0,08	0,05	0,06	0,07	0,25	0,03	0,03	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,00	0,00	0,03	0,01	0,00	0,03	0,00	0,00	0,14
Buehl (BUE)			0,10	0,02	0,02	0,12	0,01	0,04	0,10	0,01	0,00	0,00	0,00	0,00	0,03	0,00	0,03	0,00	0,07	0,00	0,00	0,03	0,01	0,00	0,00	0,00	0,00	0,06
Frankfurt (FRA)				1,08	0,99	0,16	0,25	0,54	4,32	0,21	0,05	0,04	0,00	0,00	0,23	0,04	0,68	0,00	1,75	0,15	0,11	1,18	0,08	0,04	0,12	0,00	0,00	2,59
Freiburg (FREI)					0,42	0,11	0,13	0,27	1,08	0,07	0,00	0,05	0,00	0,00	0,08	0,04	0,20	0,00	0,32	0,08	0,03	0,34	0,05	0,04	0,03	0,00	0,00	0,42
Karlsruhe (KAR)						0,08	0,09	0,27	1,14	0,03	0,00	0,04	0,00	0,00	0,07	0,03	0,14	0,00	0,29	0,03	0,03	0,23	0,04	0,04	0,04	0,00	0,00	0,54
Landau (LAN)							0,07	0,10	0,16	0,03	0,00	0,00	0,00	0,00	0,01	0,00	0,01	0,00	0,05	0,00	0,01	0,03	0,01	0,00	0,01	0,00	0,00	0,06
Lörrach (LÖR)								0,13	0,19	0,08	0,00	0,00	0,00	0,00	0,04	0,00	0,02	0,00	0,08	0,00	0,04	0,08	0,01	0,00	0,04	0,00	0,00	0,10
Offenburg (OFF)									0,49	0,06	0,01	0,03	0,00	0,00	0,09	0,03	0,10	0,00	0,13	0,00	0,03	0,21	0,03	0,04	0,03	0,00	0,00	0,25
Stuttgart (STU)										0,14	0,03	0,07	0,00	0,00	0,28	0,05	0,68	0,00	1,14	0,12	0,14	1,28	0,11	0,06	0,14	0,00	0,00	2,03
Weil (WEIL)											0,00	0,00	0,00	0,00	0,04	0,00	0,02	0,00	0,07	0,00	0,04	0,11	0,01	0,00	0,04	0,00	0,00	0,09
Weingarten (WEIN)												0,00	0,00	0,00	0,01	0,00	0,01	0,00	0,00	0,00	0,00	0,06	0,00	0,00	0,00	0,00	0,00	0,05
Colmar (COL)													0,00	0,00	0,03	0,03	0,04	0,00	0,01	0,00	0,00	0,04	0,03	0,00	0,00	0,00	0,00	0,04
Guebwiller (GUE)														0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Haguenau (HAG)															0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Mulhouse (MUL)																0,03	0,14	0,00	0,08	0,00	0,03	0,25	0,03	0,00	0,07	0,00	0,00	0,20
Saint Louis (STL)																	0,04	0,00	0,00	0,00	0,00	0,03	0,03	0,00	0,00	0,00	0,00	0,04
Strasbourg (STR)																		0,00	0,37	0,10	0,04	0,49	0,04	0,00	0,01	0,00	0,00	0,58
Thann (THA)																			0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Luxembourg (LUX)																				0,16	0,07	0,60	0,01	0,00	0,01	0,00	0,03	1,45
Aarau (AAR)																					0,00	0,08	0,00	0,00	0,00	0,00	0,00	0,10
Baden (BAD)																						0,12	0,00	0,00	0,03	0,00	0,00	0,05
Basel (BAS)																							0,04	0,06	0,12	0,00	0,07	1,00
Brugg (BRU)																								0,00	0,00	0,00	0,00	0,08
Lenzburg (LENZ)																									0,00	0,00	0,00	0,06
Liestal (LIES)																										0,00	0,00	0,09
Olten (OLT)																											0,00	0,00
Solothurn (SOL)																												0,00
Zurich (ZUR)																												

Table 52A: Intra-firm networks of High-Tech firms in the Upper Rhine region (See Figure 67; author's calculation)

	BBA	BUE	FRA	FREI	KAR	LAN	LÖR	OFF	STU	WEIL	WEIN	COL	GUE	HAG	MUL	STL	STR	THA	LUX	AAR	BAD	BAS	BRU	LENZ	LIES	OLT	SOL	ZUR
Baden Baden (BBA)		0,00	0,09	0,02	0,18	0,02	0,00	0,00	0,65	0,00	0,00	0,07	0,00	0,00	0,18	0,00	0,18	0,00	0,09	0,00	0,15	0,11	0,00	0,09	0,00	0,00	0,00	0,33
Buehl (BUE)			0,15	0,09	0,18	0,02	0,00	0,22	0,44	0,00	0,15	0,00	0,00	0,22	0,02	0,00	0,09	0,00	0,04	0,00	0,07	0,00	0,00	0,07	0,00	0,00	0,07	0,04
Frankfurt (FRA)				0,38	1,04	0,09	0,04	0,05	2,47	0,15	0,13	0,07	0,00	0,11	0,15	0,25	0,80	0,00	0,62	0,00	0,27	0,71	0,05	0,13	0,04	0,18	0,13	1,56
Freiburg (FREI)					0,35	0,04	0,00	0,00	0,76	0,00	0,00	0,00	0,00	0,11	0,02	0,00	0,02	0,00	0,20	0,00	0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,35
Karlsruhe (KAR)						0,04	0,00	0,11	1,62	0,00	0,29	0,11	0,07	0,33	0,11	0,00	0,29	0,00	0,18	0,07	0,25	0,31	0,00	0,11	0,00	0,15	0,11	0,64
Landau(LAN)							0,00	0,00	0,20	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,02	0,00	0,07	0,00	0,00	0,07	0,00	0,00	0,00	0,00	0,00	0,15
Lörrach (LÖR)								0,00	0,36	0,07	0,00	0,15	0,00	0,00	0,22	0,04	0,00	0,00	0,00	0,00	0,00	0,18	0,04	0,00	0,15	0,00	0,00	0,04
Offenburg (OFF)									0,18	0,00	0,20	0,00	0,07	0,24	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,07	0,00	0,02	0,00	0,11	0,02	0,04
Stuttgart (STU)										0,15	0,49	0,33	0,25	0,49	0,40	0,22	1,49	0,00	0,75	0,07	0,67	1,40	0,16	0,42	0,04	0,18	0,24	2,67
Weil (WEIL)											0,00	0,00	0,00	0,00	0,00	0,16	0,00	0,00	0,00	0,00	0,00	0,45	0,07	0,00	0,07	0,00	0,00	0,07
Weingarten (WEIN)												0,00	0,18	0,18	0,00	0,00	0,07	0,00	0,15	0,00	0,09	0,18	0,00	0,27	0,00	0,22	0,09	0,04
Colmar (COL)													0,00	0,00	0,22	0,00	0,07	0,00	0,00	0,00	0,07	0,11	0,00	0,00	0,00	0,00	0,00	0,15
Guebwiller (GUE)														0,07	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,00	0,00	0,07	0,00	0,00
Haguenau (HAG)															0,00	0,00	0,00	0,07	0,04	0,00	0,00	0,09	0,00	0,00	0,00	0,07	0,00	0,00
Mulhouse (MUL)																0,04	0,16	0,00	0,15	0,00	0,11	0,18	0,00	0,00	0,07	0,00	0,04	0,40
Saint Louis (STL)																	0,16	0,00	0,00	0,00	0,00	0,44	0,00	0,00	0,04	0,00	0,00	0,11
Strasbourg (STR)																		0,00	0,29	0,00	0,29	0,60	0,00	0,15	0,00	0,00	0,07	0,76
Thann (THA)																			0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Luxembourg (LUX)																				0,00	0,15	0,16	0,00	0,02	0,00	0,00	0,00	0,89
Aarau (AAR)																					0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Baden(BAD)																						0,11	0,00	0,09	0,00	0,04	0,11	0,45
Basel (BAS)																							0,16	0,00	0,18	0,11	0,00	1,00
Brugg (BRU)																								0,00	0,04	0,00	0,00	0,18
Lenzburg (LENZ)																									0,00	0,04	0,09	0,04
Liestal (LIES)																										0,00	0,00	0,00
Olten (OLT)																											0,04	0,07
Solothurn (SOL)																												0,09
Zurich (ZUR)																												

Table 53A: APS significance of FUAs in the Upper Rhine region in comparison to each other
(See Figure 70; author's calculation)

Rank	FUA	Gross Connectivity	Sum of employees and inhabitants	Significance Index
1	Basel	35.697	629.170	2,42
2	Aarau	8.373	212.856	1,68
3	Strasbourg	27.664	1.036.976	1,14
4	Freiburg	19.658	753.744	1,11
5	Karlsruhe	15.762	659.022	1,02
6	Weil	2.614	116.348	0,96
7	Offenburg	10.111	461.882	0,94
8	Mulhouse	8.306	541.712	0,66
9	Liestal	2.430	161.979	0,64
10	Baden Baden	3.591	260.528	0,59
11	Brugg	2.997	239.166	0,54
12	Buehl	2.711	251.073	0,46
13	Lörrach	3.960	381.301	0,44
14	Landau	2.508	272.832	0,39
15	Colmar	2.513	384.523	0,28

Table 54A: High-Tech significance of FUAs in the Upper Rhine region in comparison to each other
(See Figure 71; author's calculation)

Rank	FUA	Gross Connectivity	Sum of employees and inhabitants	Significance Index
1	Saint Louis	2.266	77.513	1,98
2	Baden	7.070	254.738	1,88
3	Basel	15.551	629.170	1,68
4	Baden Baden	5.631	260.528	1,47
5	Weil	2.418	116.348	1,41
6	Karlsruhe	13.310	659.022	1,37
7	Weingarten	4.662	314.330	1,01
8	Buehl	3.610	251.073	0,98
9	Mulhouse	7.443	541.712	0,93
10	Strasbourg	12.838	1.036.976	0,84
11	Colmar	4.106	384.523	0,72
12	Haguenau	2.887	296.006	0,66
13	Landau	2.221	272.832	0,55
14	Lörrach	2.839	381.301	0,51
15	Freiburg	4.988	753.744	0,45

Global network connectivity of individual economic sectors

Advanded Producer Services (APS)

Table 55A: Accounting connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = New York)
1	New York	United States of America	20.726	1,00
2	Tokyo	Japan	18.056	0,87
3	Paris	France	17.957	0,87
4	London	United Kingdom	17.578	0,85
5	Dubai	United Arab Emirates	13.990	0,67
6	Frankfurt	Germany	13.644	0,66
7	Berlin	Germany	13.603	0,66
8	Amsterdam	Netherlands	13.414	0,65
9	Moscow	Russia	13.362	0,64
10	Milan	Italy	13.212	0,64
11	Toronto	Canada	13.142	0,63
12	Shanghai	China	13.118	0,63
13	Vienna	Austria	13.093	0,63
14	Hong Kong	China	12.700	0,61
15	Zug	Switzerland	12.265	0,59
16	Madrid	Spain	12.183	0,59
17	São Paulo	Brazil	12.160	0,59
18	Sydney	Australia	12.053	0,58
19	Zurich	Switzerland	11.826	0,57
20	Istanbul	Turkey	11.763	0,57
21	Dublin	Ireland	11.761	0,57
22	Miami	United States of America	11.679	0,56
23	Copenhagen	Denmark	11.629	0,56
24	Lisbon	Portugal	11.540	0,56
25	Warsaw	Poland	11.524	0,56
26	Bruxelles	Belgium	11.132	0,54
27=	Riyadh	Saudi Arabia	11.091	0,54
27=	Los Angeles	United States of America	11.091	0,54
29	Luxembourg	Luxembourg	11.079	0,53
30	Barcelona	Spain	11.019	0,53
31	Mumbai	India	10.988	0,53
32	Munich	Germany	10.940	0,53
33	Rotterdam	Netherlands	10.787	0,52
34	Prague	Czech Republic	10.759	0,52
35	Nicosia	Cyprus	10.741	0,52
36	Stuttgart	Germany	10.679	0,52
37	Singapore	Singapore	10.655	0,51
38=	Valletta	Malta	10.631	0,51
38=	Budapest	Hungary	10.631	0,51
40	Gothenburg	Sweden	10.610	0,51

Table 56A: Management- and IT-Consulting connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = New York)
1	New York	United States of America	15.611	1,00
2	London	United Kingdom	11.520	0,74
3	Toronto	Canada	11.320	0,73
4	Stockholm	Sweden	11.207	0,72
5	Singapore	Singapore	11.029	0,71
6	Milan	Italy	10.491	0,67
7	Boston	United States of America	10.327	0,66
8	Bruxelles	Belgium	10.286	0,66
9	Washington	United States of America	10.232	0,66
10	Mumbai	India	10.109	0,65
11	Kuala Lumpur	Malaysia	9.748	0,62
12	Prague	Czech Republic	9.684	0,62
13	Helsinki/Espoo/Vantaa	Finland	9.659	0,62
14	Munich	Germany	9.560	0,61
15	Sydney	Australia	9.514	0,61
16	Paris	France	9.369	0,60
17	Rome	Italy	9.188	0,59
18	Vienna	Austria	9.151	0,59
19	Warsaw	Poland	9.093	0,58
20	Zurich	Switzerland	9.039	0,58
21	Frankfurt	Germany	9.016	0,58
22	Shanghai	China	8.925	0,57
23	Hamburg	Germany	8.791	0,56
24	Oslo	Norway	8.777	0,56
25	Hong Kong	China	8.707	0,56
26	San Francisco	United States of America	8.638	0,55
27	Copenhagen	Denmark	8.544	0,55
28	Philadelphia	United States of America	8.473	0,54
29	Madrid	Spain	8.415	0,54
30	Atlanta	United States of America	8.411	0,54
31	Amsterdam	Netherlands	8.100	0,52
32	Taipei	Taiwan	8.079	0,52
33	Berlin	Germany	8.013	0,51
34	Houston	United States of America	7.912	0,51
35	Los Angeles	United States of America	7.860	0,50
36	Stuttgart	Germany	7.798	0,50
37	Mexico City	Mexico	7.702	0,49
38	Dusseldorf	Germany	7.679	0,49
39	Beijing	China	7.657	0,49
40	Bratislava	Slovakia	7.654	0,49

Table 57A: Design, Architecture & Engineering connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Stuttgart)
1	Stuttgart	Germany	3.744	1,00
2	Munich	Germany	3.736	1,00
3	Hamburg	Germany	3.288	0,88
4	Berlin	Germany	2.551	0,68
5	Frankfurt	Germany	2.311	0,62
6	Cologne	Germany	2.178	0,58
7	Paris	France	2.140	0,57
8	Bremen	Germany	2.074	0,55
9	Barcelona	Spain	1.647	0,44
10	Leipzig	Germany	1.540	0,41
11	Mannheim	Germany	1.501	0,40
12	Madrid	Spain	1.456	0,39
13	Warsaw	Poland	1.419	0,38
14	Dusseldorf	Germany	1.333	0,36
15	Zurich	Switzerland	1.332	0,36
16	Wiesbaden	Germany	1.283	0,34
17	Vienna	Austria	1.272	0,34
18	Prague	Czech Republic	1.263	0,34
19	Bratislava	Slovakia	1.248	0,33
20	Toulouse	France	1.247	0,33
21	Bucharest	Romania	1.228	0,33
22	Nuremberg	Germany	1.213	0,32
23	Augsburg	Germany	1.196	0,32
24	Shanghai	China	1.194	0,32
25	Hanover	Germany	1.186	0,32
26	Erfurt	Germany	1.146	0,31
27	Ulm	Germany	1.139	0,30
28	Bochum	Germany	1.101	0,29
29	Wolfsburg	Germany	1.079	0,29
30	Budapest	Hungary	1.035	0,28
31	São Paulo	Brazil	1.033	0,28
32	Dresden	Germany	1.022	0,27
33	Turin	Italy	1.017	0,27
34	Ingolstadt	Germany	990	0,26
35	Moscow	Russia	938	0,25
36	Milan	Italy	933	0,25
37	Gothenburg	Sweden	893	0,24
38	Aachen	Germany	883	0,24
39	Regensburg	Germany	844	0,23
40	Kiel	Germany	833	0,22

Table 58A: Banking & Finance connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Frankfurt)
1	Frankfurt	Germany	10.530	1,00
2	Hamburg	Germany	9.372	0,89
3	Berlin	Germany	8.598	0,82
4	Munich	Germany	8.129	0,77
5	Dusseldorf	Germany	6.671	0,63
6	New York	United States of America	6.655	0,63
7	Stuttgart	Germany	5.896	0,56
8	Singapore	Singapore	5.827	0,55
9	Dortmund	Germany	5.663	0,54
10	Milan	Italy	5.652	0,54
11	Madrid	Spain	5.550	0,53
12	Dresden	Germany	5.469	0,52
13	Nuremberg	Germany	5.362	0,51
14	Bonn	Germany	5.330	0,51
15	Hanover	Germany	5.299	0,50
16	London	United Kingdom	5.278	0,50
17	Mannheim	Germany	5.269	0,50
18	Luxembourg	Luxembourg	5.262	0,50
19	Warsaw	Poland	5.002	0,48
20	Kiel	Germany	4.975	0,47
21	Essen	Germany	4.962	0,47
22	Paris	France	4.757	0,45
23	Cologne	Germany	4.711	0,45
24	Regensburg	Germany	4.677	0,44
25	Tokyo	Japan	4.643	0,44
26	Mumbai	India	4.551	0,43
27	Bremen	Germany	4.521	0,43
28	Luebeck	Germany	4.513	0,43
29	Augsburg	Germany	4.450	0,42
30	Wiesbaden	Germany	4.428	0,42
31	Bielefeld	Germany	4.382	0,42
32	Zurich	Switzerland	4.375	0,42
33	Moenchen-Gladbach	Germany	4.285	0,41
34	Amsterdam	Netherlands	4.264	0,40
35	Wuppertal	Germany	4.259	0,40
36	Hagen	Germany	4.253	0,40
37	Bochum	Germany	4.218	0,40
38	Rostock	Germany	4.210	0,40
39	Moscow	Russia	4.141	0,39
40	Bruxelles	Belgium	4.138	0,39

Table 59A: Information & Communication Services connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Paris)
1	Paris	France	5.041	1,00
2	Singapore	Singapore	4.928	0,98
3	Munich	Germany	4.858	0,96
4	Madrid	Spain	4.139	0,82
5	Beijing	China	3.432	0,68
6	Hong Kong	China	3.363	0,67
7	Vienna	Austria	3.329	0,66
8	Tokyo	Japan	3.328	0,66
9	Kuala Lumpur	Malaysia	3.298	0,65
10	Istanbul	Turkey	3.255	0,65
11	Stockholm	Sweden	3.222	0,64
12	Bruxelles	Belgium	3.213	0,64
13	Sydney	Australia	3.188	0,63
14	London	United Kingdom	3.147	0,62
15	Mexico City	Mexico	3.114	0,62
16	Warsaw	Poland	3.096	0,61
17	San Jose Palo Alto	United States of America	3.095	0,61
18	Milan	Italy	3.076	0,61
19	Zurich	Switzerland	2.999	0,59
20	Luxembourg	Luxembourg	2.916	0,58
21	Berlin	Germany	2.912	0,58
22	Dubai	United Arab Emirates	2.892	0,57
23	Seattle	United States of America	2.872	0,57
24	Johannesburg	South Africa	2.744	0,54
25	Moscow	Russia	2.699	0,54
26	Frankfurt	Germany	2.667	0,53
27	Washington	United States of America	2.621	0,52
28	Bangkok	Thailand	2.580	0,51
29	Buenos Aires	Argentinia	2.573	0,51
30	Taipei	Taiwan	2.552	0,51
31	New York	United States of America	2.543	0,50
32	Dallas	United States of America	2.539	0,50
33	São Paulo	Brazil	2.509	0,50
34	Budapest	Hungary	2.481	0,49
35=	Santiago de Chile	Chile	2.452	0,49
35=	Atlanta	United States of America	2.452	0,49
37	Dublin	Ireland	2.446	0,49
38	Dusseldorf	Germany	2.436	0,48
39	Hamburg	Germany	2.428	0,48
40	Mumbai	India	2.416	0,48

Table 60A: Insurance connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Munich)
1	Munich	Germany	5.170	1,00
2	Cologne	Germany	4.895	0,95
3	Frankfurt	Germany	3.570	0,69
4	Milan	Italy	3.420	0,66
5	Hanover	Germany	3.376	0,65
6	Stuttgart	Germany	3.363	0,65
7	London	United Kingdom	3.286	0,64
8	Paris	France	3.280	0,63
9	Berlin	Germany	3.238	0,63
10	Hamburg	Germany	3.207	0,62
11	Hong Kong	China	2.712	0,52
12	Tokyo	Japan	2.424	0,47
13	Beijing	China	2.401	0,46
14	Vienna	Austria	2.400	0,46
15	Dortmund	Germany	2.398	0,46
16	Madrid	Spain	2.389	0,46
17	Warsaw	Poland	2.306	0,45
18	Zurich	Switzerland	2.305	0,45
19	Singapore	Singapore	2.295	0,44
20	Nuremberg	Germany	2.289	0,44
21	Dusseldorf	Germany	2.268	0,44
22	Bruxelles	Belgium	2.147	0,42
23	Sydney	Australia	2.047	0,40
24	Bremen	Germany	2.038	0,39
25	Muenster	Germany	2.006	0,39
26	Shanghai	China	1.999	0,39
27	New York	United States of America	1.995	0,39
28	Wiesbaden	Germany	1.904	0,37
29	Dresden	Germany	1.884	0,36
30	Dublin	Ireland	1.846	0,36
31	Erfurt	Germany	1.826	0,35
32	Mexico City	Mexico	1.806	0,35
33	Mannheim	Germany	1.779	0,34
34	Karlsruhe	Germany	1.765	0,34
35	Toronto	Canada	1.746	0,34
36=	Leipzig	Germany	1.706	0,33
36=	Moscow	Russia	1.706	0,33
38	Kassel	Germany	1.678	0,32
39	Mumbai	India	1.641	0,32
40	Freiburg	Germany	1.601	0,31

Table 61A: Law connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Frankfurt)
1	Frankfurt	Germany	4.136	1,00
2	London	United Kingdom	3.948	0,95
3	Munich	Germany	3.397	0,82
4	Paris	France	2.980	0,72
5	New York	United States of America	2.937	0,71
6	Berlin	Germany	2.718	0,66
7	Dusseldorf	Germany	2.589	0,63
8	Bruxelles	Belgium	2.576	0,62
9	Shanghai	China	2.312	0,56
10	Hong Kong	China	2.188	0,53
11	Moscow	Russia	2.169	0,52
12	Hamburg	Germany	2.114	0,51
13	Beijing	China	2.109	0,51
14	Warsaw	Poland	1.950	0,47
15	Madrid	Spain	1.874	0,45
16	Milan	Italy	1.776	0,43
17	Rome	Italy	1.722	0,42
18	Budapest	Hungary	1.708	0,41
19	Singapore	Singapore	1.679	0,41
20	Prague	Czech Republic	1.650	0,40
21	Cologne	Germany	1.569	0,38
22	Chicago	United States of America	1.542	0,37
23	Dubai	United Arab Emirates	1.481	0,36
24	Tokyo	Japan	1.425	0,34
25	São Paulo	Brazil	1.407	0,34
26	Bucharest	Romania	1.348	0,33
27	Abu Dhabi	United Arab Emirates	1.342	0,32
28	Washington	United States of America	1.337	0,32
29	Amsterdam	Netherlands	1.330	0,32
30	Kiev	Ukraine	1.200	0,29
31	Stuttgart	Germany	1.184	0,29
32	Bratislava	Slovakia	1.140	0,28
33	Bangkok	Thailand	1.127	0,27
34	Vienna	Austria	1.084	0,26
35=	Nuremberg	Germany	1.005	0,24
35=	Stockholm	Sweden	1.005	0,24
37	Dresden	Germany	991	0,24
38	Ho Chi Minh City	Vietnam	982	0,24
39	Barcelona	Spain	979	0,24
40	Zurich	Switzerland	964	0,23

Table 62A: Logistics connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Hamburg)
1	Hamburg	Germany	27.365	1,00
2	Hong Kong	China	25.085	0,92
3	Vienna	Austria	23.181	0,85
4	Stuttgart	Germany	22.277	0,81
5	London	United Kingdom	21.631	0,79
6	Moscow	Russia	21.350	0,78
7	Copenhagen	Denmark	20.782	0,76
8	Warsaw	Poland	20.722	0,76
9	Sydney	Australia	20.722	0,76
10	São Paulo	Brazil	20.457	0,75
11	Prague	Czech Republic	20.251	0,74
12	Paris	France	20.123	0,74
13	Singapore	Singapore	20.122	0,74
14	Frankfurt	Germany	20.095	0,73
15	Basel	Switzerland	19.796	0,72
16	Barcelona	Spain	19.764	0,72
17	Shanghai	China	19.665	0,72
18	Taipei	Taiwan	19.649	0,72
19	Bucharest	Romania	19.639	0,72
20	Istanbul	Turkey	19.269	0,70
21	Nuremberg	Germany	18.873	0,69
22	Budapest	Hungary	18.836	0,69
23	Bremen	Germany	18.749	0,69
24	New York	United States of America	18.501	0,68
25	Dusseldorf	Germany	18.293	0,67
26	Kiev	Ukraine	18.260	0,67
27	Hanover	Germany	18.104	0,66
28	Ho Chi Minh City	Vietnam	18.049	0,66
29	Milan	Italy	17.923	0,65
30	Mexico City	Mexico	17.762	0,65
31	Santiago de Chile	Chile	17.737	0,65
32	Tokyo	Japan	17.713	0,65
33	Zurich	Switzerland	17.615	0,64
34	Bangkok	Thailand	17.404	0,64
35	Sofia	Bulgaria	17.289	0,63
36	Madrid	Spain	17.201	0,63
37	Bratislava	Slovakia	17.186	0,63
38	Johannesburg	South Africa	17.107	0,63
39	Manila	Philippines	16.994	0,62
40	Dublin	Ireland	16.835	0,62

Table 63A: Advertising & Media connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = New York)
1	New York	United States of America	4.585	1,00
2	London	United Kingdom	3.829	0,84
3	Vienna	Austria	3.175	0,69
4	Dusseldorf	Germany	3.040	0,66
5	Paris	France	2.808	0,61
6	Munich	Germany	2.473	0,54
7	Stockholm	Sweden	2.454	0,54
8	Bruxelles	Belgium	2.408	0,53
9	Prague	Czech Republic	2.348	0,51
10	Madrid	Spain	2.338	0,51
11	Bucharest	Romania	2.312	0,50
12	Sofia	Bulgaria	2.265	0,49
13	Copenhagen	Denmark	2.260	0,49
14	Singapore	Singapore	2.251	0,49
15	Moscow	Russia	2.248	0,49
16	Athens	Greece	2.235	0,49
17	Zagreb	Croatia	2.199	0,48
18	Warsaw	Poland	2.186	0,48
19	Hamburg	Germany	2.170	0,47
20	Budapest	Hungary	2.107	0,46
21	Berlin	Germany	2.095	0,46
22	Milan	Italy	2.094	0,46
23	Oslo	Norway	2.083	0,45
24	Istanbul	Turkey	2.080	0,45
25	Amsterdam	Netherlands	2.048	0,45
26	Helsinki/Espoo/Vantaa	Finland	1.994	0,43
27	Johannesburg	South Africa	1.983	0,43
28	Zurich	Switzerland	1.974	0,43
29=	Lisbon	Portugal	1.973	0,43
29=	Hong Kong	China	1.973	0,43
31=	Mumbai	India	1.948	0,42
31=	Tokyo	Japan	1.948	0,42
31=	Kuala Lumpur	Malaysia	1.948	0,42
31=	Taipei	Taiwan	1.948	0,42
35	Buenos Aires	Argentinia	1.917	0,42
36	Shanghai	China	1.890	0,41
37	Toronto	Canada	1.837	0,40
38=	Santiago de Chile	Chile	1.810	0,39
38=	Jakarta	Indonesia	1.810	0,39
38=	Manila	Philippines	1.810	0,39

High-Tech

Table 64A: Chemistry & pharma connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Shanghai)
1	Shanghai	China	15.163	1,00
2	Singapore	Singapore	13.659	0,90
3	São Paulo	Brazil	12.506	0,82
4	Tokyo	Japan	12.319	0,81
5	Paris	France	11.944	0,79
6	New York	United States of America	11.019	0,73
7	Moscow	Russia	10.763	0,71
8	Seoul	South Korea	10.161	0,67
9	Buenos Aires	Argentinia	10.045	0,66
10	Mexico City	Mexico	9.915	0,65
11	Bangkok	Thailand	9.513	0,63
12	Vienna	Austria	9.432	0,62
13	Johannesburg	South Africa	9.167	0,60
14	Budapest	Hungary	9.067	0,60
15	Barcelona	Spain	8.946	0,59
16	Hong Kong	China	8.902	0,59
17	Mumbai	India	8.801	0,58
18	Warsaw	Poland	8.779	0,58
19	Beijing	China	8.640	0,57
20	Milan	Italy	8.631	0,57
21	Bruxelles	Belgium	8.378	0,55
22	Kuala Lumpur	Malaysia	8.371	0,55
23	Taipei	Taiwan	8.256	0,54
24	Istanbul	Turkey	8.191	0,54
25	Munich	Germany	7.884	0,52
26	Bogotá	Colombia	7.772	0,51
27	Athens	Greece	7.736	0,51
28	Santiago de Chile	Chile	7.639	0,50
29	Ho Chi Minh City	Vietnam	7.536	0,50
30	Dubai	United Arab Emirates	7.369	0,49
31	Prague	Czech Republic	7.364	0,49
32	Sydney	Australia	7.355	0,49
33	Lyon	France	7.335	0,48
34	Stockholm	Sweden	7.234	0,48
35	Caracas	Venezuela	7.132	0,47
36	Oslo	Norway	7.119	0,47
37	Madrid	Spain	7.085	0,47
38	Jakarta	Indonesia	7.043	0,46
39	Copenhagen	Denmark	6.693	0,44
40	Helsinki/ Espoo/ Vantaa	Finland	6.619	0,44

Table 65A: Computer Hardware connectivity (Author’s calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Munich)
1	Munich	Germany	8.270	1,00
2	New York	United States of America	8.191	0,99
3	Moscow	Russia	7.828	0,95
4	Singapore	Singapore	7.767	0,94
5	Johannesburg	South Africa	7.654	0,93
6	London	United Kingdom	7.574	0,92
7	Hamburg	Germany	7.531	0,91
8	Bruxelles	Belgium	7.415	0,90
9	Vienna	Austria	7.390	0,89
10	Paris	France	7.263	0,88
11	Zurich	Switzerland	7.261	0,88
12	Stuttgart	Germany	7.126	0,86
13	Milan	Italy	7.019	0,85
14	Stockholm	Sweden	6.888	0,83
15	Sydney	Australia	6.724	0,81
16	Warsaw	Poland	6.580	0,80
17	Madrid	Spain	6.476	0,78
18	Kuala Lumpur	Malaysia	6.422	0,78
19	San Jose Palo Alto	United States of America	6.390	0,77
20	Tokyo	Japan	6.101	0,74
21	Athens	Greece	6.007	0,73
22	Prague	Czech Republic	5.966	0,72
23	Beijing	China	5.952	0,72
24	Caracas	Venezuela	5.926	0,72
25	Nuremberg	Germany	5.917	0,72
26	Buenos Aires	Argentinia	5.848	0,71
27	Istanbul	Turkey	5.815	0,70
28	Frankfurt	Germany	5.797	0,70
29	Mexico City	Mexico	5.726	0,69
30	Oslo	Norway	5.703	0,69
31	Berlin	Germany	5.659	0,68
32	Melbourne	Australia	5.644	0,68
33	Manila	Philippines	5.476	0,66
34	Bangkok	Thailand	5.444	0,66
35	Amsterdam	Netherlands	5.393	0,65
36	Dublin	Ireland	5.310	0,64
37	Helsinki/Espoo/Vantaa	Finland	5.297	0,64
38	São Paulo	Brazil	5.268	0,64
39	Hong Kong	China	5.250	0,63
40	Copenhagen	Denmark	5.228	0,63

Table 66A: Electronics connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Singapore)
1	Singapore	Singapore	8.477	1,00
2	Shanghai	China	8.354	0,99
3	São Paulo	Brazil	7.442	0,88
4	Milan	Italy	7.034	0,83
5	Vienna	Austria	6.313	0,74
6	Hong Kong	China	6.154	0,73
7	Budapest	Hungary	6.012	0,71
8	Seoul	South Korea	5.867	0,69
9	Prague	Czech Republic	5.827	0,69
10	Moscow	Russia	5.770	0,68
11	Istanbul	Turkey	5.735	0,68
12	Tokyo	Japan	5.606	0,66
13	Warsaw	Poland	5.600	0,66
14	Paris	France	5.460	0,64
15	Sydney	Australia	5.439	0,64
16	Johannesburg	South Africa	5.265	0,62
17	Beijing	China	5.251	0,62
18	Bangkok	Thailand	5.233	0,62
19	Helsinki/Espoo/Vantaa	Finland	5.134	0,61
20	Athens	Greece	5.130	0,61
21	Copenhagen	Denmark	5.093	0,60
22	Stockholm	Sweden	5.078	0,60
23	Dubai	United Arab Emirates	5.024	0,59
24	Mexico City	Mexico	4.978	0,59
25	Munich	Germany	4.743	0,56
26	Melbourne	Australia	4.658	0,55
27	Bruxelles	Belgium	4.486	0,53
28	Taipei	Taiwan	4.466	0,53
29	Barcelona	Spain	4.432	0,52
30	Santiago de Chile	Chile	4.407	0,52
31	Zagreb	Croatia	4.297	0,51
32	Buenos Aires	Argentinia	4.288	0,51
33	Bucharest	Romania	4.260	0,50
34	Sofia	Bulgaria	4.204	0,50
35	Belgrade	Serbia	4.146	0,49
36	Oslo	Norway	4.107	0,48
37	Kuala Lumpur	Malaysia	4.071	0,48
38	Bangalore	India	4.043	0,48
39	Cairo	Egypt	3.965	0,47
40	Stuttgart	Germany	3.896	0,46

Table 67A: Machinery connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Shanghai)
1	Shanghai	China	14.574	1,00
2	São Paulo	Brazil	11.930	0,82
3	Singapore	Singapore	11.490	0,79
4	Stuttgart	Germany	10.845	0,74
5	Paris	France	10.820	0,74
6	Seoul	South Korea	10.367	0,71
7	Johannesburg	South Africa	10.355	0,71
8	Istanbul	Turkey	10.244	0,70
9	Milan	Italy	9.841	0,68
10	Mexico City	Mexico	9.671	0,66
11	Moscow	Russia	9.596	0,66
12	Barcelona	Spain	9.523	0,65
13	Buenos Aires	Argentinia	9.239	0,63
14	Bangkok	Thailand	9.160	0,63
15	Munich	Germany	9.143	0,63
16	Budapest	Hungary	9.119	0,63
17	Dubai	United Arab Emirates	8.865	0,61
18	Prague	Czech Republic	8.841	0,61
19	Sydney	Australia	8.818	0,61
20	Hamburg	Germany	8.763	0,60
21	Jakarta	Indonesia	8.691	0,60
22	Hong Kong	China	8.473	0,58
23	Kuala Lumpur	Malaysia	8.284	0,57
24	Copenhagen	Denmark	8.196	0,56
25	Beijing	China	7.960	0,55
26	New Delhi	India	7.902	0,54
27	Melbourne	Australia	7.840	0,54
28	Warsaw	Poland	7.339	0,50
29	Pune	India	7.329	0,50
30	Bruxelles	Belgium	7.328	0,50
31	Santiago de Chile	Chile	7.278	0,50
32	Kiev	Ukraine	7.171	0,49
33	Bangalore	India	7.090	0,49
34	Chennai	India	7.079	0,49
35	Mumbai	India	6.666	0,46
36	Vienna	Austria	6.573	0,45
37	Detroit	United States of America	6.553	0,45
38	Madrid	Spain	6.541	0,45
39	Berlin	Germany	6.337	0,43
40	Manila	Philippines	6.298	0,43

Table 68A: Medical & optical instruments connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Singapore)
1	Singapore	Singapore	8.318	1,00
2	Tokyo	Japan	8.082	0,97
3	Seoul	South Korea	7.854	0,94
4	Shanghai	China	7.797	0,94
5	São Paulo	Brazil	7.455	0,90
6	Hong Kong	China	6.984	0,84
7	Buenos Aires	Argentinia	6.788	0,82
8	Moscow	Russia	6.752	0,81
9	Budapest	Hungary	6.650	0,80
10	Paris	France	6.595	0,79
11	Mexico City	Mexico	6.587	0,79
12	Vienna	Austria	6.366	0,77
13	Stockholm	Sweden	6.328	0,76
14	Bangkok	Thailand	6.288	0,76
15	Bruxelles	Belgium	6.168	0,74
16	Madrid	Spain	6.008	0,72
17	Zagreb	Croatia	5.962	0,72
18	Bucharest	Romania	5.844	0,70
19	Beijing	China	5.759	0,69
20	Prague	Czech Republic	5.672	0,68
21	Auckland	New Zealand	5.614	0,67
22	Taipei	Taiwan	5.438	0,65
23	Istanbul	Turkey	5.281	0,63
24	Barcelona	Spain	5.273	0,63
25	Johannesburg	South Africa	5.096	0,61
26	Milan	Italy	5.092	0,61
27	Sydney	Australia	5.051	0,61
28	Dubai	United Arab Emirates	5.045	0,61
29	Mumbai	India	4.998	0,60
30	Copenhagen	Denmark	4.915	0,59
31	Ljubljana	Slovenia	4.814	0,58
32	Helsinki/Espoo/Vantaa	Finland	4.725	0,57
33	Sofia	Bulgaria	4.652	0,56
34	Hamburg	Germany	4.640	0,56
35	Bogotá	Colombia	4.365	0,52
36	Berlin	Germany	4.354	0,52
37	Santiago de Chile	Chile	4.350	0,52
38	Belgrade	Serbia	4.313	0,52
39	New York	United States of America	4.278	0,51
40	Cairo	Egypt	4.185	0,50

Table 69A: Telecommunication connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Stockholm)
1	Stockholm	Sweden	7.128	1,00
2	Paris	France	6.919	0,97
3	Madrid	Spain	6.910	0,97
4	Munich	Germany	6.415	0,90
5	Vienna	Austria	5.912	0,83
6	Oslo	Norway	5.674	0,80
7	Singapore	Singapore	5.658	0,79
8	Copenhagen	Denmark	5.491	0,77
9	Tokyo	Japan	5.462	0,77
10	Helsinki/Espoo/Vantaa	Finland	5.440	0,76
11	Dallas	United States of America	5.356	0,75
12	Mexico City	Mexico	4.983	0,70
13	Beijing	China	4.874	0,68
14	Dublin	Ireland	4.851	0,68
15	Berlin	Germany	4.825	0,68
16	São Paulo	Brazil	4.806	0,67
17	Seoul	South Korea	4.688	0,66
18	Moscow	Russia	4.684	0,66
19	London	United Kingdom	4.675	0,66
20	Sydney	Australia	4.670	0,66
21	Dubai	United Arab Emirates	4.640	0,65
22	New York	United States of America	4.632	0,65
23	Taipei	Taiwan	4.602	0,65
24	Hong Kong	China	4.562	0,64
25	Hanoi	Vietnam	4.412	0,62
26	Gurgaon	India	4.356	0,61
27	Rome	Italy	4.316	0,61
28	Buenos Aires	Argentinia	4.247	0,60
29	Prague	Czech Republic	4.218	0,59
30	Shanghai	China	4.195	0,59
31	Jakarta	Indonesia	4.183	0,59
32	Milan	Italy	4.120	0,58
33	Cairo	Egypt	3.998	0,56
34	Washington	United States of America	3.936	0,55
35	Mumbai	India	3.911	0,55
36	Atlanta	United States of America	3.907	0,55
37	Bangkok	Thailand	3.894	0,55
38	Budapest	Hungary	3.788	0,53
39	Santiago de Chile	Chile	3.774	0,53
40	Warsaw	Poland	3.740	0,52

Table 70A: Vehicle construction connectivity (Author's calculation)

Rank	City	Country	Gross Connectivity	Proportionate Connectivity (1,00 = Shanghai)
1	Shanghai	China	12.240	1,00
2	Detroit	United States of America	10.997	0,90
3	Stuttgart	Germany	10.463	0,85
4	Paris	France	10.057	0,82
5	São Paulo	Brazil	9.598	0,78
6	Singapore	Singapore	9.400	0,77
7	Madrid	Spain	8.880	0,73
8	Barcelona	Spain	8.255	0,67
9	Tokyo	Japan	8.109	0,66
10	Beijing	China	7.880	0,64
11	Munich	Germany	7.341	0,60
12	Melbourne	Australia	7.052	0,58
13	Bruxelles	Belgium	6.919	0,57
14	Washington	United States of America	6.804	0,56
15	Bangkok	Thailand	6.780	0,55
16	Turin	Italy	6.734	0,55
17	Moscow	Russia	6.703	0,55
18	Prague	Czech Republic	6.644	0,54
19	Buenos Aires	Argentinia	6.640	0,54
20	Hamburg	Germany	6.602	0,54
21	Berlin	Germany	6.594	0,54
22	Seoul	South Korea	6.536	0,53
23	Stockholm	Sweden	6.443	0,53
24	Zurich	Switzerland	6.426	0,53
25	Istanbul	Turkey	6.330	0,52
26	Monterrey	Mexico	6.232	0,51
27	Pittsburgh	United States of America	6.100	0,50
28	Dubai	United Arab Emirates	6.077	0,50
29	Hanover	Germany	6.055	0,49
30	Chicago	United States of America	5.861	0,48
31	Athens	Greece	5.834	0,48
32	Milwaukee	United States of America	5.828	0,48
33	Bremen	Germany	5.823	0,48
34	Saarbruecken	Germany	5.777	0,47
35	Essen	Germany	5.758	0,47
36	Warsaw	Poland	5.743	0,47
37	Milan	Italy	5.684	0,46
38	Bangalore	India	5.640	0,46
39	Vancouver	Canada	5.638	0,46
40	Bucharest	Romania	5.508	0,45

Appendix B: Lists of Firms and Cities

Table 71A: All 270 APS firms in the network analysis (Authors's compilation)

Banking & Finance	
Deutsche Bank AG	Kreissparkasse Köln
Commerzbank	BHW Bausparkasse
Dresdner Bank	Deutsche Postbank
HypoVereinsbank	KfW Bankengruppe
DZ Bank	SEB
Landesbank Baden-Württemberg	DekaBank
BayernLB	Sal. Oppenheim jr. & Cie
Landesbank Berlin	Berliner Volksbank
Citibank	Sparkasse Hannover
WestLB	Deutsche Börse
Hamburger Spaarkasse	ING Group
Landesbank Hessen-Thüringen	Aareal Bank
Sparkasse KölnBonn	Eurohypo AG
Nord LB	Schwäbisch Hall
HSH Nordbank	VR Kreditwerk Hamburg

Logistics	
Deutsche Post World Net	M&M
Schenker AG	Lehnkering
Dachser	Oldendorff
GLS	Meyer&Meyer
Fiege	Emons
Rhenus Logistics	HAPAG - LLOYD
Kühne und Nagel	Panalpina
Hellmann Logistics	Wincanton
Hermes	Günter Baumann Transprot und Verpackung
TNT	ComBase
D+S europe AG	Röhlig
DEMATIC	Friedrich Zufall GmbH
DSV	Logwin AG
Mosolf	Willi Betz
Rudolph Logistik Gruppe	Chemion

Design, Architecture & Engineering	
Bilfinger Berger	euro engineering
YACHT TECCON	Tintschl AG
Hochtief	Tauw
EDAG	IABG
Bertrandt AG	Fichtner
Uponor	FTI Group
FERCHAU Engineering	RLE INTERNATIONAL

Design, Architecture & Engineering	
M+W Zander	Assystem
IAV	Luwa
Rücker	Drees & Sommer
Brunel	PCL Group
MB-technology	MVI Group GmbH
Semcon	Lahmeyer Holding
Altran	invenio
Formel D	Alten Group

Advertising and Media	
WAZ Mediengruppe	Klett Gruppe
Verlagsgruppe Georg von Holtzbrinck	Zeitungsverlag Aachen
Motorpresse Stuttgart GmbH	Rheinisch-Bergische Verlagsgesellschaft
Axel Springer	Cornelsen Verlagsgruppe
Hubert Burda DLD	Rhein-Zeitung
Heinrich Bauer Verlag	G+J
Springer Science+Business Media	Weltbild Verlagsgruppe
mindshare	Süddeutscher Verlag
vgp	Schlott Gruppe
Pro Sieben Sat 1 Media AG	DSV Gruppe
Mediaedge	RTL Group
BBDO	Direct Group
M. Dumont Schauberg	FAZ
madsack	grey croup
Sony BMG	Vogel

Law	
SALANS GmbH	Rödl & Partner
Rölfs Partner	RWT Gruppe
Freshfields Bruckhaus Deringer	Heuking Kühn Lüer Wojtek
CMS	Baker & McKenzie
Clifford Chance	Allen & Overy
Hoffmann-Eitle	Latham & Watkins
Linklaters	Graf von Westphalen
Lovells	GÖRG
Hengeler Mueller	Buse Heberer Fromm
Taylor Wessing	Bird & Bird
NÖRR STIEFENHOFER LUTZ	Shearman & Sterling
White & Case	Mayer Brown
Luther	GSK Stockmann & Kollegen
Beiten Burkhardt	SJ Berwin
Gleiss Lutz	Maiwald Patentanwalts GmbH

Accounting	
PricewaterhouseCoopers AG	DHPG
Ernst&Young	BUST
KPMG	FIDES
BDO Deutsche Warentreuhand AG	Buchstelle Landesbauernverband
ECOVIS	Verhülsdonk & Partner
Treuhand Hannover GmbH	RöverBrönner
ADS Steuerberatungsgesellschaft mbH	Solidaris Revisions-GmbH
BSB- GmbH	Dr. Dornbach & Partner GmbH
Ebner Stolz Mönning Bachem	FALK & Co GmbH
Warth & Klein GmbH	ALPHA Steuerberatungsgesellschaft
Susat & Partner OHG	WIKOM AG
PKF FASSELT SCHLAGE LANG UND STOLZ	Bansbach Schübel Brösztl & Partner GmbH
MUNKERT KUGLER + PARTNER	Curacon GmbH
MAZARS	Odenwald Treuhand GmbH
LBH-Steuerberatungsgesellschaft	WTS AG

Information and Communication Services	
Duvenbeck	United Internet AG
Swisslog	computacenter
Microsoft	mentor
GAD	Arcor
Walter Services	Bechtle
Aspect	Finanz Informatik
DB Systel	datev
Eplus	arvato
Atos Origin	SAP
Kabel Deutschland	Morpho
IDS Scheer	versatel
Fiducia	Lufthansa Systems
Telegate	Dataport
Software AG	vodafone
Autodesk	BTplc

Management- and IT-Consulting	
Logica	MATERNA GmbH
GfK SE	The Boston Consulting Group
Accenture GmbH	itelligence AG
a&o systems	Aareon
Sybase	GFT Technologies
CSC	BTC
Research International	Capgemini
adm	SQS
EXACT Software	Cirquent
McKinsey	REALTECH
msg systems	Roland Berger
BearingPoint	Deloitte

Management- and IT-Consulting	
Sagem Orga	Oliver Wyman
Steria Mummert Consulting	Mercer
CANCOM	C1 Group

Insurance	
Allianz	DEVK
R+V Versicherungen	VHV
Münchner Rück	Zurich
Generali	Die Continentale
HUK-COBURG	HDI-Gerling
AXA	Alte Leipziger - Hallesche
Gothaer	Baloise
NÜRNBERGER VERSICHERUNGSGRUPPE	Hannover Rück
Victoria	Barmenia
DKV	Concordia
SIGNAL IDUNA	D.A.S
SV Sparkassen Versicherung	INTER
ARAG AG	Kölnische Rück
Provinzial NordWest	VPV
WWK	ROLAND

Table 72A: All 210 APS firms in the network analysis (authors's compilation)

Medical & optical instruments	
B.Braun	Richard Wolf
Carl Zeiss	Maquet
Drägerwerke	BIOTRONIK
Otto Bock	CIBA Vision
JENOPTIK	GEERS Hörakustik
Leica Microsystems	Medi
Karl Storz	Leica Camera AG
Johnson & Johnson	Brasseler Group
Sirona	Membrana
Bauerfeind	Essilor
Eppendorf	DeguDent GmbH
Flemming Dental	Linos Photonics
Gambro	Analytik Jena
Hartmann	Rupp + Hubrach Optik GmbH
Sartorius	Julius Zorn GmbH

Machinery	
Schäffler Gruppe	SMS
ZF	Krones
MAN	Körber
John Deere	Federal Mogul

Machinery	
Voith AG	CLAAS
Salzgitter	Koenig & Bauer
Benteler	Tognum
Heidelberg	MTU Aero Engines
Freudenberg	TRUMPF
KSB	GKN Driveline
FESTO	Groz-Beckert
SEW	Bauer
DIEHL	KUKA
GETRAG	DEMAG
Jungheinrich	DÜRR

Computer-Hardware	
Siemens	EMC
IBM	Süss
HP	Pharmatechnik
Wincor Nixdorf	Hirschmann
Boewe Systec AG	Höft & Wessel
Avaya	Intel
Telindus	Tally Genicom
Kontron	AVM
Hama	eplan
Triumph Adler	interflex
Thales	BDT
Oce	primion
Medion	canon
Pilz	Ricoh
Maxdata	Ikon

Telecommunication	
Telgärtnter	Kathrein
Dambach	Rhode & Schwarz
Peiker	Balda
Deutsche Funkturm	Giesecke & Devrient
ADC	Nokia Systems Network
TechniSat Digital	Niscayah
S.Siedle & Söhne	Thomson
Adva	ND Satcom
OHB Technology	ISRA Vision
Funkwerk	Prettl
Nokia	Teles
Motorola	Sennheiser
Ericsson	Blaupunkt
Harman Becker	Grundig
Alcatel Lucent	Keymile

Vehicle construction	
VOLKSWAGEN	EADS
Daimler	Johnson Controls
Robert Bosch	MANN+HUMMEL
Ford	Brose
MAHLE	GRAMMER
TRW	Evobus
Porsche	Takata
Kolbenschmidt Pierburg	DURA Automotive Systems
Knorr-Bremse	Borg Warner
Behr	Eberspächer
Rheinmetall	Webasto AG
General Motors Corporation	Vossloh AG
Airbus	Edscha
Hella	Huf
BMW	WOCO

Chemistry & Pharmacy	
Symrise AG	Schott
Süd-Chemie	LANXESS
Siltronic	WACKER
Stahlgruber	Roche
Michelin	Rütgers
SGL Carbon	Gerresheimer
Goodyear	Sanofi-Aventis
Fresenius	Boehringer Ingelheim
Bayer	Nycomed
BASF	Novartis
Continental	STADA
Linde	Cognis
Henkel	HEXAL
Evonik	Grünenthal
MERCK	ALTANA

Electronics	
Osram	Enercon
NXP	Heidenhain
Dräxlmaier	Alstom
Friwo	Wika
Leoni	Sick
Epcos	Wago
Qimonda	Weidmüller
ABB	Pepperl+Fuchs
Hager Group	Endress
Thyssen Krupp	Heraeus
Infineon	Sumida
Sumitomo	AMD

Electronics	
Rittal	Phoenix
Moeller	Marquardt
E.G.O.	KOSTAL

Table 73A: 338 FUAs in Germany and neighbouring countries (Author's compilation based on ESPON 2004)

FUA	Country	FUA	Country	FUA	Country
Aachen	Germany	Duisburg	Germany	Heilbronn	Germany
Aalen	Germany	Düren	Germany	Herford	Germany
Altenburg	Germany	Dusseldorf	Germany	Hildesheim	Germany
Amberg in der Oberpfalz	Germany	Eberswalde-Finow	Germany	Hof	Germany
Ansbach	Germany	Eisenach	Germany	Hoyerswerda	Germany
Arnsberg	Germany	Emden	Germany	Ibbenbüren	Germany
Aschaffenburg	Germany	Erfurt	Germany	Ingolstadt	Germany
Aue	Germany	Erlangen	Germany	Iserlohn	Germany
Augsburg	Germany	Essen	Germany	Jena	Germany
Bad Hersfeld	Germany	Euskirchen	Germany	Kaiserslautern	Germany
Bad Kreuznach	Germany	Flensburg	Germany	Karlsruhe	Germany
Bad Nauheim	Germany	Frankfurt am Main	Germany	Kassel	Germany
Bad Oeynhausen	Germany	Frankfurt an der Oder	Germany	Kaufbeuren	Germany
Baden Baden	Germany	Freiberg	Germany	Kempten (Allgäu)	Germany
Bamberg	Germany	Freiburg im Breisgau	Germany	Kiel	Germany
Bautzen	Germany	Freising	Germany	Kleve	Germany
Bayreuth	Germany	Friedberg (Hessen)	Germany	Koblenz	Germany
Berlin	Germany	Friedrichsdorf	Germany	Konstanz	Germany
Bielefeld	Germany	Fulda	Germany	Krefeld	Germany
Bocholt	Germany	Fürth	Germany	Kulmbach	Germany
Bochum	Germany	Garmisch-Partenkirchen	Germany	Landau in der Pfalz	Germany
Bonn	Germany	Gera	Germany	Landshut	Germany
Brandenburg	Germany	Gießen	Germany	Leipzig	Germany
Braunschweig	Germany	Görlitz	Germany	Limburg	Germany
Bremen	Germany	Goslar	Germany	Lingen	Germany
Bremerhaven	Germany	Gotha	Germany	Lippstadt	Germany
Bühl	Germany	Göttingen	Germany	Lörrach	Germany
Celle	Germany	Greifswald	Germany	Lübeck	Germany
Chemnitz	Germany	Greiz	Germany	Ludwigshafen am Rhein	Germany
Coburg	Germany	Gummersbach	Germany	Lüneburg	Germany
Cologne	Germany	Hagen	Germany	Magdeburg	Germany
Cottbus	Germany	Halberstadt	Germany	Mainz	Germany
Cuxhaven	Germany	Halle	Germany	Mannheim	Germany
Darmstadt	Germany	Hamburg	Germany	Marburg an der Lahn	Germany
Deggendorf	Germany	Hameln	Germany	Memmingen	Germany
Dessau	Germany	Hamm	Germany	Merseburg	Germany
Detmold	Germany	Hanau	Germany	Minden	Germany
Dillenburg	Germany	Hanover	Germany	Mönchen-Gladbach	Germany
Dortmund	Germany	Heidelberg	Germany	Munich	Germany
Dresden	Germany	Heidenheim	Germany	Münster	Germany

Table 73A: 338 FUAs in Germany and neighbouring countries (continued)

FUA	Country
Naumburg	Germany
Neubrandenburg	Germany
Neumarkt	Germany
Neumünster	Germany
Neuruppin	Germany
Neustadt an der Wein	Germany
Neu-Ulm	Germany
Nordhausen	Germany
Nordhorn	Germany
Nuremberg	Germany
Offenbach am Main	Germany
Offenburg	Germany
Oldenburg	Germany
Osnabrück	Germany
Paderborn	Germany
Passau	Germany
Peine	Germany
Pforzheim	Germany
Pirmasens	Germany
Plauen	Germany
Potsdam	Germany
Ravensburg	Germany
Regensburg	Germany
Rendsburg	Germany
Reutlingen	Germany
Rheine	Germany
Riesa	Germany
Rosenheim	Germany
Rostock	Germany
Rudolstadt	Germany
Rüsselsheim	Germany
Saalfeld	Germany
Saarbrücken	Germany
Salzgitter	Germany
Schönebeck (Elbe)	Germany
Schwabach	Germany
Schwäbisch Gmünd	Germany
Schweinfurt	Germany
Schwerin	Germany
Siegen	Germany

FUA	Country
Singen	Germany
Speyer	Germany
Stendal	Germany
Stralsund	Germany
Straubing	Germany
Stuttgart	Germany
Suhl	Germany
Trier	Germany
Tübingen	Germany
Ulm	Germany
Villingen-Schwenningen	Germany
Weiden in der Oberpfalz	Germany
Weil (am Rhein)	Germany
Weimar	Germany
Weingarten	Germany
Wetzlar	Germany
Wiesbaden	Germany
Wilhelmshaven	Germany
Wismar	Germany
Wittenberg	Germany
Wolfen	Germany
Wolfsburg	Germany
Wülfrath	Germany
Wuppertal	Germany
Würzburg	Germany
Zwickau	Germany
Antwerp	Belgium
Hasselt	Belgium
Leuven	Belgium
Liège	Belgium
Mechelen	Belgium
Namur	Belgium
Verviers	Belgium
Aabenraa	Denmark
Esbjerg	Denmark
Haderslev	Denmark
Kolding	Denmark
Maribo	Denmark
Naestved	Denmark
Nakskov	Denmark

FUA	Country
Nykøbing	Denmark
Odense	Denmark
Ribe	Denmark
Slagelse	Denmark
Sønderborg	Denmark
Svendborg	Denmark
Tonder	Denmark
Vejle	Denmark
Belfort	France
Colmar	France
Épinal	France
Forbach	France
Guebwiller	France
Haguenau	France
Luneville	France
Metz	France
Montbéliard	France
Mulhouse	France
Nancy	France
Saint Die	France
Saint Louis	France
Saint-Avold	France
Sarrebourg	France
Sarreguemines	France
Sedan	France
Strasbourg	France
Thann	France
Thionville	France
Toul	France
Verdun	France
Vesoul	France
Bressanone	Italy
Brunico	Italy
Merano	Italy
Sondrio	Italy
Vaduz	Liechtenstein
Esch-sur-Alzette	Luxembourg
Luxembourg	Luxembourg
Almere	Netherlands
Amersfoort	Netherlands

Table 73A: 338 FUAs in Germany and neighbouring countries (continued)

FUA	Country	FUA	Country	FUA	Country
Amsterdam	Netherlands	Gorzów Wielkopolski	Poland	Winterthur	Switzerland
Apeldoorn	Netherlands	Jelenia Góra	Poland	Zofingen	Switzerland
Arnhem	Netherlands	Koszalin	Poland	Zurich	Switzerland
Assen	Netherlands	Legnica	Poland	Zug	Switzerland
Breda	Netherlands	Leszno	Poland	České Budějovice	Czech Republic
Den Bosch	Netherlands	Poznań	Poland	Chomutov	Czech Republic
Deventer	Netherlands	Świnoujście	Poland	Děčín	Czech Republic
Dordrecht	Netherlands	Szczecin	Poland	Hradec Králové	Czech Republic
Ede	Netherlands	Zielona Góra	Poland	Karlovy Vary	Czech Republic
Eindhoven	Netherlands	Aarau	Switzerland	Kladno	Czech Republic
Emmen	Netherlands	Arbon Rorschach	Switzerland	Liberec	Czech Republic
Enschede	Netherlands	Baden	Switzerland	Mladá Boleslav	Czech Republic
Geleen	Netherlands	Basel	Switzerland	Most	Czech Republic
Gouda	Netherlands	Bern	Switzerland	Pardubice	Czech Republic
Groningen	Netherlands	Biel	Switzerland	Plzeň	Czech Republic
Heerlen	Netherlands	Brugg	Switzerland	Prague	Czech Republic
Hilversum	Netherlands	Buchs	Switzerland	Teplice	Czech Republic
Leeuwarden	Netherlands	Burgdorf	Switzerland	Ústí nad Labem	Czech Republic
Lelystad	Netherlands	Chur	Switzerland		
Maastricht	Netherlands	Frauenfeld	Switzerland		
Nijmegen	Netherlands	Grenchen	Switzerland		
Tilburg	Netherlands	Heerbrugg-Altstatten	Switzerland		
Utrecht	Netherlands	Interlaken	Switzerland		
Veenendaal	Netherlands	Kreuzlingen	Switzerland		
Venlo	Netherlands	La Chaux-de-Fonds	Switzerland		
Zwolle	Netherlands	Lenzburg	Switzerland		
Amstetten	Austria	Liestal	Switzerland		
Bregenz	Austria	Luzern	Switzerland		
Dornbirn	Austria	Neuchatel	Switzerland		
Feldkirch-Rankweil	Austria	Olten	Switzerland		
Innsbruck	Austria	Pfaeffikon-Lachen	Switzerland		
Krems an der Donau	Austria	Rapperswil-Jona	Switzerland		
Leoben	Austria	Romanshorn-Amriswil	Switzerland		
Leonding	Austria	Schaffhausen	Switzerland		
Linz	Austria	Solothurn	Switzerland		
Salzburg	Austria	St. Gallen	Switzerland		
Steyr	Austria	Stans	Switzerland		
Traun	Austria	Thun	Switzerland		
Villach	Austria	Wetzikon-Pfaffikon	Switzerland		
Wels	Austria	Wil	Switzerland		

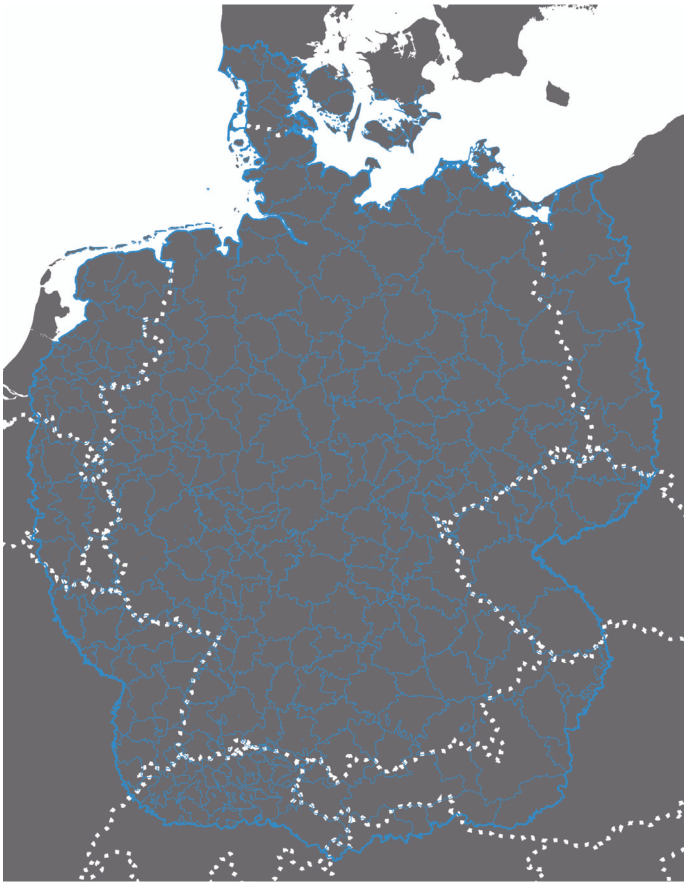


Figure 75A: 338 FUAs in Germany and neighbouring countries
(Author's compilation; visualisation: Anne Wiese)

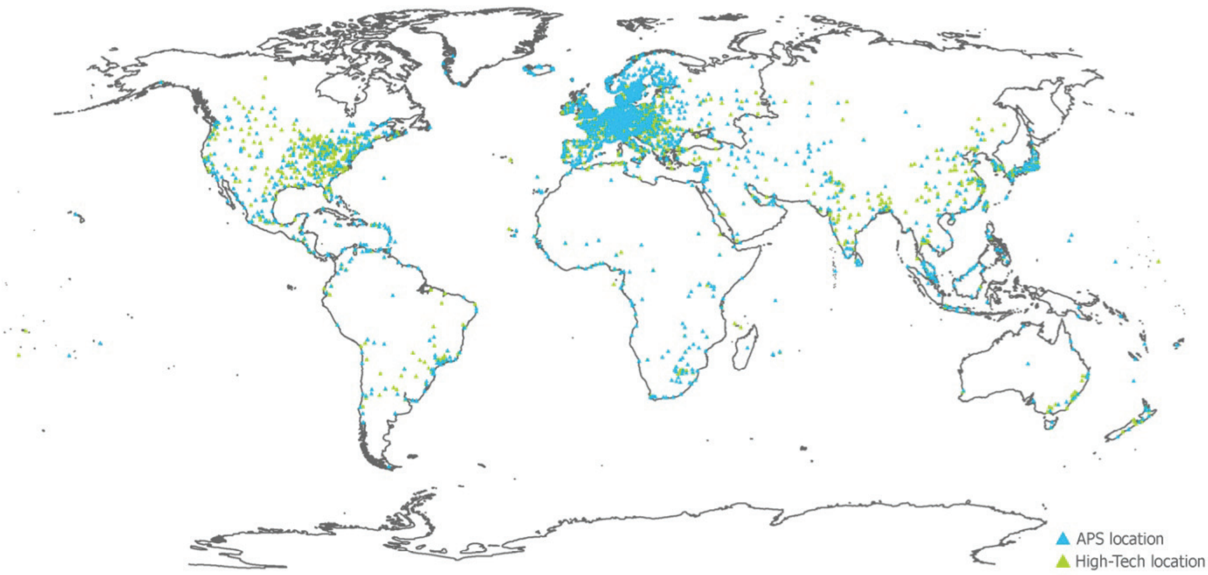


Figure 76A: All 2926 cities in the network analyses (Author's compilation; visualisation: Anne Wiese)

Table 74A: Spatial delimitation of German Mega-City Regions in the network analyses (Author's compilation[2])

FUAs in the MCR of Rhine-Main
Frankfurt am Main
Hanau
Offenbach am Main
Rüsselsheim
Wiesbaden
Mainz
Darmstadt
Aschaffenburg

FUAs in the MCR of Rhine-Ruhr
Bonn
Cologne
Düsseldorf
Duisburg
Essen
Bochum
Dortmund

FUAs in the MCR of Munich
Munich
Rosenheim
Garmisch-Partenkirchen
Kaufbeuren
Augsburg
Freising
Ingolstadt
Regensburg
Landshut

FUAs in the MCR of Hamburg
Hamburg
Lüneburg
Cuxhaven (see also MCR Bremen-Oldenburg)

FUAs in the MCR of Bremen-Oldenburg
Bremen
Oldenburg
Bremerhaven
Cuxhaven (see also MCR of Hamburg)
Wilhelmshaven
Osnabrück

FUAs in the Saxony Triangle
Magdeburg
Schönebeck (Elbe)
Dessau
Wolfen
Wittenberg
Halle
Leipzig
Merseburg
Riesa
Dresden
Altenburg
Naumburg
Freiberg
Chemnitz
Zwickau
Gera
Jena
Weimar
Erfurt
Gotha
Rudolstadt
Saalfeld
Greiz
Plauen
Aue

FUAs in the MCR of Nuremberg
Nuremberg
Fürth
Erlangen
Bamberg
Würzburg
Coburg
Kulmbach
Hof
Bayreuth
Weiden in der Oberpfalz
Amberg in der Oberpfalz
Neumarkt
Schwabach
Ansbach

FUAs in the MCR of Berlin
Berlin
Potsdam
Brandenburg
Neuruppin
Eberswalde-Finow
Frankfurt an der Oder
Cottbus

FUAs in the MCR of Stuttgart
Stuttgart
Tübingen
Aalen
Heilbronn
Pforzheim
Schwäbisch Gmünd
Reutlingen
Heidenheim

FUAs in the MCR of Rhine-Neckar
Mannheim
Ludwigshafen am Rhein
Heidelberg
Neustadt an der Weinstrasse
Speyer
Landau in der Pfalz

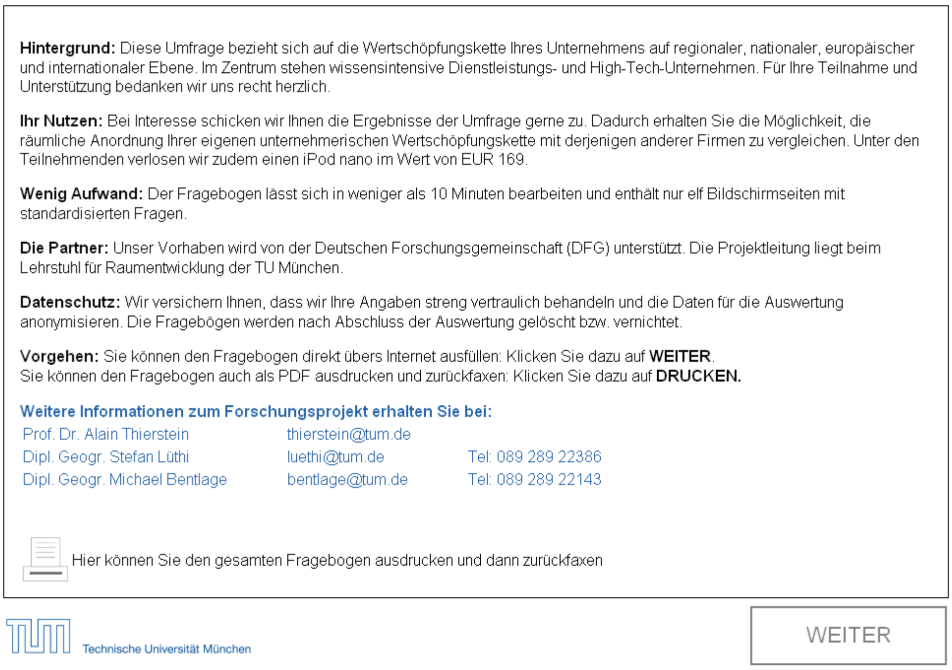
FUAs in the MCR of H-B-G-W*
Hanover
Peine
Braunschweig
Salzgitter
Hildesheim
Göttingen
Wolfsburg
Celle
Goslar
Hameln

* Hanover-Braunschweig-Göttingen-Wolfsburg

[2] The spatial delimitation of the German MCRs is based on different information sources: the delimitation of Rhine-Main is based on Freytag et al. 2006; Rhine-Ruhr is based on Knapp et al. 2006; Munich is based on Lüthi et al. 2010; the delimitation of the remaining MCRs is based on IKM 2010 (Freytag et al. 2006; Knapp et al. 2006a; Lüthi et al. 2010b; IKM 2010).

Appendix C: Technical Appendix

Web Survey[3]



Hintergrund: Diese Umfrage bezieht sich auf die Wertschöpfungskette Ihres Unternehmens auf regionaler, nationaler, europäischer und internationaler Ebene. Im Zentrum stehen wissensintensive Dienstleistungs- und High-Tech-Unternehmen. Für Ihre Teilnahme und Unterstützung bedanken wir uns recht herzlich.

Ihr Nutzen: Bei Interesse schicken wir Ihnen die Ergebnisse der Umfrage gerne zu. Dadurch erhalten Sie die Möglichkeit, die räumliche Anordnung Ihrer eigenen unternehmerischen Wertschöpfungskette mit derjenigen anderer Firmen zu vergleichen. Unter den Teilnehmenden verlosen wir zudem einen iPod nano im Wert von EUR 169.

Wenig Aufwand: Der Fragebogen lässt sich in weniger als 10 Minuten bearbeiten und enthält nur elf Bildschirmseiten mit standardisierten Fragen.

Die Partner: Unser Vorhaben wird von der Deutschen Forschungsgemeinschaft (DFG) unterstützt. Die Projektleitung liegt beim Lehrstuhl für Raumentwicklung der TU München.

Datenschutz: Wir versichern Ihnen, dass wir Ihre Angaben streng vertraulich behandeln und die Daten für die Auswertung anonymisieren. Die Fragebögen werden nach Abschluss der Auswertung gelöscht bzw. vernichtet.

Vorgehen: Sie können den Fragebogen direkt übers Internet ausfüllen: Klicken Sie dazu auf **WEITER**.
Sie können den Fragebogen auch als PDF ausdrucken und zurückfaxen: Klicken Sie dazu auf **DRUCKEN.**

Weitere Informationen zum Forschungsprojekt erhalten Sie bei:

Prof. Dr. Alain Thierstein	thierstein@tum.de	
Dipl. Geogr. Stefan Lüthi	luethi@tum.de	Tel: 089 289 22386
Dipl. Geogr. Michael Bentlage	bentlage@tum.de	Tel: 089 289 22143

Hier können Sie den gesamten Fragebogen ausdrucken und dann zurückfaxen

Technische Universität München

WEITER

[3] Visualisation of the web survey: Anne Wiese.

Bitte klicken Sie auf Ihre Branche um den richtigen Fragebogen auszudrucken

DIENSTLEISTUNGSBRANCHE

HIGH-TECH BRANCHE

ANDERE

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ZURÜCK | ENDE

Wo befindet sich der Hauptsitz Ihres Unternehmens?

Land: Bitte wählen Sie

Ort: ______ und/oder PLZ: ______

An welchem Standort sind Sie tätig?

☐ Hauptsitz des Unternehmens

oder

Land: Bitte wählen Sie

Ort: ______ und/oder PLZ: ______

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ZURÜCK | WEITER

In welcher Branche ist Ihr Unternehmen hauptsächlich tätig?

Dienstleistungsbranche

- ○ Wirtschaftsprüfung
- ○ Versicherung
- ○ Werbung und Medien
- ○ Design, Architektur, Engineering
- ○ Rechtsberatung
- ○ Bank- und Finanzdienstleistung
- ○ Management- und IT-Consulting
- ○ Informations- und Kommunikationsdienstleistung
- ○ Logistik
- ○ Andere

High-Tech-Branche

- ○ Chemie, Biotech, Pharma
- ○ Computer, Hardware
- ○ Elektronik und Elektrotechnik
- ○ Fahrzeugbau
- ○ Maschinenbau
- ○ Medizintechnik, Optik
- ○ Rundfunk- und Nachrichtentechnik
- ○ Andere

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ZURÜCK WEITER

Die Wertschöpfungskette Ihres Unternehmens

Die Fragen auf den nächsten Seiten beziehen sich auf die Wertschöpfungskette Ihres Unternehmens auf regionaler, nationaler und internationaler Ebene. Die Wertschöpfungskette definiert sich durch folgende Elemente: **Produktentwicklung**, **Leistungserstellung**, **Finanzierung**, **Marketing**, **Vertrieb** und **Kunden**.

Bitte nennen Sie im Folgenden für jedes Element dieser Wertschöpfungskette die Standorte Ihrer drei **wichtigsten** Partner. Wichtige Partner sind zum Beispiel Firmen, mit denen Ihr Unternehmen große Umsätze generiert, oder die sich in strategisch wichtigen Märkten befinden.

Bitte nennen Sie zudem, ob es sich dabei um einen firmen-internen oder firmen-externen Partner handelt. **Firmen-interne** Partner sind Unternehmen, die rechtlich zwar selbständig sein können, wirtschaftlich aber einer einheitlichen Leitung, z.B. einer Holdinggesellschaft, unterstellt sind. **Firmen-externe** Partner sind Unternehmen, die nicht zur Unternehmensgruppe oder Holdingsgesellschaft gehören.

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ZURÜCK WEITER

Ihre drei wichtigsten Partner im Bereich Produktentwicklung

Die Produktentwicklung umfasst die zielgerichtete Entwicklung neuer sowie die Weiterentwicklung bestehender Dienstleistungen von der Idee bis zur Markteinführung (z.B. die Entwicklung eines neuen Finanzierungsinstruments).

◉ Partner im Bereich Produktentwicklung

Partner 1

Handelt es sich um einen firmen-internen Partner (z.B. eine interne Entwicklungsabteilung) oder um einen firmen-externen Partner (z.B. eine private Beratungsfirma oder eine Universität)?

○ firmen-intern ○ firmen-extern

Nennen Sie den Standort und die Branche des Partners:

Land	Ort		PLZ	Branche
Bitte wählen Sie		und/oder		Bitte wählen Sie

Partner 2

Partner 3

○ Keine Partner

○ Nicht bekannt

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ZURÜCK WEITER

Ihre drei wichtigsten Partner im Bereich Leistungserstellung

Die Leistungserstellung umfasst die Konzeption und Erbringung der Dienstleistung.

◉ Partner im Bereich Leistungserstellung

Partner 1

Handelt es sich um einen firmen-internen oder um einen firmen-externen Partner?

○ firmen-intern ○ firmen-extern

Nennen Sie den Standort und die Branche des Partners:

Land	Ort		PLZ	Branche
Bitte wählen Sie		und/oder		Bitte wählen Sie

Partner 2

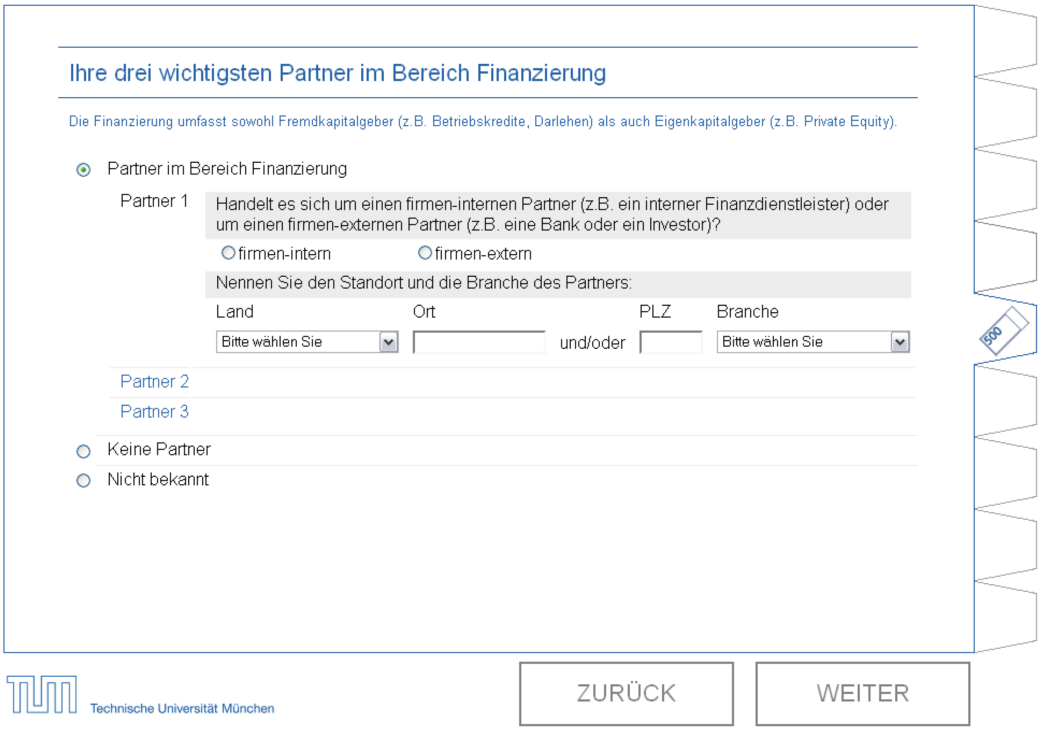
Partner 3

○ Keine Partner

○ Nicht bekannt

Technische Universität München

ZURÜCK WEITER



Ihre drei wichtigsten Partner im Bereich Finanzierung

Die Finanzierung umfasst sowohl Fremdkapitalgeber (z.B. Betriebskredite, Darlehen) als auch Eigenkapitalgeber (z.B. Private Equity).

- Partner im Bereich Finanzierung

Partner 1

Handelt es sich um einen firmen-internen Partner (z.B. ein interner Finanzdienstleister) oder um einen firmen-externen Partner (z.B. eine Bank oder ein Investor)?

- firmen-intern
- firmen-extern

Nennen Sie den Standort und die Branche des Partners:

Land: Bitte wählen Sie | Ort | und/oder | PLZ | Branche: Bitte wählen Sie

Partner 2

Partner 3

- Keine Partner
- Nicht bekannt

500

ZURÜCK | WEITER

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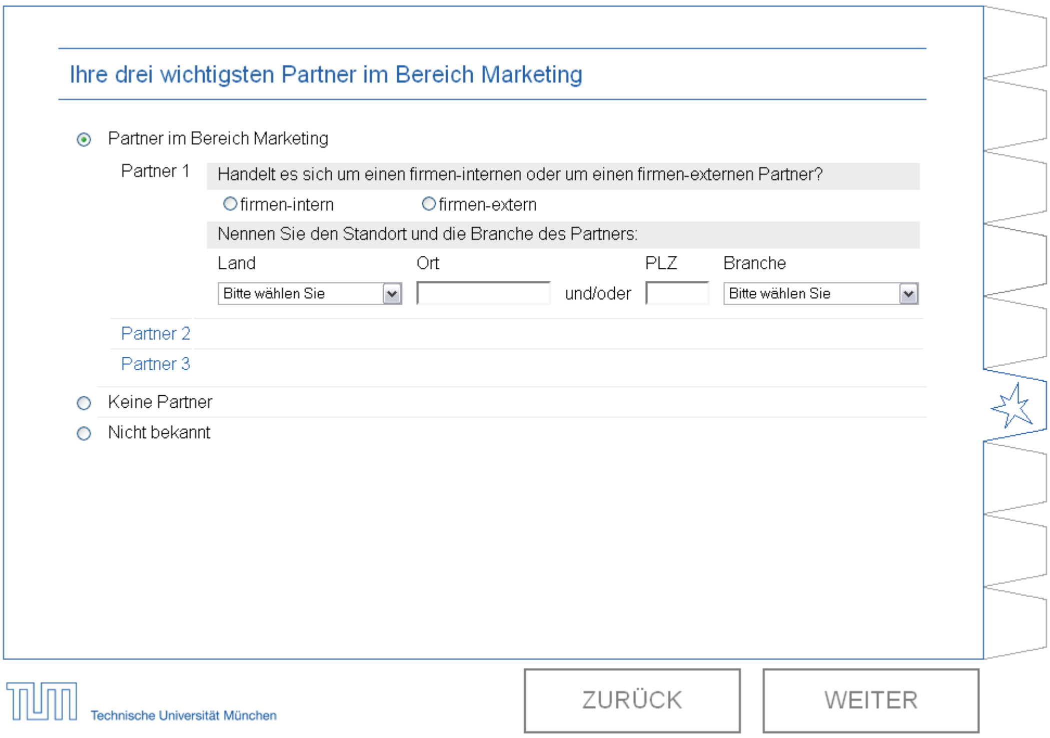


Ihre drei wichtigsten Partner im Bereich Marketing

- Partner im Bereich Marketing

Partner 1

Handelt es sich um einen firmen-internen oder um einen firmen-externen Partner?

- firmen-intern
- firmen-extern

Nennen Sie den Standort und die Branche des Partners:

Land: Bitte wählen Sie | Ort | und/oder | PLZ | Branche: Bitte wählen Sie

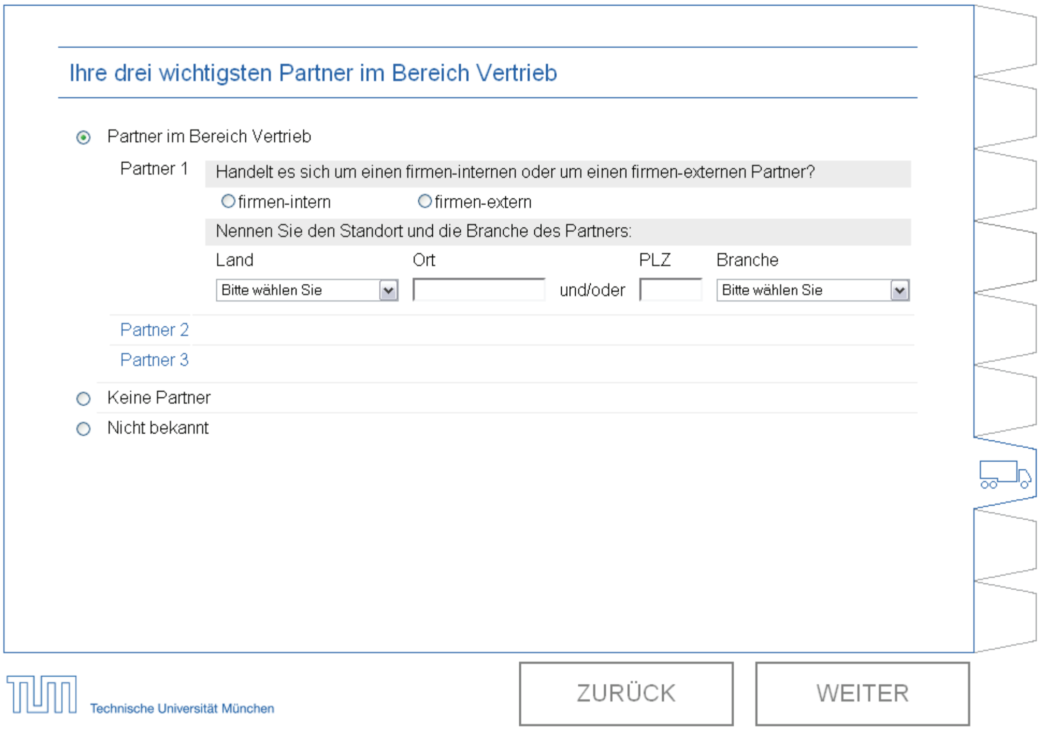
Partner 2

Partner 3

- Keine Partner
- Nicht bekannt

ZURÜCK | WEITER

Technische Universität München



Ihre drei wichtigsten Partner im Bereich Vertrieb

◉ Partner im Bereich Vertrieb

Partner 1

Handelt es sich um einen firmen-internen oder um einen firmen-externen Partner?

○ firmen-intern ○ firmen-extern

Nennen Sie den Standort und die Branche des Partners:

Land	Ort		PLZ	Branche
Bitte wählen Sie		und/oder		Bitte wählen Sie

Partner 2

Partner 3

○ Keine Partner

○ Nicht bekannt

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ZURÜCK WEITER

Ihre drei wichtigsten Kunden

◉ Kunden

Kunde 1

Handelt es sich um einen firmen-internen Kunden (z.B. ein interner Abnehmer) oder um einen firmen-externen Kunden?

○ firmen-intern ○ firmen-extern

Nennen Sie den Standort und die Branche des Partners:

Land	Ort		PLZ	Branche
Bitte wählen Sie		und/oder		Bitte wählen Sie

Kunde 2

Kunde 3

○ Keine Kunden

○ Nicht bekannt

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ZURÜCK WEITER

Wie viele Beschäftigte hat Ihr Unternehmen an Ihrem Standort?

- ○ Weniger als 10
- ○ 10 - 49
- ○ 50 - 99
- ○ 100 - 249
- ○ 250 - 499
- ○ 500-999
- ○ 1000 - 4999
- ○ 5000 und mehr
- ○ keine Angabe

Welche Funktion haben Sie in Ihrem Unternehmen?

Funktion: ______ ☐ keine Angabe

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ZURÜCK WEITER

Haben Sie Interesse an den Ergebnissen dieser Umfrage?

○ ja ○ nein

Dürfen wir Sie für ein Interview kontaktieren?

○ ja ○ nein

Möchten Sie an der Verlosung des iPod nano teilnehmen?

○ ja ○ nein

Kontaktperson: ______
Telefon: ______
E-Mail: ______

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ZURÜCK ENDE

Vielen Dank,

dass Sie an der Umfrage teilgenommen haben!

Sie können das Fenster nun schließen.

info Hier erhalten Sie weitere Informationen über den Lehrstuhl für Raumentwicklung der TU München

Technische Universität München

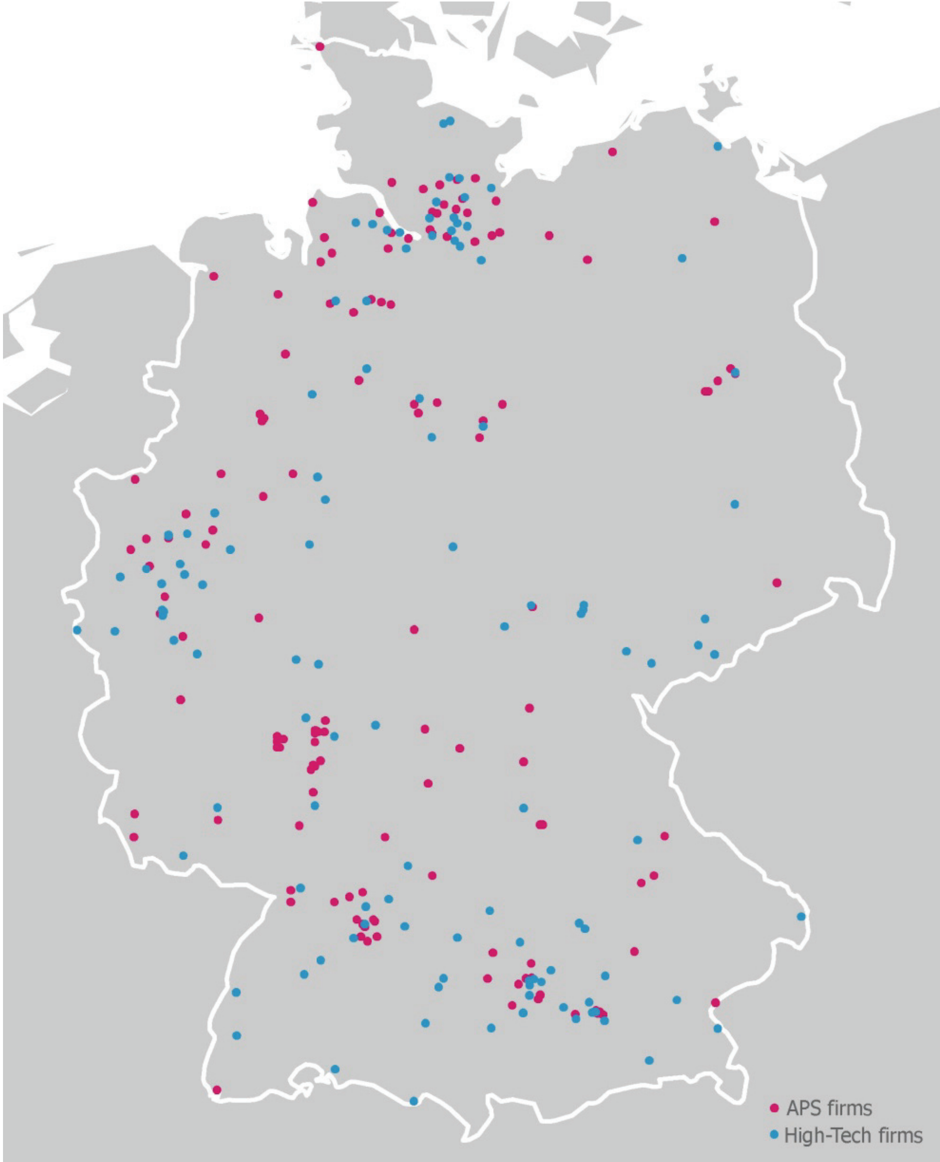

Figure 77A: Response web survey in Germany (Visualisualistion: Michael Bentlage)

Semi-structured questionnaire

Technische Universität München

Interview: Firma XY

Standortverflechtungen der Wissensökonomie und die Folgen für deutsche Metropolregionen

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Stadt und Landschaft
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Konzeptioneller Hintergrund

Im Innovationsprozess spielt Wissen als strategischer Wettbewerbsfaktor sowie die Fähigkeit zur Steuerung von unternehmerischen Wertschöpfungsketten eine entscheidende Rolle. Einerseits geht es darum, hochqualifizierte Menschen zu gewinnen, denn Humankapital ist eine der wichtigsten Schlüsselgrößen in der sich immer weiter ausbreitenden Wissensökonomie. Auf der anderen Seite werden die gesteigerten Möglichkeiten der Informations- und Kommunikationstechnologien für die Entstehung, Nutzung und sogar Ausbeutung von Wissen in seiner vielfachen Erscheinungsform verantwortlich gemacht.

Der systematische Einsatz von Wissen im Sinne einer Kombination von wissenschaftlichem und erfahrungsgestütztem Wissen im unternehmerischen Wertschöpfungsprozess trägt wesentlich zur Re-Konfiguration von Regionen bei. Regionen stehen unter einem erhöhten Druck der Standortkonkurrenz. Besonders attraktiv sind jene Räume, in denen es gelingt, spezifisches Wissen zu bündeln und unternehmerischen Innovationsprozessen zuzuführen. Abzuzeichnen beginnt sich, dass firmeninterne und firmenexterne Standortnetze wissensintensiver Mehrbetriebsunternehmen sich aufgrund der vielfältigen Anforderungen der Wissensökonomie innerhalb von mehrpoligen, urbanen Kompetenzräumen konzentrieren.

Gesprächsziele

Ausgehend von diesen konzeptionellen Grundlagen interessiert uns

- welche Standortstrategie Ihr Unternehmen verfolgt und wie sich die Standortdynamik über die Zeit entwickelt hat.
- welche regionalen, nationalen und internationalen Netzwerke Ihr Unternehmen nutzt, um neue Produkte und Dienstleistungen zu entwickeln.
- welche persönlichen Interaktionen und Kommunikationsgewohnheiten Sie praktizieren.
- welche Bedeutung räumliche Nähe zu firmeninternen und firmenexternen Partnern hat.

Gesprächsrahmen

Das Interview ist für 60 Minuten veranschlagt. Das Gespräch wird von Mitarbeitenden der TU München geführt. Ihre Antworten werden streng vertraulich behandelt und für die Auswertung anonymisiert.

Technische Universität München

Fakultät für Architektur
Institut für Entwerfen
Stadt und Landschaft
Lehrstuhl für Raumentwicklung

Fragebereiche

Konkret werden im Gespräch folgende Fragen thematisiert:

Standortstrategie und -dynamik

→ Abbildung 1 zeigt die wichtigsten Standorte Ihrer Firma.

- Welche Rolle spielt der Standort Essen im Vergleich zu den anderen firmeninternen Niederlassungen? Welche Stärken und Schwächen weist der Standort Essen auf?
- Wie haben sich die Beziehungen zu den anderen Niederlassungen Ihrer Firma in den letzten drei Jahren verändert? Was müsste im Bereich ‚Information und Kommunikation' geschehen, dass sich die Anordnung Ihrer Standorte verändert?

→ Abbildung 2 zeigt die Top-Standorte der größten Informations- und Kommunikationsdienstleister, die in Deutschland tätig sind.

- Wie interpretieren Sie diese Anordnung der Standorte im Vergleich zu Ihrer eigenen Firma? Wie verändert sich Ihre Branche als Gesamtes? Wo befinden sich die Zukunftsmärkte Ihrer Branche? Wie reagieren Sie auf diese Dynamik?

Firmeninterne und -externe Netzwerke

- Welche Überlegungen sind ausschlaggebend, ob Sie eine Aktivität firmenintern oder firmenextern organisieren?
- Wie läuft ein typisches (Innovations-) Projekt in Ihrer Firma ab? Wann sehen Sie die Projektbeteiligten? Wann kommunizieren Sie virtuell?
- Wie wichtig sind räumliche Nähe und face-to-face Kontakte im Innovationsprozess?

Unternehmerische Wertschöpfungskette

→ Abbildung 3 zeigt Ihre Antworten aus dem Websurvey. Die Wertschöpfungskette Ihrer Firma ist offenbar auf unterschiedliche Standorte verteilt.

- Was ist die Besonderheit an diesen Standorten?
- Welche Bedeutung hat der Hauptsitz im Innovationsprozess?

Kontaktdaten

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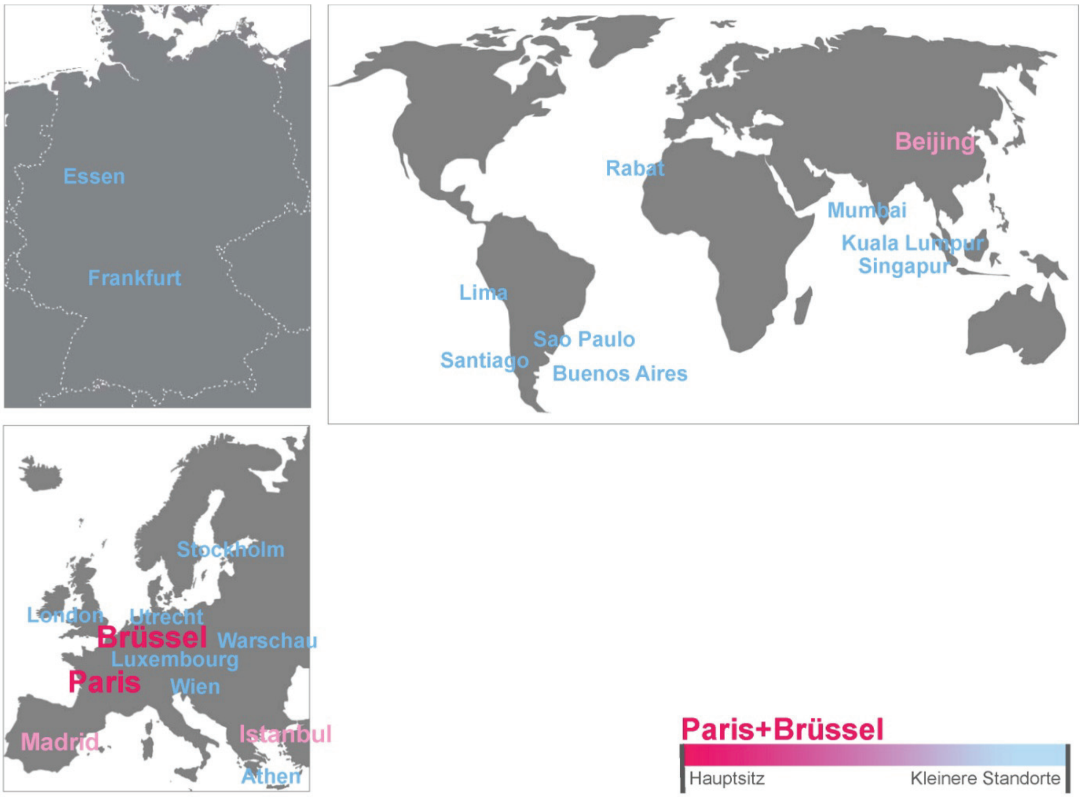

Abbildung 1: Die wichtigsten Standorte von Firma XY.

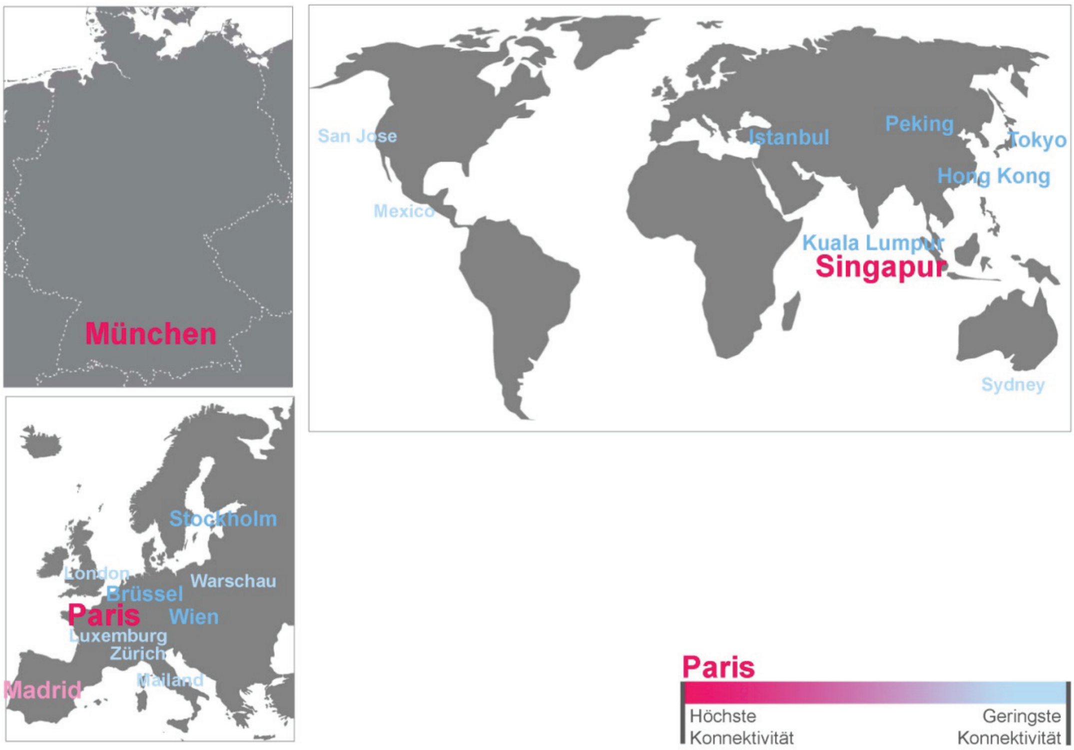

Abbildung 2: Top Standorte Informations- und Kommunikationsdienstleistung.

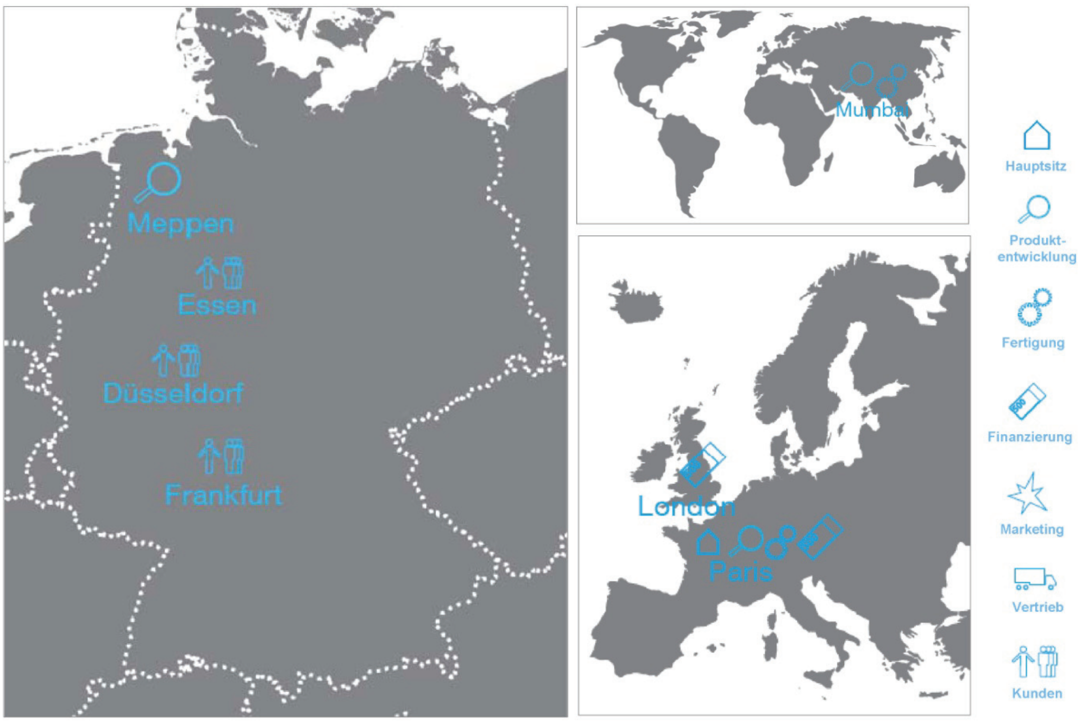

Abbildung 3: Die Wertschöpfungskette von Firma XY.

Table 75A: List of interviews

No.	Date	Location	Sector	
1	09.08.2010	Munich	High-Tech	
2	20.09.2010	Landshut	High-Tech	
3	20.09.2010	Munich	APS	
4	21.09.2010	Munich	APS	
5	23.09.2010	Munich	High-Tech	Telephone interview
6	27.09.2010	Zeulenroda	High-Tech	Telephone interview
7	27.09.2010	Gersthofen	High-Tech	
8	01.10.2010	Friedberg (Augsburg)	High-Tech	
9	04.10.2010	Mering	APS	
10	04.10.2010	Wiesloch	APS	Interview: Michael Bentlage
11	05.10.2010	Schwalbach am Taunus	High-Tech	
12	05.10.2010	Giessen	High-Tech	
13	06.10.2010	Leverkusen	APS	
14	07.10.2010	Essen	High-Tech	
15	07.10.2010	Essen	APS	
16	08.10.2010	Beckum	High-Tech	
17	11.10.2010	Oldenburg	APS	
18	11.10.2010	Bremen	APS	
19	12.10.2010	Barsbüttel (Hamburg)	High-Tech	
20	13.10.2010	Lübeck	High-Tech	
21	13.10.2010	Gross Grönau	APS	
22	14.10.2010	Zwönitz	High-Tech	
23	19.10.2010	Kronberg am Taunus	APS	
24	20.10.2010	Cologne	APS	Telephone interview
25	20.10.2010	Munich	APS	
26	29.10.2010	Zurich	APS	

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