Open access • Journal Article • DOI:10.1111/J.1471-0374.2010.00277.X

Intra-firm and extra-firm linkages in the knowledge economy: the case of the emerging mega-city region of Munich — Source link

Stefan Lüthi, Alain Thierstein, Viktor Goebel

Institutions: Technische Universität München, Federal Statistical Office

Published on: 01 Jan 2010 - Global Networks-a Journal of Transnational Affairs (Blackwell Publishing Ltd)

Topics: Knowledge economy

Intra-firm and extra-firm linkages in the knowledge economy: the case of the emerging mega-city region of Munich

STEFAN LÜTHI,[*] ALAIN THIERSTEIN[†] AND VIKTOR GOEBEL[‡]

[*†]*Technische Universität München, Chair for Territorial and Spatial Development, Arcisstrasse 21, 80333 München, Germany*
luethi@raumentwicklung.ar.tum.de
thierstein@raumentwicklung.ar.tum.de

[‡]*Swiss Federal Statistical Office, Spatial Analysis Section, Espace de l'Europe 10, CH-2010 Neuchâtel, Switzerland*
viktor.goebel@bfs.admin.ch

Abstract *With the aim of identifying emerging patterns of spatial development and the driving forces behind the associated process, in this article we draw together two threads of interlinked phenomena. First, we look at how multi-location firms from the knowledge economy develop their intra-firm networks internationally. Second, we establish the partners with which these firms have working relationships along individual chains of value, and in which these extra-firm linkages are located. We start from a conceptual background that combines the location behaviour of firms with a value chain approach. We analyse the two main pillars of the knowledge economy – advanced producer services (APS) and high-tech firms. A case study carried out in the greater Munich area provides the empirical basis and draws on quantitative and qualitative research methods. The results provide evidence that the greater Munich area can be regarded simultaneously as a hierarchically organized polycentric mega-city region and high-grade localized system of value chains.*

Keywords MEGA-CITY REGION, KNOWLEDGE ECONOMY, VALUE CHAIN, ADVANCED PRODUCER SERVICES FIRMS, HIGH-TECH FIRMS, MUNICH

Globalization has entailed a reorganization of spatial development processes on the global, European, national and regional scales. New forms of hierarchical and network development and functional differentiation between cities can be observed (Friedmann 1986; Sassen 2001). Scott (2001) and, lately, 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

Global Networks 10, 1 (2010) 114–137. ISSN 1470–2266.

among firms. Hence, the traditional hierarchical model of a core city dominating its urban hinterland is becoming increasingly obsolete. Instead, a process of selective decentralization of particular urban functions, and the simultaneous reconcentration of others, has led to the emergence of polycentric mega-city regions (Kloosterman and Musterd 2001; Lüthi et al. 2008; Thierstein et al. 2008). This emerging urban form is spread out over a large area containing a number of cities more or less within commuting distance, and one or more international airports that link the region with other parts of the world (Hoyler et al. 2008b).

Different attempts have been made to handle these extended urban regions analytically, and a variety of research projects and publications concerned with polycentricity at the city-regional scale has been realized (for example ESPON 2004; Hall and Pain 2006; Hoyler et al. 2006; Hoyler et al. 2008a; Thierstein et al. 2006). Furthermore, a number of labels have been used to denote the identified new metropolitan form (Hoyler et al. 2008b); for instance polycentric urban regions (Kloosterman and Musterd 2001), global city-regions (Scott 2001) or – as in this article – mega-city regions (Hall and Pain 2006). The main objective of this article lies in the exploration of the mega-city region hypothesis through combining the World City Network research with a value chain approach. By analysing the two main pillars of the knowledge economy – advanced producer services (APS) and high-tech firms – we first look at how multi-location firms from the knowledge economy develop their intra-firm networks internationally. Second, we look for the partners with which these firms have working relationships along individual chains of value, and in which these extra-firm linkages are located. A case study in the greater Munich area provides the empirical basis drawing on both quantitative and qualitative research methods.

The article is structured in three main sections. The first section focuses on the concept of mega-city regions by discussing two associated theoretical approaches: World City Network and value chain models. In the second section we present the research concept and the main findings of our case study about the emerging mega-city region of Munich. And finally, in the third section, we conclude by synthesizing the main findings and proposing an agenda for further research activities.

Theoretical background

In this article, the emergence of polycentric mega-city regions is understood as a spatial phenomenon that results from two interdependent processes – World City Networking and value-added relations between knowledge intensive enterprises. In this respect, it is possible to differentiate between two streams of theoretical thinking, namely World City Network models and value chain models. Unfortunately, these literatures have developed quite independently and with little cross-referencing. In the following sections, the main arguments of the World City Network and the value chain models will be discussed with a view to showing their differences and similarities and relating them to the concept of emerging mega-city regions.

World City Network models

Much of world city research has been related to the emergence of a globally networked knowledge economy in which advanced producer services (APS) firms play a predominant role (Sassen 2001). In this respect, Saskia Sassen's global city approach is an important contribution. It provides a new geography of centrality in which city centres or central business districts form the heart of the global urban network. The functional centrality of these global cities leads to an increasing disconnection of city centres from their broader hinterlands or adjacent metropolitan region. The reason for this disconnecting process lies, according to Sassen, in the location strategies of APS firms as spearheads of the rising global knowledge economy. These enterprises are increasingly located just within the city centres of economic regions and connect these places directly with other city centres in the world.

In contrast to Saskia Sassen's global city approach, John Friedmann, with his concept of a world city, argues that the territorial basis of world cities comprises not only the central city but also the whole economic space of the surrounding region. Therefore, world cities are often polycentric urban regions containing a number of historically distinct cities that are located in more or less close proximity. This fundamental difference between John Friedmann's world cities and Saskia Sassen's global cities are well described by Derudder (2006: 2034):

> 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.

Furthermore, John Friedmann describes the rise of a transnational urban network as a major geographical transformation of the capitalist world economy whose production systems are increasingly internationalized. This reconfiguration results in a new international division of labour whose main agents are multinational enterprises with complex spatial organizational structures. It is the presence of these multinational enterprises that makes world cities into geographical places of great economic power (Friedmann 1986).

Another heuristic framework about network cities is provided by Manuel Castells's highly influential concept of a space of flows. He (Castells 1996: 412) describes it as follows:

> Our societies are constructed around flows: flows of capital, flows of information, flows of technology, flows of organizational interactions, flows of images, sounds and symbols. … 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 argues that the new spatial logic is determined by the pre-eminence of the space of flows over the space of places. By space of flows he 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 localization.

While Friedmann and Castells offer a heuristic and theoretical framework on why globalization requires a networked conception of cities, with his World City Network approach Peter Taylor (2004) provides an empirical instrument for analysing inter-city relations in terms of the organizational structure of the global economy. With his team at Loughborough University – the Globalisation and World Cities Study Group (GaWC) – he analyses inter-city relations using a methodology in which relationships between cities are not measured directly. Instead, he uses a proxy by analysing the internal structures of large APS firms and revealing the relationships between head offices and other branches located all over the world. In this way he focuses on the distribution of branch offices of individual companies and assumes connectivity of locations by emphasizing the existence of a network in line with the idea of potential knowledge exchange between the branch offices.

However, as Thierstein et al. (2008) argue, this kind of approximation does not tell the whole story of the nature and quality of business activities between those different locations. Knowledge exchange and business activities arise not only through branch office networks, but also and primarily from the division of labour between different companies. In many cases, outsourcing strategies with respect to single activities are more efficient and lead to higher quality 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 between competitors open the opportunity for formal and informal knowledge exchange within the same field of business. To grasp these networks fully, it is necessary to analyse not only the connectivity within a single firm but also the value chain relations between different enterprises and sectors.

Furthermore, to tap the full potential of the World City Network approach, we propose to apply it not only to APS firms but also to high-tech enterprises. High-tech enterprises are also part of the knowledge economy. To understand the geographies of globalization processes in the knowledge economy, one has to account simultaneously for both the APS and the high-tech sectors because both of them are integral parts of mega-city region development. Krätke for example argues that in both the APS and high-tech sectors, which constitute the key sectors of an increasingly knowledge-based and innovation-driven economy, an ongoing process of selective spatial concentration in urban agglomerations and metropolitan regions leads to the development of strong cluster potentials, which raise the productivity and innovation capacity of these regional economic centres and contribute to an increase of workplaces, particularly in these branches of industry (Krätke 2007: 4).

All in all, we argue that a value chain approach is well able to provide a complementary asset to World City Network models and helps to understand the changing nature of international trade and spatial industrial organization.

Value chain models

Studies from a range of disciplines show that the value chain approach has become much more prevalent and elaborate in the past ten years. Its argumentation starts form the notion of a value-added chain, as developed by international business scholars who have focused on the strategies of firms in the global economy. In its most basic form, a value-added 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). Hence, the key questions in this literature are which activities and technologies a firm keeps in-house and which should be outsourced to other firms, and where the various activities should be located (Gereffi et al. 2005).

A rich literature has evolved to explain how global industries are organized and governed (Coe et al. 2008a). Three sets of terminology have become especially prominent. An early, but still very active body of research exists on Global Commodity Chains (GCC), a term that Gary Gereffi has popularized in a large number of publications since 1994. The GCC framework pays particular attention to the powerful role that large retailers and highly successful branded merchandisers have come to play in the governance of global production and distribution.

In the last decade, however, transnational giants have changed quite dramatically, outsourcing many activities and developing strategic alliances with competitors. They have become less vertically integrated and more network-oriented (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. 2008a). Thereby, the value chain is understood as providing the full range of activities that firms and workers do to bring a product or a service from its conception to its end use and even beyond (Gereffi et al. 2005).

The third approach, finally, is the Global Production Network (GPN) framework, initially developed by researchers in Manchester (Henderson et al. 2002). GPNs can be defined as the globally organized nexus of interconnected functions and operations through which goods and services are produced, distributed and consumed (Coe et al. 2004). Thereby, the process of embeddedness, both territorially and within business networks is of great importance. Henderson et al. (2002) argue that the mode of territorial embeddedness or the degree of a GPN firm's commitment to a particular location is an important factor for value creation, enhancement and capture.

Although the GCC, GVC and GPN frameworks enable a focus on worldwide networks of production processes, there are some shortcomings that must be addressed by future research activities. First, the study of the actual geographies of value chains has remained relatively underdeveloped (Brown et al. this issue). Coe et al. (2004) even argue that the Global Commodity Chain approach still remains preoccupied with the nation-state as the main geographical scale of analysis (for example OECD 2008;

Tokatli et al. 2008). A second, more specific limitation in value chain research is that the empirical scope of analysis has mainly been concerned with a small number of primary commodities and industrial sectors (for example Hassler 2003; Palpacuer and Parisotto 2003; Pilat et al. 2008; Rothenberg-Aalami 2004) and pays little attention to APS enterprises. A third shortcoming, finally, is the fact that value chain research has an underdeveloped set of tools for the operationalization 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. this issue).

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 fundamental spatial models of flows (Brown et al. this issue) and take economic globalization and the spatio-economic behaviour of firms as the holistic starting point of their analysis (Jacobs 2008). Besides these similarities, there are two major differences between them. The first concerns the information flow in firm networks. World city research focuses in particular on *intra-firm* networks of APS firms, whereas value chain models concentrate on *extra-firm* relationships and the global division of labour, value and power within the supply chains of goods (Jacobs 2008). The second difference concerns the geographical scale of investigation. Whereas the World City Network focuses mainly on the *city* as a spatial analytical entity, the value chain model often remains preoccupied with the nation state as the geographical scale of analysis.

Emerging mega-city regions

Mega-city regions are not a completely new phenomenon. Jean Gottmann originally made similar observations as long ago as 1961 in his pioneering study of *Megalopolis: the urbanized Northeastern seaboard of the United States* (Gottmann 1961). A few years later, Sir Peter Hall (1966) observed that next to the traditional 'highly centralized giant city' there exists a 'polycentric type of metropolis'. This polycentric metropolis consists of 'a number of smaller, specialized, 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). However, the most recent rediscovery of the concept 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). Peter Hall and Kathy Pain emphasize its large-scale nature and developing polycentric structure by defining 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)

This definition is based on Friedmann's world city concept, which argues – in contrast to Saskia Sassen's global cities – that the territorial basis of world cities comprises not only the central city but also the entire economic space of the surrounding region. On a wider spatial scale, such polycentric systems are interlinked with other city regions forming European and global knowledge networks, as proposed by Peter Taylor's (2004) concept of the World City Network. The key point of this conception is that mega-city regions are not solely defined 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.

Different attempts have been made to analyse the polycentric structure of emerging mega-city regions in Europe and Germany (for example, Krätke 2007; Krätke and Brandt 2009; Kujath 2005; Kujath and Schmidt 2007). One of the most recent empirical research activities is the INTERREG IIIB Study POLYNET – on the sustainable management of European polycentric mega-city regions (Hall and Pain (2006) provide a comprehensive illustration of the POLYNET results). POLYNET aimed to investigate the polycentricity of the following eight mega-city regions in northwest Europe and their current state of functional division of labour – Southeast England, the Paris region, central Belgium, the Dutch Randstad, Rhine-Main, RhineRuhr, northern Switzerland, and Greater Dublin (Hall 2007). With its seminal research project, POLYNET introduced a new way of looking at polycentric urban structures and hierarchies adopting Peter Taylor's World City Network approach on the mega-city region scale (Taylor et al. 2008). The study started from the premise that business service firms offer a strategic lens through which to examine intercity relations within and beyond larger urban regions, building theoretically on Saskia Sassen's (2001) identification of advanced producer services as crucial actors and outcomes of globalization and localization processes, on Manuel Castells's (1996) notion of a 'space of flows', and on Peter Taylor's (2004) concept of a 'World City Network' (Hoyler et al. 2008a). The POLYNET study advanced the theoretical debate on large polycentric urban regions on the basis of new empirical evidence from northwestern Europe. Its main conclusion is that polycentricity emerges as a scale-dependent phenomenon based on the coming together of various business service networks of different organizational architectures and scalar reach (Hoyler et al. 2006). The mega-city region, in its various guises, is becoming a more general phenomenon in advanced economies (Hoyler et al. 2008b).

The emerging mega-city region of Munich

In the following section – referring to the theoretical discussion above and to the argument of Thierstein et al. (2008) concerning the combination of the World City

Network model with a value chain approach – we present our research concept and the main findings of a case study carried out in the greater Munich area. We thus extend the POLYNET approach by two important dimensions: first, we investigate not only APS enterprises but also high-tech firms, which form another important pillar of the knowledge economy, and not only in Germany. Second, we extend the analysis by also looking at extra-firm networks of knowledge-intensive enterprises along their individual chains of value added.

Main hypotheses

Starting from the theoretical and conceptual considerations discussed above, we propose three central hypotheses with respect to the greater Munich area. Referring to the mega-city region definition of Peter Hall and Kathy Pain (2006), the first hypothesis suggests that there is an emerging mega-city region of Munich defined as physically separated but functionally networked socio-economic space:

> *Hypothesis 1:* Secondary cities in proximity to Munich and Munich itself are linked together by interlocking networks of APS firms, defining the greater Munich area as an emerging polycentric mega-city region.

The second hypothesis suggests that knowledge-intensive business operations and flows are associated with a hierarchical polycentric pattern of urban development. The central question concerns the extent to which the functional urban hierarchy within the greater Munich area is associated with different sectors and scales of knowledge-intensive activities:

> *Hypothesis 2:* There is a steep functional urban hierarchy within the greater Munich area, with Munich as primary city in relation to international intra-firm connectivities; in terms of regional intra-firm connectivities, however, this functional urban hierarchy is less pronounced.

The third hypothesis understands the greater Munich area as a spatial system of socio-economic 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:

> *Hypothesis 3:* Extra-firm linkages of APS and high-tech firms tend to concentrate in the greater Munich area, which, as a consequence, is evolving into a high-grade localized system of value chains.

The study area

Munich is one of the most competitive metropolitan areas in Germany. Several companies operating at 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. In many rankings based on economic indicators and soft location factors Munich is the leading city in Germany. However, as in many other European cities, the greater Munich area is faced with urban sprawl, increasing traffic and criss-cross commuting patterns as well as increasing prices for real estate, especially in the core of the agglomeration (Lüthi et al. 2007).

The spatial expansion of economic networks over recent decades led to the emergence of a functional space of economic interrelations within the greater Munich area. It is important to recognize that this greater Munich area is not a clearly defined region but a spatial concept approximating a functional space of economic interrelations. Analysing this functional space is an explicitly explorative project involving a field that has hitherto received little attention in Germany. Notable exceptions are the POLYNET case studies on RheinRuhr (Knapp and Schmitt 2008; Schmitt and Knapp 2006) and Rhine-Main (Hoyler et al. 2008a).

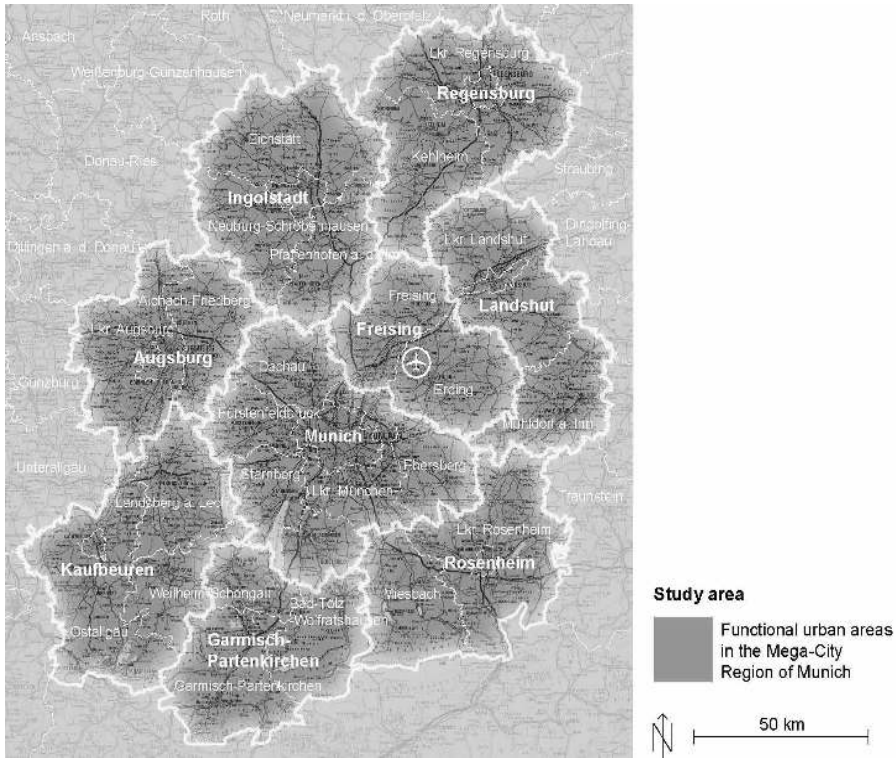
However, for the quantitative analysis of our case study, it was necessary to decide on a working definition that delimits the greater Munich area in a pragmatic way. To define the outer borderline of the study region, we calculated the area that can theoretically be reached within a one-hour car journey from Munich city centre. This corresponds approximately to a radius of 70 km. This methodology is based on the GEMACA (Group for European Metropolitan Areas Comparative Analysis) approach using commuter data as functional criteria for the delimitation of metropolitan areas (GEMACA 1996). Within this 60-minute travel-to-work radius, the main analytical building blocks are constituted by nine functional urban areas (FUAs), as defined by the ESPON research project 111, with potential for polycentric development in Europe (ESPON 2004). These are München, Kaufbeuren, Garmisch-Partenkirchen, Rosenheim, Landshut, Freising, Regensburg, Ingolstadt and Augsburg (Figure 1). FUAs are defined as having an urban core of at least 15,000 inhabitants and over 50,000 in total population; the definition of the rings is based on 45-minute isochrones. Further details of the FUA delineation can be seen in the Annex Report D of the ESPON Project 111 (Schürmann 2004).

Sampling strategy

In this case study, we analyse the location behaviour of knowledge-intensive enterprises focusing particularly on APS and high-tech firms. The sampling strategy follows a top–down approach in two steps. In the first step, the APS and high-tech sectors are operationalized on the basis of the international NACE (nomeclature générale des activités économiques) classification. For the APS sector, we basically adopted the operationalization used in the POLYNET study (Hall and Pain 2006) to effectuate direct comparisons. The empirical operationalization of the high-tech sector, however, is based on the Oslo manual of the OECD (OECD 2005) (Table 1).

In the second step, the sample of knowledge intensive firms whose intra-firm and extra-firm networks are analysed is defined. The firms have to meet four criteria: first, they have to belong to a knowledge-intensive economic sector as defined above. Second, they have to belong to the largest knowledge-intensive firms in the mega-city region of Munich, measured my means of employment size. Third, they have to be multi-branch enterprises with at least one office location in the study area. Having met these conditions, firms are finally selected on the basis of the availability of information on their office networks. The result of this process was a basic set of 164 APS firms and 155 high-tech enterprises.

Figure 1: Area of the case study



Source: authors' illustration.

In identifying APS and high-tech firms within the emerging mega-city region of Munich, the data set from Hoppenstedt has been 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 order to take all FUAs and all branches adequately into account, we gathered additional information about important knowledge-intensive enterprises by checking websites of local and regional bodies and business associations.

Table 1: Studied sectors, NACE codes in brackets

Advanced Producer Services (APS)	high-tech
accounting (7412)	chemistry & pharma (24)
insurance (66, 672)	machinery (29)
banking & finance (65, 671)	computer (30)
management & IT-consulting (72, 7413, 7414, 7415)	electrical machinery (31)
law (7411)	telecommunication (32)
logistics (3p & 4p) (6024, 611, 612, 621, 622, 631, 632, 634, 64)	medical & optical instruments (33)
design & architecture (742)	vehicle construction (34, 35)
advertising & media (744, 221, 921, 922, 924)	

Source: authors' compilation.

The interlocking network model

The analysis of intra-firm networks is based on the methodology of the Globalisation and World Cities Study Group (GaWC) as used for the POLYNET study (Taylor et al. 2008). This approach estimates city connectivities from the office networks of multi-location multi-branch enterprises. 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. The empirical work comprises two steps.

In a first step, we developed a so-called 'service activity matrix'. This matrix is defined by FUAs in the lines and knowledge-intensive firms in the columns. Each cell in the matrix shows a service value (v) that indicates the importance of an FUA to a firm. The importance is defined by the size of an office location and its function. By analysing the firms' websites from September 2006 to February 2007, all office locations are rated at a scale of 0 to 3. The standard value for a cell in the matrix is 0 (no presence) or 2 (presence). If there is a clear indication that a location has a special relevance within the firm network (for example headquarter, supra-office functions) its value is upgraded to 3. If the overall importance of a location in the firm-network is very low (for example small agency) the value is downgraded to 1.

In the second step, we used the interlocking network model established by Taylor (2004) to estimate connectivities between FUAs within and beyond the emerging mega-city region of Munich. The primary outputs of the interlocking network analysis are network connectivities, a measure that estimates how well connected a city is within the overall intra-firm network. There are different kinds of connectivity values. The connectivity between two FUAs (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 FUAs for one firm:

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

This approach seems reasonable when the following assumptions are made (see Derudder and Taylor 2005: 74–5). First, offices generate more flows within a firm's network than to other firms in their sector. This is inherently plausible in a context where protecting global brand image through providing seamless service is the norm. Second, 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 office networks where larger offices have special functions like control and provision of specialized knowledge.

To calculate the total connectivity between two FUAs, one has to summarize the elemental interlock for all firms located in these two FUAs. This leads to the *city interlock* (r_{ab}):

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

Aggregating the city interlocks for a single FUA produces the *interlock connectivity* (N_a). This describes the importance of an FUA within the overall intra-firm network.

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

Finally, if we relate the interlock connectivity for a given FUA to the FUA with the highest interlock connectivity, we gain an idea of its relative importance in respect to the other FUAs that have been considered.

The value chain approach

Extra-firm relationships have been analysed by means of an internet-based survey running from April to May 2007. The survey combines relational data on firm locations with the degree and importance of working interrelationships along individual firms' chain of value. The empirical analysis is based on 1800 APS and high-tech firms of the emerging mega-city region of Munich, whereas 258 enterprises have completed the survey satisfactorily. Hence, the rate of return is 14.3 per cent. The distribution of the numbers of companies questioned varies widely across the branches under study. With 15 per cent, companies in the area of machinery were the most frequent participants, followed by companies in management consulting and electrical machinery with 13 per cent. Companies in chemistry and pharmaceuticals, third and fourth party logistics, banking and finance, advertising and media, design and architecture, vehicle construction and the telecommunication sectors participated between

4 and 10 per cent. At 1 per cent and 2 per cent, accounting, computer, medical and optical instruments, insurance and law companies form the smallest groups.

The web survey comprised three sections. In the first section information is gathered about the firm's business location and the spatial range where they source inputs for their products from. In the second, the firms are asked to localize and assess the importance of their extra-firm relations to other APS and high-tech firms. And finally, in order to relate the extra-firm relationships to a stylized value chain, the responding firms have to localize their business activities along the individual value chain elements of 'research & development', 'processing', 'marketing', 'sales & distribution' and 'customers'. With this procedure, we obtained a comprehensive picture about the spatial value chain patterns of APS- and high-tech firms in the mega-city region of Munich on the global, European, national and regional scale.

Networks of knowledge in the emerging mega-city region of Munich

Let us now take a closer look at the empirical results. This will be done along the three hypothesis suggested above. First, we show how interlocking intra-firm networks of APS firms define an emerging polycentric mega-city region of Munich. Based on these intra-firm networks, we then present the functional urban hierarchy within the mega-city region referring to different geographical scales. And third, referring to the extra-firm analysis, we present the extent to which the mega-city region of Munich can be seen as a localized system of value chains.

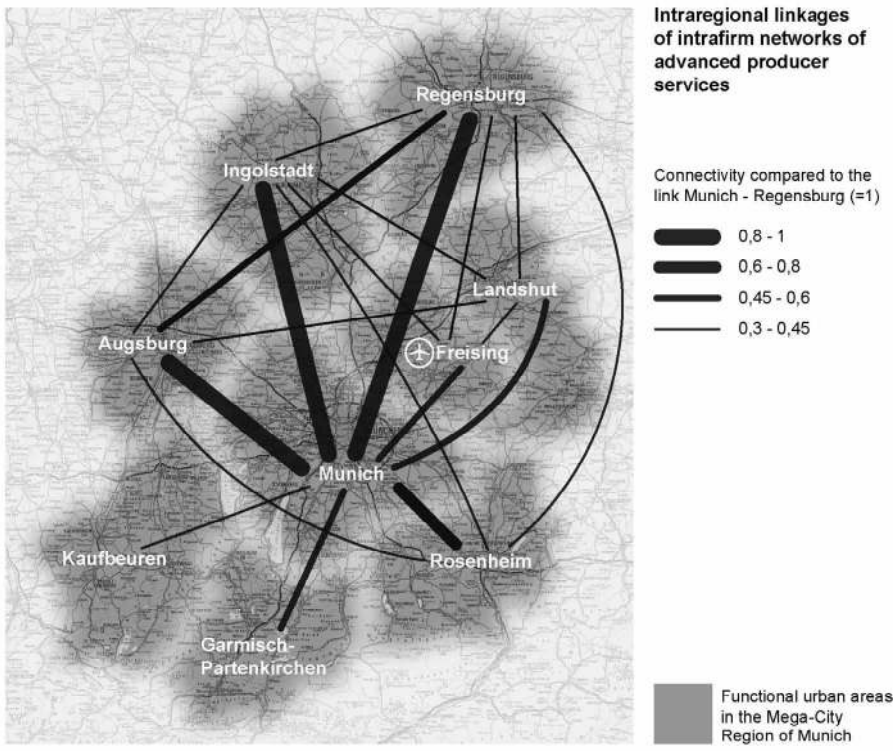
The greater Munich area as an emerging polycentric mega-city region

The increasing importance of network economies has introduced new thinking about space, place and scale that interprets regions as unbounded, relational spaces. From a relational point of view, regions can be defined by their linkages and relations within and beyond their territorial boundaries (Pike 2007). The linkages of the knowledge economy in the greater Munich area are facing pronounced structural change due to the reorganization 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 spatial organization of intra-firm networks. Figure 2 shows the spatial patterns of the intra-firm connectivity between APS firms on the regional scale. The thickness of the lines 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 Regensburg. This high value is because many APS firms have relatively important and therefore highly-rated locations in the cities of both Munich and Regensburg.

The most important finding of Figure 2 is that the predominant part of intra-firm networks is located within the demarcation of what we have been labelling from the outset of our research as the emerging mega-city region of Munich. Since the FUAs within the study area are more closely linked with each other than with outlying FUAs, they begin to form a conglomerate of functionally linked FUAs that merits being labelled as 'emerging Mega-City Region of Munich'. The increasing com-

plexity of network economies leads to a kind of paradox associated with this emergence. The inter-urban functional linkages are found to be extending and intensifying, while at the same time global functions are clustering and centralizing. While specialized global functions are concentrated in Munich itself, proximate FUAs are gaining complementary service functions. Interlocking networks of APS firms link these different agglomerations together, thus defining the emerging mega-city region of Munich as physically separated but functionally networked socio-economic space.

Figure 2: Intra-firm connectivity between APS firms at regional level



Source: authors' calculation.

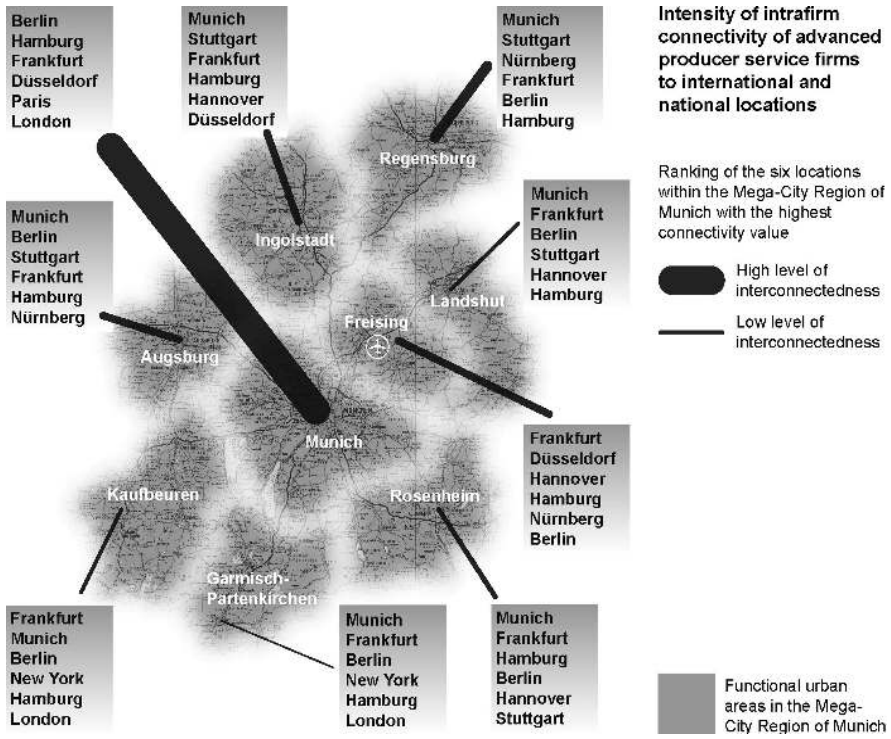
The greater Munich area as a hierarchical urban system

We shall now deal with the question of to what extent the greater Munich area can be understood as a hierarchical urban system. Figures 3 and 4 show the spatial dimension of the intra-firm connectivity for APS and high-tech firms on the national and international scale. For each FUA, the six most closely connected locations are listed. The thickness of the lines reflects the total international connectivity value of the FUAs created by intra-firm interlocking networks.

Regarding the APS sector in Figure 3, Munich is most strongly linked with four large national cities (Berlin, Hamburg, Frankfurt and Düsseldorf) followed by Paris and London as the first European destinations. This is a surprising finding because it

could be assumed that – in an increasingly globalized world – international linkages would be more important for the APS sector in Munich. Another interesting feature concerns the connectivities in the secondary cities around Munich. Most of them are primarily connected to Munich, generally followed by further German locations. This means that APS firms in these locations mainly have offices in Munich or other national urban centres, whereas offices in European or even international locations are quite rare. Hence, in the case of APS interlocking networks, medium-sized and small urban centres in the greater Munich area are not directly integrated into international networks of knowledge-intensive economic activities. Instead, they are well integrated into large-scale regional networks of knowledge exchange. The city of Munich, however, is a central node and international gateway for smaller centres in the emerging mega-city region and acts as an important international knowledge-hub.

Figure 3: Intensity and ranking of connectivity values created by intra-firm networks of APS companies

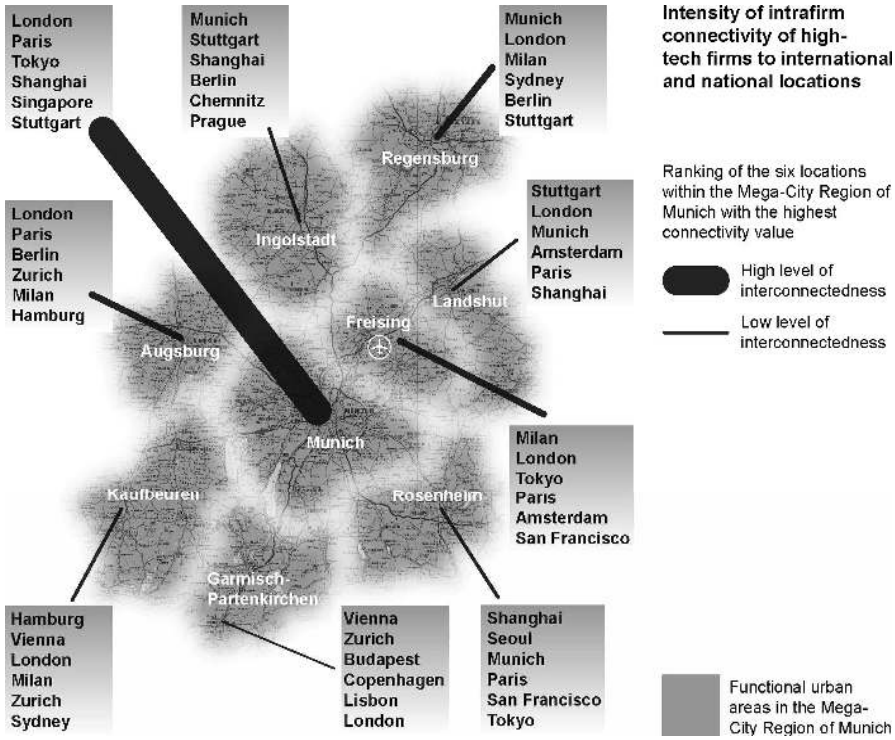


Source: authors' calculation.

The globalization of intra-firm networks becomes particularly clear in the case of high-tech companies (Figure 4). Both, Munich and the surrounding secondary FUAs are dominated by international and national connectivities. The reason for this lies in the physical fragmentation of production whereby the various stages are optimally located across different sites as firms find it advantageous to source more of their

inputs globally. This finding is supported by an OECD (2008) study, showing that high-tech and medium-high tech industries are on average more internationalized than less technology-intensive industries or service sectors. However, as we shall see in the next section, the globalization 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 that may create spillover benefits that investing firms can absorb. 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.

Figure 4: Intensity and ranking of connectivity values created by intra-firm networks of high-tech companies

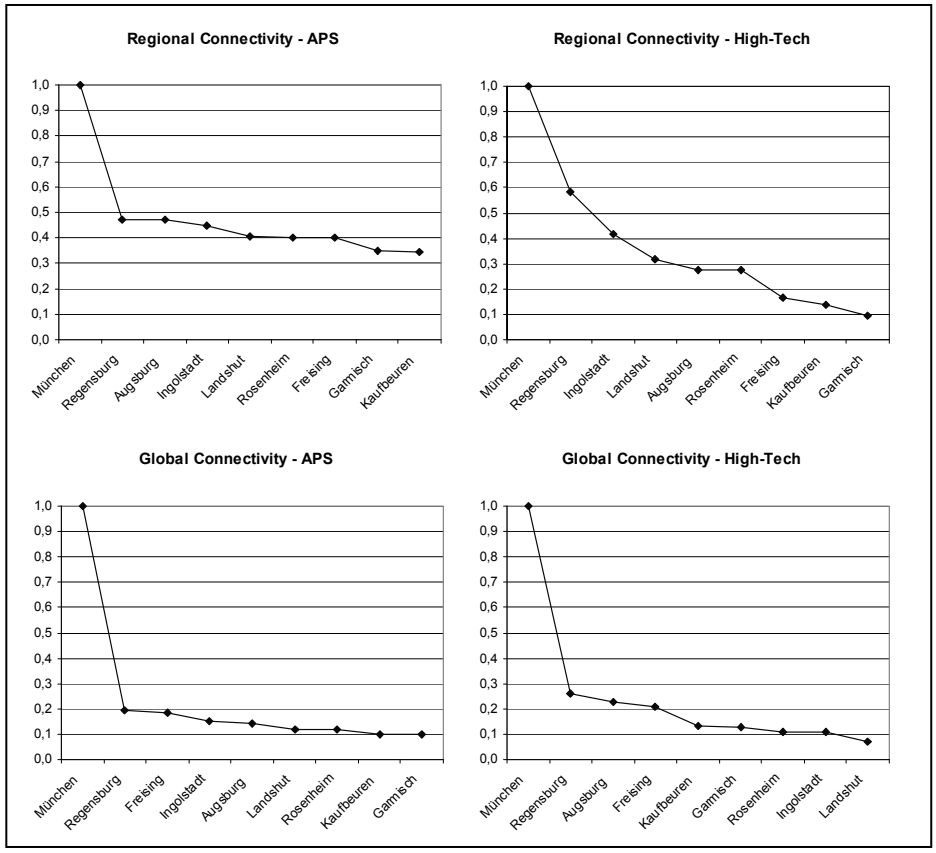


Source: authors' calculation.

Another way to show the hierarchical polycentric pattern within the greater Munich area is to plot the connectivity values in a graph. Figure 5 shows the functional urban hierarchy for both the global and the regional scale and for the APS and high-tech sector. On the X-axis, there are the nine FUA, which 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 within the mega-city region.

Figure 5: Global and regional connectivity of the FUAs in the mega-city region of Munich – APS and high-tech firms



Source: authors' calculation.

The results show considerable differences between the two geographical scales. On the global level, the gap between Munich and the other FUAs of the mega-city region is remarkably wide. That means that small FUAs are less integrated in global intra-firm networks of APS and high-tech firms. On the regional level, however, the secondary cities reach a considerable portion of the connectivity value of Munich. On this geographical scale, the functional urban hierarchy is clearly less pronounced. Generally speaking, the larger the geographical scale of intra-firm networks is, the higher the significance of the FUA of Munich gets in comparison with its surrounding secondary cities.

In the framework of the POLYNET study, similar results are found for the APS sector in Germany's Rhine-Main region, which encompasses the cities of Frankfurt am Main, Wiesbaden and Mainz, but extending widely outwards as far as Hanau and Aschaffenburg in the east and Darmstadt in the south. The analysis of network connectivities confirms Frankfurt's dominant position as the major hub of knowledge-intensive business services on both national and international scale. On the national scale, Frankfurt is part of the 'urban circuit' of those German cities (Frankfurt, Hamburg, Munich, Düsseldorf, Berlin, Stuttgart and Cologne) that have long constituted the apex of a polycentric national configuration of cities and metropolitan regions, characterized by complementary functional and sectoral specialization (Blotevogel 2000). On the international scale, Frankfurt clearly acts as 'first city' for internationally orientated APS firms and therefore constitutes a key gateway to the other major cities and towns in Germany and the world (Hoyler et al. 2008a).

In contrast to Munich and Rhine-Main, the RhineRuhr region – one of the world's largest polycentric Mega-City Regions, embracing 30 to 40 towns and cities with a total population of ten million people – has no obvious 'core city'. As the POLYNET study shows, the metropolitan cores of RhineRuhr – Dortmund, Essen, Duisburg, Düsseldorf, Cologne and Bonn – are characterized by quite balanced regional and national connectivity patterns. This means that these regional centres are inter-connected almost to the same extent by regional and nationally-oriented APS firms. For international connectivities, however, the relative importance of Düsseldorf increases drastically, which underlines its important function as an international knowledge gateway connecting the mega-city region to a wider space of flows. The reason for this lies in Düsseldorf's increasing tertiary sector, which emerged during the second half of the twentieth century. Today it is one of the leading centres of the German advertising and fashion industry (Knapp and Schmitt 2008).

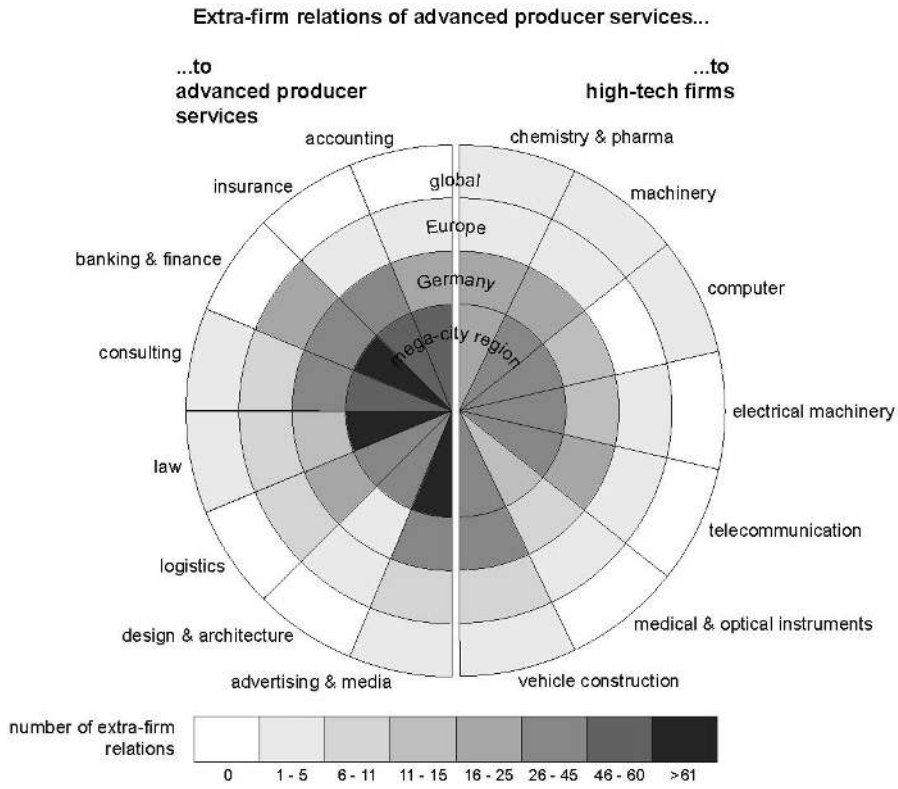
The greater Munich area as a localized system of value chains

The analyses so far outline the structural organization and spatial impact of intra-firm networks. In this section we present the results of the extra-firm analysis, which has been conceptualized by a value chain approach and realized by means of a web survey.

Figure 6 highlights the spatial patterns of extra-firm connectivities of APS firms on a regional, national, European and global scale. It is important to note that Figure 6 is a diagram based on the number of interactions as stated by the responding firms in the internet-based survey. The different shades of the grey colour in the legend illustrate the amount of firm-external interrelations. The darker the grey colour, the greater the number of interactions reported by the responding APS firms.

For APS firms, the strongest relations are located within the own mega-city region. The most frequent interactions are with other APS firms, in particular insurance, law, advertising and media companies. Extra-firm relations to the high-tech sector, on the other hand, are less pronounced, but still strongly concentrated within the greater Munich area. Hence, the figure shows quite clearly that geographical proximity to other enterprises appears to be a driving force towards generating extra-firm networks and interactions.

Figure 6: Extra-firm relations of APS firms of the emerging mega-city region of Munich



Source: authors' calculation.

For high-tech firms, the spatial pattern of extra-firm networks is slightly different. Figure 7 shows the findings for high-tech enterprises. As in the case of APS firms, the predominant part of extra-firm networks is located within the demarcation of the emerging mega-city region of Munich. Hence, geographical proximity to other enterprises appears to be of importance for high-tech enterprises too.

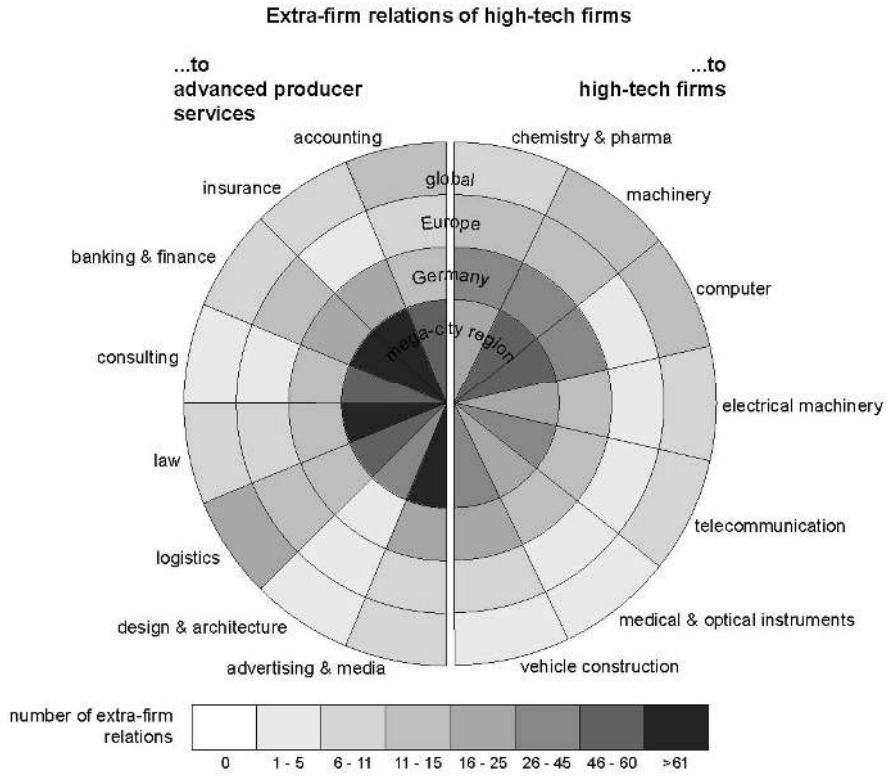
However, in contrast to the APS networks, high-tech firms within the greater Munich area display a remarkable level of global relations. This can be seen by the many dark sectors in the outer ring of Figure 7. To compete successfully in the global economy, high-tech firms have to rely on resources and expertise provided by firms in other economic areas. In this sense, the greater Munich area is not a self-sustaining system, but interconnected in a wide space of flows composed of flows of information, capital, goods and people travelling along infrastructure such as roads, railways, aviation routes and, increasingly, telecommunications.

Furthermore, Figure 7 indicates that third and fourth party logistic services play a central role in high-tech enterprises, even on the global scale. This highly sophisticated set of logistics service providers has emerged as a result of time and

quality-based global competition with some developing out of traditional transportation companies (rail, road, shipping, airlines), some from wholesalers and trading companies, while others are entirely new forms of logistics organizations (Coe et al. 2008b). These firms appear to be important integrators that assemble the resources, capabilities and technology of their own and other organizations to design, build and run comprehensive global supply-chain solutions.

However, as in the case of APS firms, the high-tech firms' strongest relations, namely to the accounting, insurance, law as well as the advertising and media sectors, are located on the mega-city-region scale. This means that these sectors provide important services for the knowledge economy of the mega-city region as a whole and for high-tech firms in particular. These branches assume an important role as an entrepreneurial support network within the emerging mega-city region of Munich.

Figure 7: Extra-firm relations of high-tech firms in the mega-city region of Munich



Source: authors' calculation.

In sum, all of these findings provide clear evidence for the initially proposed hypothesis that extra-firm linkages of knowledge-intensive enterprises concentrate in the emerging mega-city region of Munich, which, as a consequence, is evolving into a high-grade localized system of value chains. However, it must be stressed that such

localized systems of value chains are not self-contained urban systems; instead, they are integrated into wide economic networks on different geographical scales.

Conclusion

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 who form networks on different spatial scales. More than the pure locational perspective, this relational perspective makes it possible to highlight how different parts within and beyond mega-city regions are interacting with each other. The debate in the social sciences about the importance of geographical proximity has recently begun to acknowledge that local and global ties contribute positively to knowledge generation (Boschma 2005; Torre and Rallet 2005). Geographical clustering promotes a depth of knowledge production and is driven by the globalization of markets and services facilitated by developments in information and communication technologies. Knowledge-intensive businesses are agents that build spatially concentrated knowledge gateways between the regional and global economies.

The greater Munich area can be regarded simultaneously as a hierarchically organized polycentric mega-city region and as a high-grade localized system of value chains. Hence, the three initially suggested hypotheses can be verified. This process involving the emergence of a newly networked urban hierarchy is driven above all by knowledge-intensive enterprises. The examination of their value creation processes clearly reveals that they follow a functional and networked logic of both independent and interdependent institutions throughout the value chain. Here, we found evidence that Munich plays an important role for all other FUAs in the mega-city region, particularly in relation to its international gateway-function for knowledge-intensive businesses. However, the FUA of Munich, which has around 2.2 million inhabitants, is too small to concentrate all of the major functions of the mega-city region in its own location. The complementary combination of Munich and the supplemental centres elevates the emerging mega-city region of Munich to a competitive level in the context of the global economy.

The real impact of changing value chains on spatial development is difficult to grasp. On the one hand, there is an accelerated concentration of highly advanced and knowledge-intensive functions in just a few centres, while on the other hand a diffusion of associated functions and urban sprawl can be found (Lüthi et al. 2007). These contradictory processes pose an enormous challenge for the forthcoming research agenda, as both polycentric and monocentric tendencies are outcomes of the same process towards a more knowledge-intensive economy. Thus, further research activities must deal with the following specific aspects.

First, to understand spatial development processes more thoroughly, we need a conceptualization that integrates both economic and non-economic actors in a comprehensive research design. Each of the non-economic actors – such as nation-states, civil society organizations, labour and consumers – has very different spatialities from those of firms (Coe et al. 2008b). Second, to obtain a picture of the spatial patterns of

Global Production Networks, future research must place a special focus on international gateway infrastructures, such as airports, seaports and high-speed train nodes. These sites are locations of highly specialized logistics services. It is safe to assume that these third and fourth party logistics providers will play an important role in the increasingly globalizing knowledge economy. Third, intra-firm and extra-firm linkages between APS and high-tech firms must be analysed on a more detailed regional scale. The smallest analytical entities should be at least functional urban areas. This makes it possible to identify and contextualize large-scale urban structures and hierarchies and the role of small and medium sized cities and towns within the globalizing knowledge economy. Fourth, to understand better the interplay between location strategies of knowledge-intensive enterprises, geographical proximity and polycentric mega-city regions, additional qualitative investigations need to be carried out, for example by means of qualitative network analyses. Finally, new methods of analysing and visualizing polycentric development need to be established 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 to the establishment of large-scale metropolitan governance.

References

Blotevogel, H. H. (2000) 'Gibt es in Deutschland Metropolen?', in D. Matejovski (ed.) *Metropolen: Laboratorien der Moderne*, Frankfurt am Main: Campus, 179–208.

Boschma, R. (2005) 'Proximity and innovation: a critical assessment', *Regional Studies* 39 (1), 61–74.

Brown, E., B. Derudder, C. Parnreiter, W. Pelupessy, P. J. Taylor and F. Witlox (2010) 'World City Networks and Global Commodity Chains: towards a world systems integration, *Global Networks*, 10 (1), 12–34.

Castells, M. (1996) *The rise of the network society*, Malden: Blackwell Publishers.

Coe, N. M., M. Hess, H. W-c. Yeung, P. Dicken and J. Henderson (2004) 'Globalizing regional development: a Global Production Networks perspective', *Transactions of the Institute of British Geographers*, 29 (4), 468–84.

Coe, N. M., P. Dicken and M. Hess (2008a) 'Introduction: Global Production Networks – debates and challenges', *Journal of Economic Geography*, 8, 267–69.

Coe, N. M., P. Dicken and M. Hess (2008b) 'Global Production Networks: realizing the potential', *Journal of Economic Geography*, 8, 271–95.

De Backer, K. and E. Basri (2008) 'The internationalisation of R&D', in OECD (ed.) *Staying competitive in the global economy*, Paris: OECD, 219–48.

Derudder, B. (2006) 'On conceptual confusion in empirical analyses of a transnational urban network', *Urban Studies*, 43 (11), 2027–46.

Derudder, B. and P. Taylor (2005) 'The cliquishness of world cities', *Global Networks*, 5 (1), 71–91.

ESPON (2004) *ESPON Project 1.1.1. Potentials for polycentric development in Europe. Final Report*, Luxembourg: European Spatial Planning Observation Network. http://www.espon.eu/mmp/online/website/content/projects/259/648/file_1174/fr-1.1.1_revised-full.pdf, accessed 18 April 2009.

Friedmann, J. (1986) 'The world city hypothesis', *Development and Change*, 17, 69–83.

GEMACA (1996) *North-west European metropolitan regions*, Paris: Group for European Metropolitan Area Comparative Analysis.

Gereffi, G., J. Humphrey and T. Sturgeon (2005) 'The governance of Global Value Chains', *Review of International Political Economy*, 12 (1), 78–104.

Gottmann, J. (1961) *Megalopolis: the urbanized northeastern seaboard of the United States*, New York: Twentieth Century Fund.

Hall, P. (1966) *The world cities*, London: Weidenfeld & Nicolson.

Hall, P. (1999) 'Planning for the mega-city: a new Eastern Asian urban form?', in J. F. Brotchie, P. Hall, P. Newton and J. Dickey (eds) *East West perspectives on 21st century urban development: sustainable Eastern and Western cities in the new millennium*, Aldershot: Ashgate, 3–36.

Hall, P. (2007) 'Delineating urban territories. Is this a relevant issue?', in N. Cattan (ed.) *Cities and networks in Europe: a critical approach of polycentrism*, Paris: John Libbey Eurotext, 3–14.

Hall, P. and K. Pain (2006) *The polycentric metropolis: learning from mega-city regions in Europe*, London: Earthscan.

Hassler, M. (2003) 'The global clothing production system: commodity chains and business networks', *Global Networks*, 3 (4), 513–31.

Henderson, J., P. Dicken, M. Hess, N. M. Coe and H. W-c. Yeung (2002) 'Global Production Networks and the analysis of economic development', *Review of International Political Economy*, 9 (3), 436–64.

Hoyler, M., T. Freytag and C. Mager (2006) 'Advantageous fragmentation? Reimagining metropolitan governance and spatial planning in Rhine-Main', *Built Environment*, 32 (2), 124–36.

Hoyler, M., T. Freytag and C. Mager (2008a) 'Connecting Rhine-Main: the production of multi-scalar polycentricities through knowledge-intensive business services', *Regional Studies*, 42 (8), 1095–111.

Hoyler, M., R. C. Kloosterman and M. Sokol (2008b) 'Polycentric puzzles: emerging mega-city regions seen through the lens of advanced producer services', *Regional Studies*, 42 (8), 1055–64.

Jacobs, W. (2008) 'Global Value Chains, port clusters and advanced producer services: a framework for analysis', paper presented at the Annual Meeting of the Association of American Geographers, 15–19 April, Boston, MA.

Jacobs, W. C. Ducruet and P. de Langen (2010) 'Integrating world cities into production networks: the case of port cities', *Global Networks*, 10 (1), 92–113.

Kloosterman, R. and S. Musterd (2001) 'The polycentric urban region: towards a research agenda', *Urban Studies*, 38, 623–33.

Knapp, W. and P. Schmitt (2008) 'Discourse on "metropolitan driving forces" and "uneven development": Germany and the RhineRuhr conurbation', *Regional Studies*, 42 (8), 187–204.

Kogut, B. (1985) 'Designing global strategies: comparative and competitive value-added chains', *Sloan Management Review*, 26 (4), 15–28.

Krätke, S. (2007) 'Metropolisation of the European economic territory as a consequence of increasing specialisation of urban agglomerations in the knowledge economy', *European Planning Studies*, 15 (1), 1–27.

Krätke, S. and A. Brandt (2009) 'Knowledge networks as a regional development resource: a network analysis of the interlinks between scientific institutions and regional firms in the metropolitan region of Hanover, Germany', *European Planning Studies*, 17 (1), 43–63.

Kujath, H. J. (ed.) (2005) *Knoten im Netz*, Münster: Lit Verlag.

Kujath, H. J. and S. Schmidt (2007) 'Wissensökonomie und die Entwicklung von Städtesystemen', http://www.irs-net.de/download/wp_staedtesysteme.pdf, accessed 20 April 2009.

Lüthi, S., A. Thierstein and V. Goebel (2007) 'Spatial development on the quiet in the mega-city region of Munich', paper presented at the European Regional Science Association (ERSA) September 2007.

Lüthi, S., A. Thierstein and V. Goebel (2008) 'Intra-firm and extra-firm linkages of the knowledge economy: the case of the mega-city region of Munich', paper presented at the annual meeting of the Association of American Geographers (AAG), Boston, 26 March.

OECD (2005) *Oslo manual: guidelines for collecting and interpreting innovation data*, Paris: OECD.

OECD (2008) *Staying competitive in the global economy*, Paris: OECD.

Palpacuer, F. and A. Parisotto (2003) 'Global production and local jobs: can global enterprise networks be used as levers for local development?', *Global Networks*, 3 (2), 97–120.

Pike, A. (2007) 'Editorial: whither regional studies?', *Regional Studies*, 41 (9), 1143–48.

Pilat, D., A. Cimper, K. Olsen and C. Webb (2008) 'The changing nature of manufacturing in OECD economies', in OECD (ed.) *Staying competitive in the global economy: compendium of studies on Global Value Chains*, Paris: OECD, 103–40.

Rothenberg-Aalami, J. (2004) '"Coming full circle"? Forging missing links along Nike's integrated production networks', *Global Networks*, 4 (4), 335–54.

Sassen, S. (2001) *The global city: New York, London, Tokyo*, second edition, Princeton, NJ: Princeton University Press.

Schmitt, P. and W. Knapp (2006) 'RheinRuhr als polyzentrischer "Raum der Orte" im "Raum der Ströme"', *Zeitschrift für Wirtschaftsgeographie*, 50, 217–31.

Schürmann, C. (2004) *Morphological analysis of urban areas based on 45-minute isochrones: annex report D to ESPON project 111 potentials for polycentric development in Europe*, Luxembourg: ESPON Monitoring Committee.

Scott, A. J. (2001) *Global city-regions: trends, theory, policy*, Oxford: Oxford University Press.

Simmie, J. (2003) 'Innovation and urban regions as national and international nodes for the transfer and sharing of knowledge', *Regional Studies*, 37 (6), 607–20.

Taylor, P. J. (2004) *World City Network: a global urban analysis*, London: Routledge.

Taylor, P. J., D. M. Evans and K. Pain (2008) 'Application of the interlocking network model to mega-city-regions: measuring polycentricity within and beyond city-regions', *Regional Studies*, 42 (8), 1079–93.

Thierstein, A. and A. Förster (eds) (2008) *The image and the region: making mega-city regions visible!*, Baden: Lars Müller Publishers.

Thierstein, A., C. Kruse, L. Glanzmann, S. Gabi and N. Grillon (2006) *Raumentwicklung im Verborgenen: Untersuchungen und Handlungsfelder für die Entwicklung der Metropolregion Nordschweiz*, Zürich: NZZ Buchverlag.

Thierstein, A., S. Lüthi, C. Kruse, S. Gabi and L. Glanzmann (2008) 'Changing value chain of the knowledge economy: spatial impact of intra-firm and inter-firm networks within the emerging mega-city region of northern Switzerland', *Regional Studies*, 42 (8), 1113–31.

Tokatli, N., N. Wrigley and Ö. Kizilgün (2008) 'Shifting global supply networks and fast fashion: made in Turkey for Mark & Spencer', *Global Networks*, 8 (3), 261–80.

Torre, A. and A. Rallet (2005) 'Proximity and localization', *Regional Studies*, 39 (1), 47–59.

Wildemann, H. (2003) *Supply chain management: Effizienzsteigerung in der unternehmensübergreifenden Wertschöpfungskette*, Münster: TCW Transfer-Centrum.

