

Interlocking firm networks in the German knowledge economy. On local networks and global connectivity

Stefan Lüthi, Alain Thierstein, Michael Bentlage

Munich University of Technology

Abstract

We assume that the territory of Germany is experiencing a reorganisation of functional division of labour in favour of the knowledge economy. New forms of network economies and functional differentiation between cities and towns can be observed. The increasing importance of emerging network economies has introduced new lines of thinking about space, place and scale that interprets regions as unbounded, relational spaces. The key aim of the paper is to set out a theoretical context and then to empirically investigate the functional polycentric patterns and interlocking networks of Advanced Producer Services (APS) and High-Tech firms. We start from a conceptual background that brings together the location behaviour of multi-branch multi-location firms with a world city network approach. The paper looks at the extent to which the functional urban hierarchy within the German space economy is associated with different special scales and economic sub-sectors. Interim results provide evidence that the German territory can be regarded as a hierarchically organized space economy in which only few cities establish substantial international connectivities and economic strength.

Key words: Germany, knowledge economy, Advanced Producer Services firms, High-Tech firms, interlocking firm networks

1. Introduction

The main motivation of our research is the question how to interpret global trends in spatial development. The process of internationalization and globalization of the economy, politics and culture seems again to boil down to the question whether ,the world is flat‘ (Friedman 2005) or whether ,the world is spiky‘ (Florida 2005). Thomas Friedman’s (2005) hypothesis builds upon the levelling effect of information and communications technology (ICT) arguing that it is a series of ICT-related modes of organization of production and services that has

enabled a workforce of millions of well qualified people to enter global competition. India and China, together with Russia and other post-Soviet countries, have therefore helped to make the world more flat in terms of opportunities to compete for jobs and add value (Friedman 2005). In contrast, it is Richard Florida's hypothesis (2005) that the world – despite the flattening impacts of ICT – is still a very spiky place, with only a very limited number of truly global players. Florida argues that globalization has indeed had a levelling effect in as much as more players have entered the competition. But the growing importance of the knowledge economy – and its requirements for talented and creative people, high-quality urban locations and organizational networking – produces a counter-force that brings about a spatial concentration of added value and innovation to only a very few truly global urban areas (Florida 2005). Indeed, although developments in ICT have shrunk the world, the 'end of geography' or 'the death of distance' seems not to come true (O'Brien 1992; Cairncross 1997). Why do geographical concentrations of economic activity not only still exist but also represent the normal state of affairs? Why do 'sticky places' continue to exist in 'slippery space' (Markusen 1996)?

The key for understanding these questions is to think of economic processes in terms of connections of activities, linked through both physical and non-physical flows in networks. The increasing importance of network economies has introduced new lines of 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 major advantage of adopting such a network approach to understanding the knowledge economy is that it helps us to appreciate the interconnectedness of economic activities across different geographical scales (Dicken 2007). What links people together across time and space? How are things and people connected and embedded economically? In what ways do goods, information and capital flow and why are they channelled down to particular vertices and nodes? Thinking in terms of networks forces us to theorize socioeconomic processes as intertwined and mutually constitutive (Howells 2000). Therefore, regional science needs to conceive the roles that locality plays as individual nodes in the networks of national and international linkages.

The aim of this paper is to set out a theoretical context and then to empirically investigate the functional polycentric patterns and interlocking networks of Advanced Producer Services (APS) and High-Tech firms in the German space economy. We start from a conceptual background that brings together the location behaviour of multi-branch multi-location firms

with a world city network approach. More than a pure locational perspective, this relational research design makes it possible to highlight how cities and towns within and beyond the German territory are interlocked with each other. The paper is structured in six main sections. First of all, we focus on the functional logic of the knowledge economy by discussing both the functional logic of knowledge creation and the main features of business organization. The second section presents the spatial consequences of these functional patterns by examining key spatial concepts such as knowledge spillovers, the role of proximity and business functions in space. Based on these findings, we then are going to introduce our main hypothesis: the German city hierarchy hypothesis. Subsequently, the empirical model is expounded and the main findings about the functional urban hierarchy in the German space economy are presented. The last section concludes by synthesizing the main findings and putting them into the theoretical context.

2. The functional logic 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; Cooke et al. 1998). The OECD (1999) for example underlines 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). If researchers want to analyze how space is affected by the knowledge economy, they have to understand its functional logic, that is the functional logic of knowledge creation and the functional logic of business organization. We shall deal with these issues in the next two sections.

2.1 The functional logic of knowledge creation

There is a widespread agreement in academic literature that knowledge has become the main source of economic development in advanced regions and nations. Tödtling et al. (2006) argue that 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). In order to develop a better understanding of the functional logic of knowledge creation the meaning of knowledge and its different approaches have to be analyzed in greater detail.

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). In his classic work *The Tacit Dimension*, Michael Polanyi's famous phrase "we can know more than we can tell" (1966:4) lays at the heart of his distinction between explicit and tacit knowledge (Gertler 2003). **Explicit knowledge** can be codified in formal and systematic language and shared in the form of data, scientific formulae, specifications, manuals, blueprints and the like. It can be processed, transmitted and stored relatively easily. **Tacit knowledge**, in contrast, refers to knowledge that is highly personal and hard to formalize. 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). However, a strict distinction between explicit and tacit knowledge is problematic. Indeed, 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 (1966) saw explicit and tacit knowledge as essentially complementary because all forms of codified knowledge require tacit knowledge in order to be useful (Polanyi 1966). Hence, the binary argument of whether knowledge is codified or tacit in nature can be criticized as too narrow to understand knowledge creation processes; there is a need to go beyond this simple dichotomy.

One way to overcome this conceptual oversimplification is to distinguish between synthetic, analytical, and symbolic types of knowledge (Laestadius 1998; Asheim and Coenen 2005). **Analytical knowledge** refers to activities where scientific knowledge based on formal models and codification is highly important. Thereby, knowledge inputs are often based on reviews of existing studies and on the application of scientific principles and methods. Knowledge processes are formally organized and the outcomes tend to be documented in reports, electronic files or patent descriptions. **Synthetic knowledge** refers to economic activities, where innovation mainly takes place through the application of novel combinations of existing knowledge, for example in plant engineering or advanced industrial machinery. In this case, new knowledge is created by solving specific problems during the interaction process with customers, suppliers or research establishments. And finally, **symbolic knowledge** is related to the aesthetic attributes of products. It involves the creation of designs and images in order to create economic value of cultural artefacts. The dynamic development of cultural industries such as media, design or fashion indicates the increasing significance of this type of knowledge (Cooke et al. 2007). As a result of the growing complexity of knowledge creation and the diversity of different knowledge types, firms increasingly need to

acquire new knowledge to supplement their internal knowledge bases by collaborating with external firms.

This leads us to the notion of the knowledge economy. There is no commonly accepted definition of what the knowledge economy is. 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 characterized by exploitation of new knowledge in order to create more new knowledge” (Cooke 2002:4p). This explanation comes quite close to Castell’s (2000:17) finding that “the action of knowledge upon knowledge itself” is the main source of productivity. He 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). 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. Therefore, we define the knowledge economy as:

“this part of the economy, in which highly specialized 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 1). Firstly, the knowledge economy uses highly specialized knowledge and skills based on the combination of scientific knowledge and operating experiences. So, 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 organizations as a way to acquire specialized knowledge from different parts of the value chain. By taking such a network perspective, the knowledge economy is viewed as a dynamic process, characterized 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 markets or new organizational structures, and – most importantly – to transform them into marketable products. And finally, 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 specialized knowledge and skills.

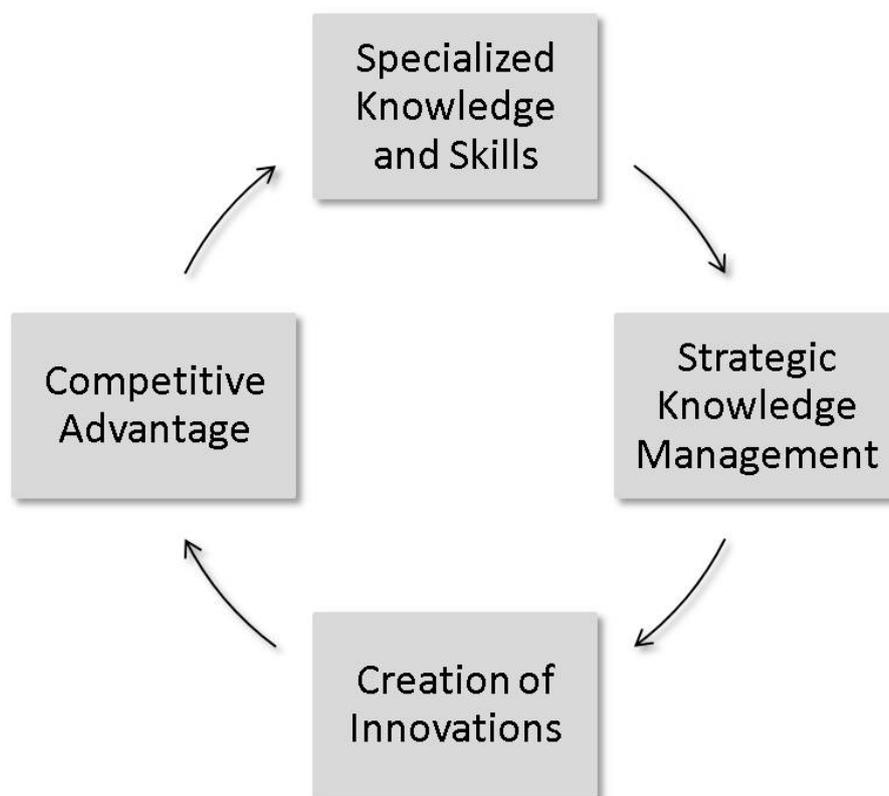


Figure 1: Key attributes of the knowledge economy.

Two important pillars of the knowledge economy are Advanced Producer Services (APS) and High-Tech firms. *Advanced Producer Services (APS)* can be defined as “a cluster of activities that provide specialized services, embodying professional knowledge and processing specialized 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 essential common characteristic of these branches is that they generate, analyse, exchange and trade information making them to key intermediaries in the

knowledge economy. Because they are increasingly provided by firms with offices in many cities worldwide, flows of information within and between APS firms have a crucial role in linking cities to the global economy (Pain and Hall 2008). However, 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 globalization 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 processes. 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 characterized 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) expenditures to sales; and (4) a worldwide market for its products. Not only is the technology very advanced, but it also continuously changing, at a much faster rate of progress than other industries” (Rogers and Larsen 1984:29). All in all, the importance of the systemic interplay between Advanced Producer Services (APS) and High-Tech industries has to be emphasized. Wood (2005:430p) for example warns us to tab into the “sector fallacy”, separating service and manufacturing functions rather than recognizing them as essentially inter-dependent and complementary to each other (Wood 2005). The competitive advantage of firms never depends on a single input, but always on conjunctions of expertise in and between various phases of the production process.

2.2. The functional logic of business organization

“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). With this statement, 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 organizational structures are the key players of economic and spatial development. Firms must be flexible to respond rapidly to competitive and market changes. They must benchmark continuously to achieve best practice. Often, they must outsource to gain efficiencies and they must nurture a few core competencies in the race to stay ahead of rivals. Increasing competitive pressure forces them to optimize the coordination between entrepreneurial tasks as well as the range of services and products that are provided (Picot et al. 2008). Dicken (2007) argues that production networks are coordinated and regulated primarily through the various forms of intra- and extra-

organizational relationships of business firms that constitute the economic system of market economies (Dicken 2007). In turn, key features of intra-firm and extra-firm networks will be discussed briefly.

More than any other institutions, *intra-firm networks* of transnational corporations (TNCs) have come to be seen as important shapers of the contemporary global economy (Dicken 2007). According to the OECD (2008), 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 setting 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. Because global competition has been intensified, companies have been forced to innovate more quickly and to develop commercially viable products and services more rapidly. Knowledge has become increasingly multidisciplinary and global in scope, making innovation both more expensive and riskier. At the same time, some barriers to the dispersion of innovations have become less significant owing to rapid developments in information and communication technology. These trends imply changes in the governance of TNCs, with important implications for the role of subsidiaries in recognising and exploiting the potential for innovation (OECD 2008). The dilemma facing TNCs is that they need to be globally efficient, geographically flexible, and capable of capturing the benefits of worldwide knowledge resources incorporated in their branches, all at the same time (Dicken 2007). In order to analyze these intra-firm patterns, organizational scholars such as Bartlett and Ghoshal (2002) focus on the individual manager – rather than on the firm – as their main unit of analysis (Bartlett and Ghoshal 2002). Bartlett and Ghoshal (2002) argue that we are now witnessing the emergence of a new organizational management model, characterized by a high capacity to develop flexible coordination processes. The organizational architectures of TNCs are converging toward a common configuration, in which increasingly specialized units worldwide were linked into an integrated network of operations that enable them to achieve their multidimensional strategic objectives of efficiency, responsiveness, and innovation (Bartlett and Ghoshal 2002).

Intra-firm hierarchies of leading knowledge-intensive companies are only one set of connections among many (Coe et al. 2010). No firm is completely self-sufficient. It is now widely admitted that the most advanced activities of knowledge-intensive firms are deeply inscribed in wide *external networks* of suppliers, subcontractors and business clients, many of whom are small- and medium-sized enterprises (Storper 1992). In the 1970s, the unique

competitive advantage of firms primarily reflected their ability to internally produce and organize proprietary assets. Since the turn of the millennium, the emphasis is more on their capabilities to access and organize knowledge intensive assets from throughout the world; and to integrate these not only with their existing competitive advantages, but with those of other firms 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 and lead to a higher 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 upstream and downstream inputs and costumers, which represents the different elements of the value chain in the knowledge economy.

3. The spatial logic of the knowledge economy

The functional logic of the knowledge economy has significant impacts on the spatial development in metropolitan areas. Based on the preceding functional discussion, the following chapter will examine the spatial logic of the knowledge economy by analyzing the spatial patterns of both knowledge creation and business organization.

3.1 The spatial logic of knowledge creation

From the definition and description of knowledge outlined above, the next question is why geography is important to the understanding of knowledge creation? According to Amin and Cohendet (2004), the power of context – spatial and temporal – should be placed at the centre of any theorization of knowledge formation (Amin and Cohendet 2004). Malecki (2000) describes this aspect as the “local nature of knowledge” and highlights the necessity to accept 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). This observation begs the question of how knowledge creation can be analyzed empirically and

how it can be mapped in a geographical context. In this regard, the concept of knowledge spillovers becomes important.

In the last decade, there have been a growing number of studies which have tried to analyze the presence and significance of *knowledge spillovers* (Gallié 2009; Capello 2009; Audretsch and Keilbach 2008). A number of authors have demonstrated through econometric methods that knowledge spillovers are closely related to spatial proximity (Cooke et al. 2007). For example, Jaffe et al. (1993) find 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). A geographical distance decay of knowledge spillovers is also 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). These examples show that geography still seems to count in terms of knowledge creation processes.

However, the extensive literature on knowledge spillovers has also left many questions unanswered. For example: What does proximity mean? How close is close? 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 2000). In the academic debate, the notions of relational, organizational, cognitive, social, institutional and geographical proximity are most frequently discussed. *Relational proximity* is supported by a rich and diversified infrastructure of global travel and communication, including rapid and frequent trains and flights, sophisticated logistics networks to keep freight and people on the move, and easy access to a variety of real-time and interactive communication media facilities (Amin and Cohendet 2004). *Organizational proximity* means the ability of an organization to make its member interact with each other (Torre and Rallet 2005). It relates to “complementary resources held by players that could potentially participate in a common productive process, within the same organization, or within a set of interacting organizations” (Carrincazeaux et al. 2008:619). *Cognitive proximity* means that people who share the same knowledge base may learn from each other more easily than people without the same expertise. Individuals need cognitive proximity in order to communicate, understand, absorb and process new information successfully (Boschma and Iammarino 2009). *Social proximity* indicates that economic relations are embedded in a social context. It can be defined as “socially embedded relations between agents at the micro-level” (Boschma 2005:66). In contrast to social proximity, which focuses more on micro-processes, *institutional proximity* is associated with

the institutional framework on the macro-level. Institutional proximity is an enabling factor, providing stable conditions for the creation of knowledge (Boschma 2005). **Geographical proximity**, finally, can be defined as “kilometric distance that separates two units (individuals, organizations, towns) in geographical space” (Torre and Rallet 2005:49). Short distances bring people together and enable them to exchange tacit knowledge. The larger the distance between these people, the less the intensity of the positive externalities, and the more difficult it becomes to transfer tacit knowledge.

Overall, it seems that there is a strong awareness that different dimensions of proximity are critical to the competitive advantage of firms and regions. Many authors have contributed to the literature by putting emphasis on the many economic advantages of being co-located geographically. However, in doing so, they have also pointed out that other dimensions of proximity are a key in understanding the knowledge creation process of firms.

3.2 The spatial logic of business organization

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). Choosing the right location is becoming an increasingly important part of a company’s strategy. The outcome of this location decision-making process has a direct impact on the locational structure of the firm and the spatial organization of its business functions. Different business functions have different needs in terms of location and tend to develop rather distinctive spatial patterns. Some of them tend to be spatially dispersed; others are spatially concentrated and co-located with other parts of the value-chain.

Commonly, six business functions are distinguished, representing the major parts of a firm’s value chain: control and coordination, research and development, processing and production, financing, marketing as well as sales and distribution. **Control and coordination** functions are mostly concentrated in corporate and regional headquarters. According to Castells (1989) they continue to be situated in the central business districts of metropolitan areas, although metropolitan dominance has been eroded in terms of competition from the suburbs (Castells 1989). **Research and development** is characterized by a complex sequence of activities with different locational requirements. The need for a highly skilled labor force as well as proximity to universities and research institutions often confines R&D facilities to large metropolitan regions (Dicken 2007). The locational requirements of **production and processing** units vary considerably from one industry to another. However, as Dicken (2007) argues, during the past decades, a new organizational form of production has become

prominent: knowledge intensive firms increasingly spread their production units globally as part of a worldwide intra-firm sourcing strategy (Dicken 2007). *Financial services* are fundamental to the operations of the knowledge economy. Higher-order financial functions are heavily concentrated in the major global financial centres of the world – such as New York, London and Tokyo (Sassen 2001). Front-office functions, in contrast, have to be close to customers leading to spatially dispersed branch networks of retail banks supplying final demand. *Marketing* functions are often concentrated in corporate headquarters, too. Increasingly, however, they are located in regional headquarters or close to R&D activities in order to adapt marketing decisions to local conditions and consumer's tastes (Dicken 2007). *Sales and distribution* units, finally, tend to be rather small and very widely dispersed because they need to be as close as possible to the markets served by the firm. They must be sensitive to local conditions in order to feed back relevant information and to tailor the firm's products to local tastes (Dicken 2007).

4. The hypothesis of the German city hierarchy

The purpose of this paper 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. To what extent is the functional urban hierarchy within and between German cities associated with different spatial scales and sectors of knowledge-intensive activities? How has the globalization of economic activity – and the current global financial crisis – affected this highly polycentric 'national' urban system? Are German cities part of two distinct urban configurations, one nation-based, reflecting the federal structure of Germany, the other linking into a global network of cities, echoing the country's claim to be world champion in foreign trade? Starting from the theoretical and conceptual considerations discussed above, we propose three central hypotheses with respect to the German space economy:

- H1: Advanced Producer Services (APS) and High-Tech firms located in Germany show different connectivity patterns because they pursue different business strategies.
- H2: The mere size of a German agglomeration does not automatically increase its functional significance in terms of global connectivity.
- H3: The development of global markets and networks create a steep functional urban hierarchy in the German space economy. For national networks, this functional urban hierarchy is less pronounced.

These hypotheses have to be seen in the context of the world city network debate. From the seminal work of Peter Hall (1966) about the characteristics of world cities to the pioneering work of Saskia Sassen (1991) about the global city, the central facet of the world city literature has been to rank cities according to their disproportionate geoeconomic power in the world-system (Beaverstock et al. 1999). In much of this comparative research, different urban settlements are ranked according to one or more variables, such as population and employment size, headquarter totals etc. In this context, however, the term ‘hierarchy’ is ambiguous and there is a great temptation to interpret such rankings as hierarchies. But of course, such rankings do not prove the existence of an urban hierarchy since this can only be defined as relations between cities and towns (Taylor 2007). In order to overcome this shortcoming, we apply the interlocking network model developed by the Globalization and World Cities Study Group (GaWC) at Loughborough University to analyze global connectivity patterns and functional urban hierarchies in the German knowledge economy (Taylor 2004).

5. The interlocking network model

The interlocking network model estimates potential city connectivities from the office networks of multi-branch, multi-location enterprises. These office networks represent the functional logic of the knowledge economy in a spatial perspective. The empirical work involves three stages. In the first stage, we created a company database comprising the biggest multi-location Advanced Producer Services and High-Tech firms located in Germany. The result of this process was a basic set of 270 Advanced Producer Services and 210 High-Tech enterprises. In the second stage, we rated these office locations on the basis of their importance in the overall intra-firm network by analysing the firms’ websites. The importance is defined by the size of an office location and its function. The basic premise of this method is that the more important the office, the greater its flow of information to other office locations. In the third stage, finally, we used the interlocking network model established by Taylor (2004) to estimate connectivities between cities and towns within and beyond the German space economy (Taylor 2004). The primary output of this model is network connectivity, a measure that estimates of how well connected a city is within the overall intra-firm network of knowledge intensive enterprises.

The analytical building blocks are built by so called Functional Urban Areas (FUAs) 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; the definition of the rings is based on 45-minute isochrones. Further details about the FUA delineation can be seen in the Annex Report D of the ESPON Project 111 (Schürmann 2004). All in all, 186 FUAs in Germany and 2749 cities outside Germany have been integrated into the network analysis.

6. The functional urban hierarchy in the German knowledge economy

In the following sections, the main findings of the interlocking network analysis are presented. We start with the connectivity patterns at the global scale, and then zooming in to show the finer-grained hierarchical textures on the national and regional level.

6.1 The functional urban hierarchy at the global scale

Around 25 years ago, the Japanese management writer Kenichi Ohmae (1985) coined the term “global triad” to argue that the world economy is now essentially organized around a tri-polar macro-regional structure, whose three pillars are North America, Europe and East Asia (Ohmae 1985). According to Dicken (2007) these three macro-regions together contain 86 per cent of both total world GDP and total world merchandise exports. Furthermore, they are the focus of the vast majority of the world’s foreign direct investment (Dicken 2007).

This global triad hypothesis is supported by the findings of our interlocking network analysis. Figure 2 shows the top 20 cities in terms of the interlock connectivities for Advanced Producer Services (APS) firms. A big font size in dark red illustrates a high, a small font size a low interlock connectivity. New York, London, Hamburg, Paris and Frankfurt indicate the highest connectivity values. Generally, three macro-regions seem to be of particular importance for Advanced Producer Services firms located in Germany. Firstly, there is Germany itself. Six German cities rank in the top 20: Hamburg, Frankfurt, Munich, Berlin, Stuttgart and Düsseldorf. These cities can be regarded as kind of ‘urban circuit’ that constitutes the top of the German functional urban hierarchy. Secondly, we have Europe. 14 European cities rank in the top 20. This is a clear indication that German Advanced Producer Services firms are strongly focused on the European space economy. And thirdly, we have the emerging markets in Asia: Hong Kong, Singapore, Shanghai and Tokyo. All of them rank in the top 20 in terms of the connectivity that is created by intra-firm networks of Advanced Producer Services firms.

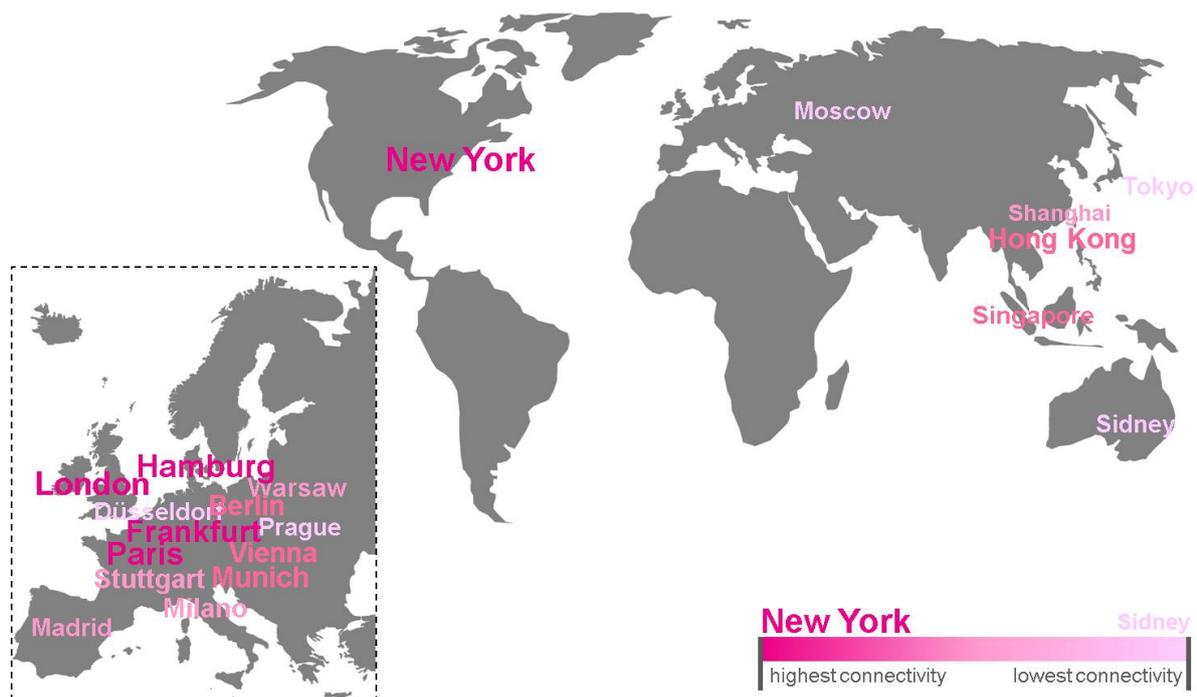


Figure 2: Global connectivity of APS firms.

Figure 3 shows the same situation for High-Tech firms. In contrast to Advanced Producer Services, the High-Tech sector seems to be characterized by many more extra-European locations: Shanghai, Singapore, Paris and Sao Paulo are the most connected cities in our High-Tech analysis. Again, three macro-regions stand particularly out: East Asia, Eastern Europe as well as Central and South America. With Shanghai, Singapore, Tokyo, Seoul, Peking, Bangkok and Hong Kong, Asia seems to be clearly the most important economic area for High-Tech industries that have at least one location in Germany. With Vienna, Budapest and Prague, three East European centres also rank in the top 20. This actually means that many High-Tech firms located for example in Vienna have also office locations in Prague and Budapest. In this context, Vienna seems to act as a kind of gateway to Eastern Europe, a hypothesis that has been cited many times in the context of the Eastern enlargement of the European Union. And finally, we have Central and South America. Whereas for Advanced Producer Services no South American city appears in the top 20, for High-Tech firms, Sao Paulo and Buenos Aires emerge as important locations for German High-Tech enterprises.

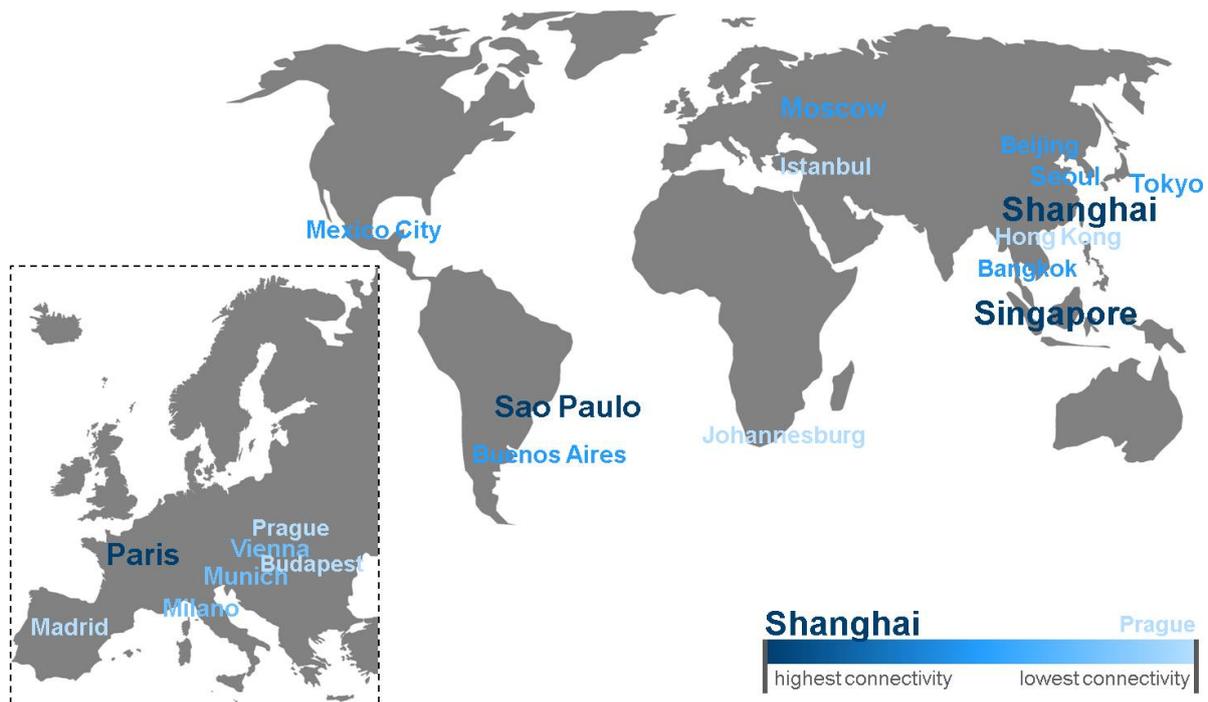


Figure 3: Global connectivity of High-Tech firms.

As we can see from this global perspective, Advanced Producer Services and High-Tech activities have a very uneven and highly concentrated global geography. Such a global perspective is quite useful, but it obscures the finer-grained texture of what is actually happening on the country level. Therefore, let us now take a closer look at the national scale, in order to reveal the functional urban hierarchy within the German space economy.

6.2 The functional urban hierarchy at the national scale

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 largest merchandise exporter, the third largest commercial services exporter, and the third most important source of foreign direct investment (Dicken 2007). However – as Dicken (2007) indicates – for a long period of time, Germany's growth in GDP has been below the world average and it still faces problems in integrating the former East Germany into the world economy. This leads to a steep functional urban hierarchy in the German space economy, in spite of the efforts undertaken by German policy makers to provide equivalent social conditions in all sub-regions of Germany.

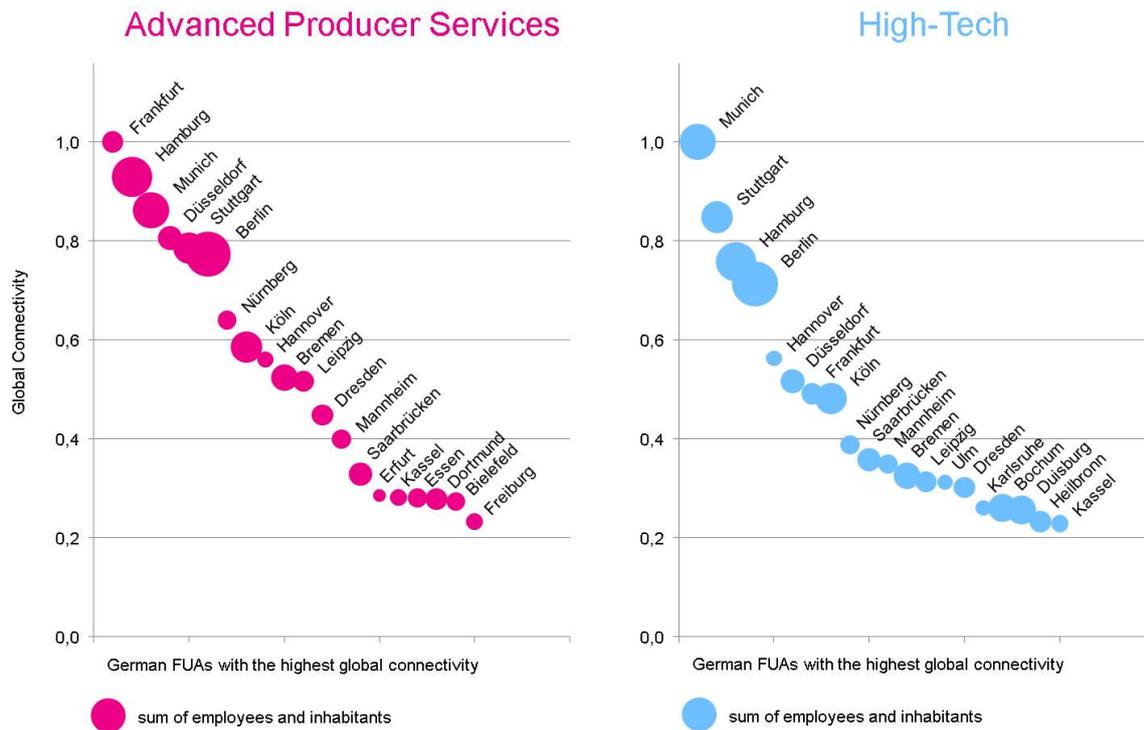


Figure 4: Functional urban hierarchy based on global interlocking networks.

Figure 4 shows the functional urban hierarchy in the German space economy for *global* interlocking networks. On the X-axis, there are the top 20 German agglomerations with the highest global connectivity. On the Y-axis, the global connectivity values relative to the top Functional Urban Area is displayed. These values illustrate how well a Functional Urban Area is connected to extra-European destinations such as New York, Tokyo, Sidney etc. The size of the circles illustrates the sum of employees and inhabitants and gives us an impression about the sheer size of the corresponding agglomeration. The strong concave curve progression for both Advanced Producer Services and High-Tech firms indicates a relatively steep functional urban hierarchy. In the case of Advanced Producer Services, there is a top group of 6 Functional Urban Areas: Frankfurt in the first position, followed by Hamburg, Munich, Düsseldorf, Stuttgart and Berlin. 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. Surprisingly, Frankfurt – which is in the first position in Advanced Producer Services networks – does not emerge in a top position in the High-Tech sector.

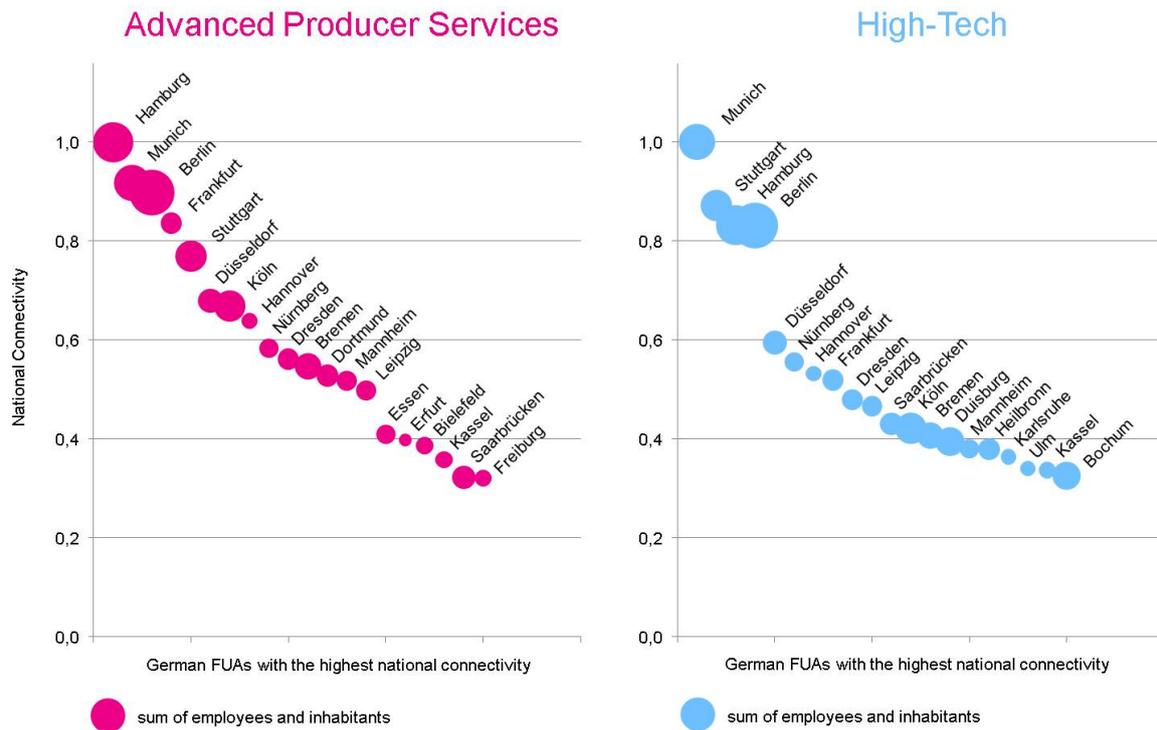


Figure 5: Functional urban hierarchy based on national interlocking networks.

Figure 5 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 Functional Urban Areas in Germany. For Advanced Producer Services, the distinction between the top group and the rest of the German agglomerations is not that clear anymore. For High-Tech firms, on the other hand, the top locations in Germany are obvious: Munich in the first position, followed by Stuttgart, Hamburg and Berlin.

The main conclusions of these findings are that the functional urban hierarchy in the German space economy emerges as a scale-dependent phenomenon, based on the coming together of various business networks of different organizational architectures and scalar reach. For High-Tech firms – whatever spatial scale we are looking at – the top cities in the functional urban hierarchy are clear: Munich, Stuttgart, Hamburg and Berlin are at the top.

6.3 The functional urban hierarchy at the regional scale – the case of Rhine-Ruhr

Finally, let us take a closer look at the regional scale, especially at the Rhine-Ruhr region. Rhine-Ruhr is one of the world's largest polycentric city-regions, embracing 30-40 towns and cities with a total population of some 10 million people, and with no obvious core city. Although the Rhine-Ruhr still has a relatively strong industrial base, de-industrialisation is

taking place all across the region. However, some cities have been able to offset job losses in the Ruhr's industrial sector with new jobs in the emerging knowledge economy. Due to several agglomeration advantages, some cities – 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 and Schmitt 2008).

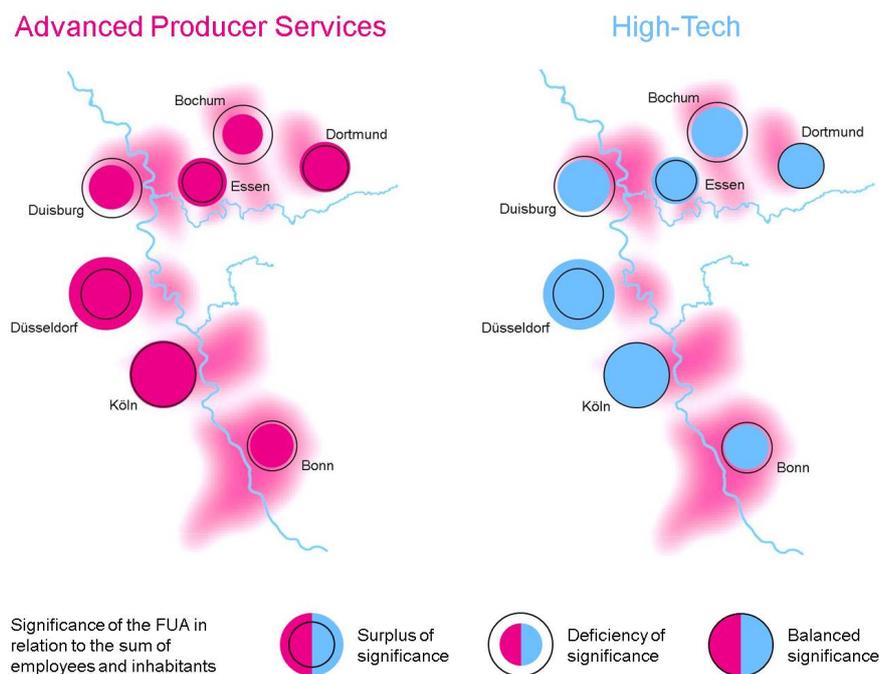


Figure 6: Significance of Functional Urban Areas in the Rhine-Ruhr region based on Advanced Producer Services and High-Tech networks.

The importance of Düsseldorf can also be seen in Figure 6. It shows the significance of the most important Functional Urban Areas in the Rhine-Ruhr for Advanced Producer Services and High-Tech firms. In order to get an impression about the relative significance of the Functional Urban Areas within the Rhine-Ruhr region, the interlock connectivity for each agglomeration is illustrated in relation to the sum of its inhabitants and jobs. The coloured circle illustrates the connectivity value for the Functional Urban Area; the black ring shows its sum of inhabitants and jobs. An outer coloured circle indicates a higher connectivity as expected in terms of inhabitants and jobs, representing a surplus of significance. A smaller coloured circle, in contrast, indicates a deficiency of significance.

For Advanced Producer Services networks, Düsseldorf, Dortmund and Essen are the only agglomerations that show a clear surplus of significance. Bochum and Duisburg, on the other hand, seem to be less important. For High-Tech networks, Düsseldorf and Essen are the only agglomerations having a clear surplus of significance. Dortmund indicates a balanced, Duisburg and Bochum – again – a deficiency of significance. These findings give evidence that Düsseldorf can be seen as the central gateway of the Rhine-Ruhr region connecting the whole area to the global “space of flows” (Castells 2000). Furthermore, it can be seen that the mere size of an agglomeration does not automatically correlate with its global significance. Köln for example – the fourth biggest city in Germany – is clearly less integrated in global networks of the knowledge economy than the smaller city of Düsseldorf. 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 have been relocated from Bonn to Berlin. Subsequently, in spite of many negative prognoses, Bonn has developed quite successfully in economic terms, not at least because of the huge amount of subsidies being paid in compensation for the loss of the capital status (Knapp et al. 2005). For a long time, this was leading to a surplus of significance, as a previous studies confirm (Thierstein et al. 2006; Knapp et al. 2006). However, this advance seems to shrink: Figure 6 shows that Bonn indicates now a slight deficiency of significance.

7. Conclusion

The key aim of this paper was to set out a theoretical context and then to empirically investigate the functional polycentric patterns and interlocking networks of Advanced Producer Services and High-Tech firms in the German space economy.

In the theoretical part, we have seen that knowledge has become the main source of economic development in advanced regions. The often cited binary argument of whether knowledge is codified or tacit in nature has been identified as being too narrow to understand knowledge creation processes. The growing variety of different knowledge forms – synthetic, analytical and symbolic – increasingly forces firms to acquire external knowledge in order to stay competitive in the global economy. For this reason, we suggest a definition of the knowledge economy that accounts for the strategic importance of knowledge in the innovation process: the knowledge economy is this part of the economy, in which highly specialized knowledge and skills are strategically combined from different parts of the value chain in order to create innovations and to sustain competitive advantage. In order to do this, knowledge-intensive

firms establish various forms of intra-firm and extra-firm networks at different geographical scales. The organizational architectures of intra-firm networks are converging towards a configuration, in which specialized units worldwide were linked into an integrated network of operations that enable them to achieve their multidimensional strategic objectives of efficiency, responsiveness and innovation (Bartlett and Ghoshal 2002). At the same time, these firms are deeply inscribed into wide external networks of suppliers, subcontractors and business clients along the value chain. This nexus of intra-firm and extra-firm networks has significant impacts on the spatial logic of the knowledge economy. Overall, there is a strong awareness on the many economic advantages for firms of being co-located geographically. However, other dimensions of proximity – such as relational, organizational, cognitive, social and institutional proximity – are also a key in understanding the knowledge creation process of firms. This leads to the fact that different business functions have different needs in terms of location, so that they tend to develop rather distinctive spatial patterns. Some of them tend to be spatially dispersed; others are spatially concentrated with other parts of the value chain.

Our empirical analysis on the German knowledge economy shows that the growing importance of knowledge-intensive activities – and its requirements for high-quality urban locations – brings about a spatial concentration of connectivity to only a very few urban areas. On the global scale, Asia emerges as an important destination for High-Tech firms located in Germany. Advanced Producer Services, in contrast, are strongly focused on the European space economy. On the national scale, interlocking networks of the knowledge economy create a steep functional urban hierarchy in the German space economy. And on the regional scale, we have identified that the mere size of an agglomeration does not automatically correlate with its functional significance. All in all, these findings bear a great challenge for the German policy goal to create equivalent social conditions in all sub-regions of Germany. Whereas these policy principles rest on a normative and territorial logic actual spatial development tendencies follow a functional logic, largely driven by market forces.

References

- Amin, Ash and Cohendet, Patrick (2004): *Architectures of knowledge. Firms, capabilities, and communities*. Oxford, New York: Oxford University Press.
- Anselin, Luc; Varga, Attila and Acs, Zoltan (1997): *Local Geographic Spillovers between University Research and High Technology Innovations*. In: *Journal of Urban Economics* 42: 422-448.
- Asheim, Bjørn T. and Coenen, Lars (2005): *Knowledge Bases and Regional Innovation Systems: Comparing Nordic Clusters*. In: *Research Policy* 34(8): 1173-1190.
- Audretsch, David B. and Keilbach, Max (2008): *Resolving the knowledge paradox: Knowledge-spillover entrepreneurship and economic growth*. In: *Research Policy* 37(10): 1697–1705.
- Bartlett, Christopher A. and Ghoshal, Sumantra (2002): *Managing Across Borders. The Transnational Solution*. Boston: Harvard Business School Press.
- Beaverstock, Jon V.; Smith, Richard and Taylor, Peter J. (1999): *A Roster of World Cities*. In: *Cities* 16(6): 445-458.
- Boschma, Ron (2005): *Proximity and Innovation: A Critical Assessment*. In: *Regional Studies* 39(1): 61-74.
- Boschma, Ron and Iammarino, Simona (2009): *Related Variety, Trade Linkages, and Regional Growth in Italy*. In: *Economic Geography* 85(3): 289-311.
- Bottazzi, Laura and Peri, Giovanni (2003): *Innovation and spillovers in regions: Evidence from European patent data*. In: *European Economic Review* 47: 687-710.
- Cairncross, Frances (1997): *The Death of Distance*. London: Orion Business.
- Capello, Roberta (2009): *Spatial Spillovers and Regional Growth: A Cognitive Approach*. In: *European Planning Studies* 17(5): 639-658.
- Carrincazeaux, Christophe; Lung, Yannick and Vicente, Jérôme (2008): *The Scientific Trajectory of the French School of Proximity: Interaction- and Institution-based Approaches to Regional Innovation Systems*. In: *European Planning Studies* 16(5): 617-628.
- Castells, Manuel (1989): *The Informational City. Information Technology, Economic Restructuring, Urban-Regional Process*. Oxford: Blackwell Publishers.
- Castells, Manuel (2000): *The rise of the Network Society. The Information Age: Economy, Society and Culture, Vol. 1, 2. Ed.* Malden: Blackwell Publishers.
- Coe, Neil; Dicken, Peter; Hess, Martin and Yeung, Henry Wai-Cheung (2010): *Making connections: Global Production Networks and World City Networks*. In: *Global Networks* 10(1): 138–149.
- Cooke, P; Uranga, M.G and Etxebarria, G (1998): *Regional systems of innovation: an evolutionary perspective*. In: *Environment and Planning A* 30: 1563 - 1584.
- Cooke, Philip (2002): *Knowledge Economies. Clusters, learning and cooperative advantage*. London: Routledge.
- Cooke, Philip; De Laurentis, Clara; Tödtling, Franz and Trippel, Michaela (2007): *Regional Knowledge Economies. Markets, Clusters and Innovation*. Cheltenham, Northampton: Edward Elgar.

- Dicken, Peter (2007): *Global Shift. Mapping the Changing Contours of the World Economy*, 5. Ed. London: SAGE Publications.
- Dunning, John H. (2000a): The eclectic paradigm as an envelope for economic and business theories of MNE activity. In: *International Business Review* 2000(9): 163–190.
- Dunning, John H. (2000b): *Regions, Globalisation and the Knowledge Economy*. Oxford: Oxford University Press.
- ESPON (2004): ESPON Project 1.1.1. Potentials for polycentric development in Europe. Project Report. Final Report. Luxembourg: European Spatial Planning Observation Network ESPON.
http://www.espon.eu/mmp/online/website/content/projects/259/648/file_1174/fr-1.1.1_revised-full.pdf, accessed 07.05.2007.
- Florida, Richard (2005): The world is spiky. The world in numbers. Globalization has changed the economic playing field, but hasn't leveled it. *The Atlantic*, Nr.26(3), October 2005: 48-51.
- Friedman, Thomas L. (2005): *The World is Flat. A Brief History of the Twenty-First Century*. New York: Farrar, Strauss and Giroux.
- Gallié, Emilie-Pauline (2009): Is Geographical Proximity Necessary for Knowledge Spillovers within a Cooperative Technological Network? The Case of the French Biotechnology Sector. In: *Regional Studies* 43(1): 33 - 42.
- Gertler, Meric S. (2003): Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there). In: *Journal of Economic Geography* 2003(3): 75-99.
- Gomes-Casseres, Benjamin (1996): *The Alliance Revolution: the New Shape of Business Rivalry*. Cambridge, MA: Harvard University Press.
- Hall, Peter and Pain, Kathy (2006): *The Polycentric Metropolis. Learning from Mega-City Regions in Europe*. London: Earthscan.
- Howells, Jeremy (2000): Knowledge, innovation and location. In: Bryson, John R.; Daniels, Peter W.; Henry, Nick and Pollard, Jane (ed.), *Knowledge, Space, Economy*. London, New York: Routledge.
- Howells, Jeremy (2002): Tacit Knowledge, Innovation and Economic Geography. In: *Urban Studies* 39(5-6): 871-884.
- Jaffe, Adam B.; Trajtenberg, Manuel and Henderson, Rebecca (1993): Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations. In: *The Quarterly Journal of Economics* 108: 577-598.
- Knapp, Wolfgang; Scherhag, Daniela and Schmitt, Peter (2005): POLYNET Action 2.1. Qualitative analysis of service business connections. Rhine - Ruhr. London: Institute of Community Studies/The Young Foundation & Polynet Partners.
- Knapp, Wolfgang and Schmitt, Peter (2008): Discourse on 'Metropolitan Driving Forces' and 'Uneven Development': Germany and the RhineRuhr Conurbation. In: *Regional Studies* 42(8): 1187–1204.
- Knapp, Wolfgang; Schmitt, Peter and Danielzyk, Rainer (2006): RhineRuhr: Towards Compatibility? Strategic Spatial Policies for a Specific Configuration of Polycentricity. In: *Built Environment* 32(2): 137-147.

- Kujath, Hans-Joachim (Hrsg.) (ed.) (2005): Knoten im Netz. Serie Stadt- und Regionalwissenschaften, Strukturplanung, Institut für Regionalentwicklung und (ed.). Münster: Lit Verlag.
- Laestadius, Staffan (1998): Technology level, knowledge formation and industrial competence in paper manufacturing. In: Eliasson, Gunnar K.; Green, Christopher and McCann, Charles R. (ed.), *Micro Foundations of Economic Growth*. Ann Arbor: The University of Michigan Press: 212-226.
- Malecki, Edward J. (2000): Creating and Sustaining Competitiveness. Local Knowledge and Economic Geography. In: Bryson, John; Daniels, Peter; Henry, Nick and Pollard, Jane (ed.), *Knowledge, Space, Economy*. London, New York: 103-119.
- Markusen, Ann (1996): Sticky places in slippery space - A typology of industrial districts. In: *Economic geography* 72(3): 293-313.
- Nonaka, Ikujiro; Ryoko, Toyama and Noboru, Konno (2000): SECI, Ba and Leadership: a Unified Model of Dynamic Knowledge Creation. In: *Long Range Planning* 33: 5-34.
- O'Brien, Richard (1992): *Global Financial Integration: The End of Geography*. London: Royal Institute of International Affairs.
- OECD (1996): *The knowledge-based economy*. Paris: OECD.
- OECD (1999): *Managing National Innovation Systems*. Paris: OECD.
- OECD (2008): *Staying Competitive in the Global Economy. Compendium of Studies on Global Value Chains*. Paris: OECD publishing.
- Ohmae, Kenichi (1985): *Macht der Triade: die neue Form weltweiten Wettbewerbs*. Wiesbaden: Gabler.
- Pain, Kathy and Hall, Peter (2008): Informational Quantity Versus Informational Quality: The Perils of Navigating the Space of Flows. In: *Regional Studies* 42(8): 1065–1077.
- Picot, Arnold; Reichwald, Ralf and Wigand, Rolf (2008): *Information, Organization and Management*. Heidelberg: Springer-Verlag.
- Pike, Andy (2007): Editorial: Whither Regional Studies? In: *Regional Studies* 41(9): 1143-1148.
- Polanyi, Michael (1966): *The tacit dimension*. London: Loutledge & Kegan Paul.
- Porter, Michael E. (1990): *The competitive advantage of nations*. London and Basingstoke: Macmillan Press.
- Rogers, Everett M. and Larsen, Judith K. (1984): *Silicon valley fever. Growth of high-tech culture*. New York: Basic Books.
- Sassen, Saskia (2001): *The Global City: New York, London, Tokyo, 2. Ed.* Oxford: Princeton University Press.
- Schamp, Eike W. (2003): Knowledge, Innovation and Funding in Spatial Context: The Case of Germany. In: Thierstein, Alain and Schamp, Eike W. (ed.), *Innovation, Finance and Space*. Frankfurt: Selbstverlag Institut für Wirtschafts- und Sozialgeografie der Johann Wolfgang Goethe Universität: S. 179-193.
- Schoenberger, Erica (2000): The Management of Time and Space. In: Clark, Gordon L.; Feldman, Maryann P. and Gertler, Meric S. (ed.), *The Oxford Handbook of Economic Geography*. Oxford: Oxford University Press: 317-332.

- Schürmann, Carsten (2004): Morphological Analysis of Urban Areas Based on 45-minute Isochrones. Annex Report D to ESPON Project 1.1.1 Potentials for Polycentric Development in Europe. Luxembourg: ESPON Monitoring Committee.
- Storper, Michael (1992): The limits to globalization: Technology districts and international trade. In: *Economic Geography* 68(1): 60-93.
- Taylor, Peter J. (2004): *World City Network: A Global Urban Analysis*. London: Routledge.
- Taylor, Peter J. (2007): A Brief Guide to Quantitative Data Collection at GaWC, 1997-2001. <http://www.lboro.ac.uk/gawc/guide.html>, accessed 14.05.2010.
- Thierstein, Alain; Kruse, Christian; Glanzmann, Lars; Gabi, Simone and Grillon, Nathalie (2006): *Raumentwicklung im Verborgenen. Untersuchungen und Handlungsfelder für die Entwicklung der Metropolregion Nordschweiz*. Zürich: NZZ Buchverlag.
- Tödting, Franz; Lehner, Patrick and Tripl, Michaela (2006): Innovation in Knowledge Intensive Industries: The Nature and Geography of Knowledge Links. In: *European Planning Studies* 14(8): 24.
- Torre, André and Rallet, Alain (2005): Proximity and Localization. In: *Regional Studies* 39(1): 47-59.
- Wood, Peter (2002): *Consultancy and Innovation: The Business Service Revolution in Europe*. London: Routledge.
- Wood, Peter (2005): A Service-Informed Approach to Regional Innovation – or Adaptation? In: *The Service Industries Journal* 25(4): 429-445.