

Intra firm networks in the German knowledge economy. Economic performance of German agglomerations from a relational perspective

Authors:

Dipl. Geogr. Michael Bentlage, Prof. Dr. Alain Thierstein

Munich University of Technology

Chair for Territorial and Spatial Development

Arcisstr. 21, D-80333 Munich

Phone: +49 89 289-22143

E-Mail: bentlage@tum.de

Abstract

Flows and inter-linkages between and within polycentric metropolitan regions have become a fundamental topic in regional sciences. The knowledge economy as a primary driver of spatial restructuring is forming these relations by generating knowledge within a spatially fine graded division of labour. This process drives companies to cooperate in intra firm networks which in turn evoke patterns of interdependent spatial entities.

The aim of the paper is twofold. Firstly, we analyze spatial patterns within these firm networks and secondly we combine this network approach with the performance of the economic and spatial structure of German agglomerations. We assume that relations of German Agglomerations constitute a new form of hierarchical urban systems. We hypothesize that the position of locations within the functional urban hierarchy depends on the spatial scale of analysis: global, European, national or regional.

Furthermore, we combine this relational perspective with an analysis of the economic performance within these spatial entities. Here we assume that intensive interaction between functional urban areas has a high influence on their performance with regard to output indicators like gross domestic product. Therefore we apply methods of spatial and network

autocorrelation. We hypothesize that relational proximity to emerging markets influences the economic performance of German Agglomerations intensively.

Keywords: knowledge economy, network analysis, spatial clustering, economic development, relational perspective.

1 Introduction

In the second half of the twentieth century the production factor knowledge gained on importance within the value-added process (Kujath and Schmidt 2007: 3-7). This shift towards a knowledge intensive economy led to changes in spatial configurations and networks of firms (Kujath and Stein 2009). The growing relevance of the knowledge economy and its tendencies towards both spatial concentration and global dispersal have induced new forms of hierarchical and network development, as well as functional differentiation between cities and towns (Lüthi, Thierstein and Bentlage 2011).

Knowledge is a fundamental resource to create innovations and to strengthen the economic performance of regions. Given that knowledge is applied and created within a complex system of division of labour, the interaction of people involved in this process is crucial. In particular, tacit knowledge, which is mainly based on experience, can only be transferred in learning processes. Therefore the access to knowledge is a main key driver for economic development. Thus, the world is spiky and population, patents as well as number of scientific citations are located in several urban centres in Northern America, Europe and South-East Asia (Florida 2005).

This paper combines a relational perspective (Bathelt and Glückler 2003, 2002) on economic processes with a reflection of economic performance of German agglomerations. The relational perspective in our view is given by the interaction between firm locations of the knowledge economy. Interaction is a fundamental precondition to generate and apply explicit and implicit knowledge (Polanyi 1967). In particular, the latter form of knowledge which is also called tacit knowledge requires face-to-face contacts because it is mainly based on experiences which only can be transferred in situations of learning-by-doing. Taylor (2004) introduced an empirical framework to assess relations between cities (Taylor 2004) and suggested to define hierarchies among cities by their grade of being integrated into a world system. This relational research design makes it possible to highlight how cities and towns within and beyond the German territory are interlocked with each other and how strong the economic performance depends on linking-up to those networks. The main hypothesis of this paper is: the better agglomerations are linked-up by knowledge intensive firms, the better the economic performance is. Therefore, we apply a set of multiple regression analyses in which we integrate data of physical accessibility, employment and non-physical interaction. We show that network connectivity and relations to growing markets have significant impacts on economic performance in Germany.

This paper is a draft version with preliminary quantitative results. Section two gives a theoretical insight in the relation between knowledge economy and economic performance. Section three introduces the database. Section four contains the results of our regression analyses and discusses the economic performance from a relational perspective. Finally, section five concludes our findings with with a forecast on further research questions.

2 The knowledge economy and its logic of action

Knowledge is held to be the fundamental resource within the process of innovation and therefore it strengthens the economic performance of a region. In recent years a considerable body of work has been developed in order to explain the shift towards a knowledge-based economy (OECD 1996; Cooke 2002; Amin and Cohendet 2004; Kujath 2005). Nevertheless, there is no commonly accepted definition of what the knowledge economy is. According to Cooke et al. (2007) it is not only the use of knowledge that is important to define the knowledge economy, but also the *knowledge creation process* (Cooke et al. 2007:27). 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).

Based on this argument, we suggest a definition of the knowledge economy that not only accounts for the knowledge creation process but also for its strategic importance in the innovation process. It needs to be recognized that the profit imperative is an important logical principle shared by all knowledge-intensive firms. It is not only the creation of new knowledge that preoccupies their managers, but also the appropriation of surplus value (Sokol, van Egeraat and Williams 2008:1143). Therefore, we apply the following definition:

The knowledge economy is that 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 the fact that the knowledge economy is causally determined by four mutually reinforcing attributes (Figure 1). First of all, the knowledge economy uses highly specialized knowledge and skills based on the combination of scientific knowledge and operating experiences. 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. The outcome of these networking activities is innovation in a Schumpeterian sense, which is the creation of new products, new production methods, new services, new markets or new organizational structures, and – most importantly – the transformation of these into marketable results. 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.



Figure 1: Key attributes of the knowledge economy (author's illustration).

In terms of economic sectors, the knowledge economy can be understood as an interdependent system of Advanced Producer Services (APS) and High-Tech firms. 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 2002:3). The essential common characteristic of these sectors is that they generate, analyse, exchange and trade information, making them spearheads and key intermediaries in the knowledge economy (Sassen 2001:90).

However, APS are not the only determining element in the process of structural change towards the knowledge economy. In order to understand the geography of globalization, one has to account simultaneously for both APS- and High-Tech-sectors. Castells (2000), for example, argues that what is true for top managerial functions and financial markets is also applicable to High-Tech manufacturing. As in the case of APS, the spatial division of labour that characterizes High-Tech manufacturing translates into worldwide connections with a

series of intra-firm and extra-firm linkages between different operations in different locations along the value chain (Castells 2000:444).

All in all, the importance of the systemic interplay between APS and High-Tech industries has to be emphasized. Wood (2005:430p), for example, warns us to beware of 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.

2.1 The functional logic of the knowledge economy

If researchers want to analyse how space is affected by the production processes of APS and High-Tech firms, they have to understand the functional logic of knowledge creation and business organization. We shall deal with these issues in the next two sections.

The functional logic of the knowledge creation

When one considers the knowledge intensity of APS and High-Tech firms, it becomes clear that knowledge creation has become increasingly complex and interdependent in recent years. There is a wide variety of knowledge sources available to firms, and there is more collaboration and division of labour among actors along the value chain. The process of knowledge creation requires a dynamic interplay between tacit and explicit forms of knowledge as well as strong interaction between people within organizations and between them. Therefore physical accessibility plays an important role (Thierstein, Goebel and Lüthi 2007: 88).

According to Polanyi (1967), knowledge can be divided into two major categories: codified and tacit knowledge (Polanyi 1967). Codified knowledge can be applied, expressed and standardized. Hence, it is a marketable good that can easily be distributed over time and space. New information and communication technologies offer the opportunity of increasingly codifying and commodifying knowledge and making it tradable across long distances, which means that codified knowledge becomes more and more de-territorialized. This enables companies to source activities and inputs globally and to benefit from relational proximity and international knowledge spill-overs. Tacit knowledge, in contrast, refers to knowledge, that cannot be easily transferred. It comprises skills based on interactions and experiences. Tacit knowledge and personal experience are necessary in order to make use of codified knowledge in creative and innovative processes (Schamp 2003:181).

The functional logic of business organization

The knowledge-creation process is influenced by the organisational capacity of knowledge-intensive firms. They must be sufficiently 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, Reichwald and Wigand 2008:237). Dicken (2007) argues that production networks are coordinated and regulated primarily through the various forms of intra- and extra-organizational relationships of business firms (Dicken 2007:154).

Intra-firm networks of transnational corporations (TNCs) provide an important internal framework for identifying and transferring information between different business units. 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 by 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 (OECD 2008:8). Similarly, Bartlett and Ghoshal (2002) argue that the organisational architectures of TNCs are converging toward a configuration, in which specialized units worldwide are linked to form an integrated network of operations enabling them to achieve efficiency, responsiveness, and innovation (Bartlett and Ghoshal 2002:101p).

The specific design of intra-firm and extra-firm networks depends on whether tacit or codified knowledge forms the basis of the organisational design. Firms have to decide whether face-to-face communication is preferable, whether knowledge of experts can be codified, or whether knowledge brokers such as consulting firms should be engaged (Picot, Reichwald and Wigand 2008:464). In the empirical part of this paper (see section 6), we focus on intra-firm networks within the knowledge economy. Empirical findings on extra-firm relations along the value chain are illustrated in previous publications (Lüthi, Thierstein and Goebel 2010; Thierstein et al. 2008).

2.2 The spatial logic of the knowledge economy

The functional logic of the knowledge economy has a significant impact on the spatial and the economic development. Based on the requirements for knowledge creation and business organisation, most corporations in the knowledge economy develop their location network as part of their overall business strategy. This strategy considers both where a firm's internal

functions should be placed and where suppliers and customers should be located. These internal and external linkages are woven across physical space, not only connecting firms and parts of firms together, but also more or less dispersed cities and towns, leading to two fundamental spatial processes in the knowledge economy: agglomeration economies and global network economies.

Agglomeration economies

Agglomeration economies are generic geographical processes mapping the microeconomic logic of knowledge creation and business organization in space. Early theories on agglomeration economies are strongly inspired by Alfred Marshall (1920), who argued that spatial concentration could confer external economies on firms as they concentrate in particular cities (Marshall 1920). Marshall's concept was taken up by Hoover (1937) who grouped the sources of agglomeration advantages into internal returns of scale, localisation and urbanisation economies. Localisation economies reflect the tendency for firms in closely related industries to locate in the same place; urbanization economies, on the other hand, arise from the diversity and the more general characteristics of a city (Hoover 1937). Based on these early agglomeration theories, a second wave of agglomeration models was developed in the 1980s onwards to explain why local space is still important for newly-developing firms of production. For example: the new industrial district (Becattini 1991), the innovative milieu (Maillat, Quévit and Senn 1993) or the regional innovation system (Cooke 1992).

The commonality of these approaches is that they acknowledge geographical proximity as an important determinant for the innovation activities of knowledge-intensive firms. A number of authors have demonstrated through econometric methods that knowledge spill-overs are closely related to spatial proximity (Anselin, Varga and Acs 1997; Bottazzi and Peri 2003; Jaffe, Trajtenberg and Henderson 1993; Breschi and Lissoni 2009). The importance of face-to-face contacts in communication and the tacit nature of much of this communication still make geographical proximity a crucial factor in knowledge creation. Short distances bring people together and enable them to exchange tacit knowledge. This leads to the development of localized knowledge pools, which are in turn characterized by personal contacts and informal information flows, both within and between firms of the knowledge economy. The spatial concentration of these information-flows influences scanning and learning patterns, as well as the sharing of localized knowledge and the innovation capabilities of knowledge-intensive firms (Howells 2000:58p).

Global network economies

The functional logic of the knowledge economy not only has a significant impact on agglomeration economies, but also on global network economies. Although there is strong evidence that knowledge is highly concentrated in a minority of city-regions, it is unlikely that all the knowledge required by a firm for innovation can be found within a single region. Companies have to spread activities globally to source inputs and to gain access to new markets. High-Tech industries, for example, use global sourcing to improve existing assets or to create new technological assets by locating R&D facilities abroad (OECD 2008:10). In order to realise global sourcing strategies successfully, relational proximity – especially organisational and time proximity – is important. Organisational proximity is needed to control uncertainty and opportunism in the knowledge creation process (Boschma 2005:65). It creates a sense of belonging, which facilitates interaction and offers a powerful mechanism for long-distance coordination (Torre and Rallet 2005:54). Time proximity, on the other hand, is supported by a rich and diversified infrastructure of global travel and communication, such as rapid and frequent trains and flights, and easy access to interactive communication facilities. It covers important aspects of ‘being there’, but it does not demand enduring co-location and local embedding (Amin and Cohendet 2004:105).

All in all, the spatio-economic behaviour of knowledge-intensive firms leads to the emergence of a world city network. Two major world city network approaches are of particular importance for this study. The first approach is John Friedmann’s (1986) ‘world city’ concept, which focuses upon the decision-making activities and power of TNCs in the context of the international division of labour. He argues that “key cities throughout the world are... ‘basing points’ in the spatial organisation and articulation of production and markets” (Friedmann 1986:71).

The second approach is Saskia Sassen’s ‘Global City’ concept, which associates cities with their propensity to engage with the internationalization and concentration of APS firms in the world economy (Sassen 2001:90). Sassen (1994) defines global cities as “strategic sites in the global economy because of their concentration of command functions and high-level producer-services firms oriented to world markets” (Sassen 1994:145).

A central motivation of the world city literature has been to rank cities according to their economic power in the worldwide city-system (Beaverstock, Smith and Taylor 1999:446). In much of this comparative research, different urban settlements are ranked according to one or more variables, such as population and employment size, headquarters totals etc. In this context, however, the term ‘hierarchy’ is ambiguous. There is a great temptation to interpret such rankings as hierarchies. But such rankings, of course, 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 brook this shortcoming, the empirical part of this paper applies the 'world city network' approach of Taylor (2004) to analyze global connectivity patterns and functional urban hierarchies in the German knowledge economy (Taylor 2004). This approach provides an empirical instrument for analysing inter-city relations in terms of the organizational structure of knowledge-intensive firms. It reveals the relationships between head offices and other branches located all over the world, building theoretically on Saskia Sassen's identification of APS as crucial production process in global cities.

Knowledge economy and physical accessibility

As mentioned above explicit and tacit knowledge are different in the way people have to interact. Since the transfer of tacit knowledge requires direct face-to-face interactions, the findings of Polanyi (1967) are not only important for firms but also for regions. Innovative activities have been shown to be highly concentrated in a minority of urban regions (Simmie 2003). The main reason why these regions play an important role in the supply of knowledge is that firm networks benefit from geographical proximity and local knowledge spill-overs. Malecki (2000) describes this 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. While codified knowledge is easily replicated, assembled and aggregated (...), other knowledge is dependent on the context and is difficult to communicate to others. Tacit knowledge is localised in particular places and contexts (...)" (Malecki 2000: 110).

The distribution and transfer of codified and tacit knowledge as well as the interplay between geographical and relational proximity forms a key basis for the development of regions. On the one hand, the concentration of knowledge resources in particular regions influences the roles that they may play in the global economy. On the other hand, the dynamics of knowledge exchange within and between regions contribute to either the maintenance or change in those roles within the functional urban hierarchy. This raises questions over the relative importance of regional versus international knowledge spill-overs. Simmie (2003) shows that knowledge intensive firms combine a strong local knowledge capital base with high levels of connectivity to similar regions in the international economy. In this way they are

able to combine and decode both codified and tacit knowledge originating from multiple regional, national and international sources (Simmie 2003).

3 Data and performance

3.1 Accessibility and Gross Domestic Product

Data on accessibility and Gross Domestic Product (GDP) were originally calculated for NUTS¹ 3 level. Accessibility data for the year 2006 was provided by the European Spatial Planning and Observation Network (ESPON).

Accessibility is defined by *“how easily people in one region can reach people in another region”* (ESPON 2009: 4). Therefore this calculation indicates the potential for activities and enterprises in the region to access markets and activities in other regions and calculated the population in all other European Regions, weighted by the travel time to get there (ESPON 2009:7). This so-called potential measure was introduced by Hansen to indicate opportunities for interaction (Hansen 1959). Therefore physical accessibility acts as a counterpart to non-physical interaction, which will be defined in section 3.2.

The values used here are indexes calculated for 27 members of the European Union. A value below 100 indicates accessibility, which is lower than the European average. In contrast, values above 100 represent accessibility above the European average. These data from NUTS 3 regions were converted to the spatial units of Functional Urban Areas (FUA) to combine them with data of intra-firm networks. Hence, accessibility data of FUAs reflect an area-weighted average of data from NUTS 3 regions. FUAs are agglomerations, which are defined by an average commuting time of 60 min around a defined centre (ESPON 2004).

Figure 2 shows exemplarily the calculation of data for FUAs and a comparison of air accessibility of NUTS 3 entities on the left hand side and FUA on the right hand side. Multimodal accessibility includes the potential accessibility by road, rail and air traffic. While calculating data from NUTS 3 entities for FUAs, figures for Munich may be misleading due to the fact that Munich FUA is less compact than FUAs such as Nuremberg and Fürth. In other words the area-weighted averages do not reflect the relative accessibility of Munich FUA. This can be explained by the different spatial structures of the FUAs. For instance, the FUAs Nuremberg, Fürth, and Erlangen are small compared to the FUA of Munich. Furthermore, the FUAs Nuremberg, Fürth and Erlangen are gathered directly around the airport of Nuremberg.

¹ Nomenclature of unités territoriales statistiques

This phenomenon is known as the modifiable areal unit problem. The forming of spatial entities might radically influence analytical results (Openshaw 1984).

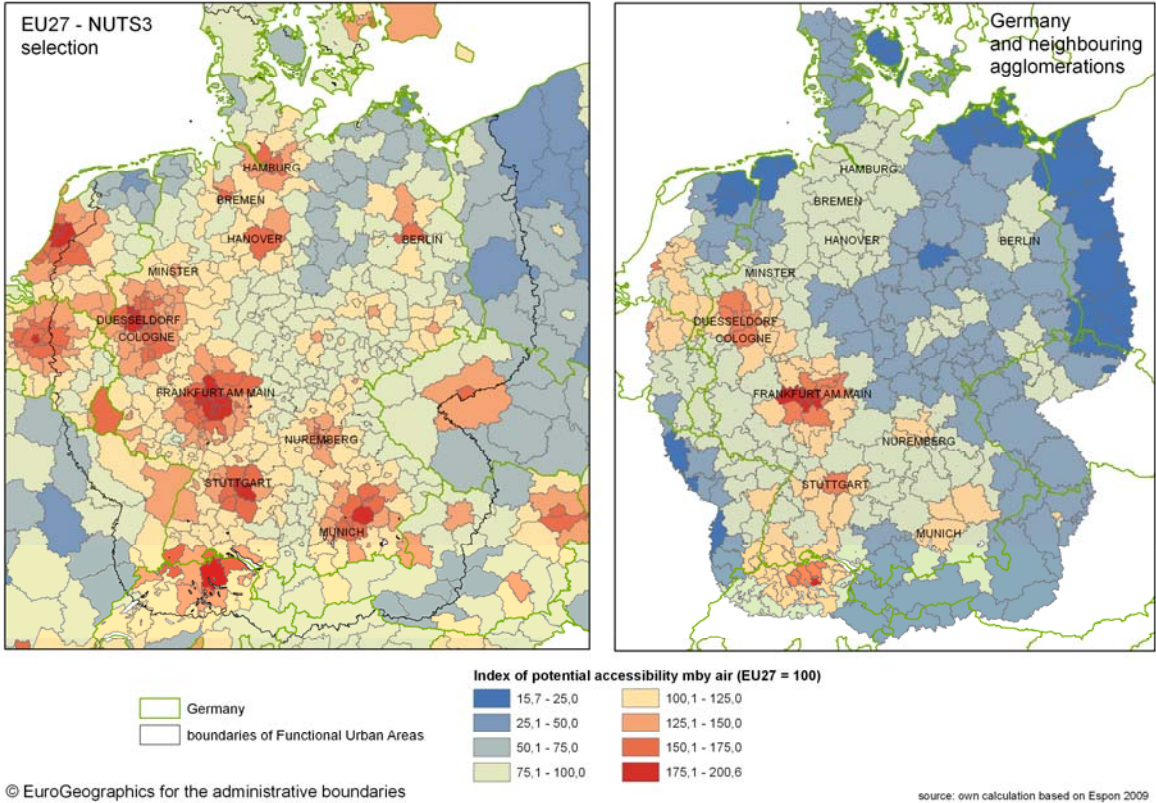


Figure 2: Calculation of accessibility by air for Functional Urban Areas

Figure 3 shows the GDP for the FUAs which are mainly within the boundaries of Germany. In our analysis we use only 186 FUAs because data for Switzerland and Denmark were not available. Values of GDP for the year 2008 are obtained from Eurostat (2011).

The FUAs Berlin, Munich, Hamburg, Frankfurt and the Rhine-Ruhr area around Cologne have the highest GDP. Smallest values can be found in the geographical centre and the eastern parts of Germany.

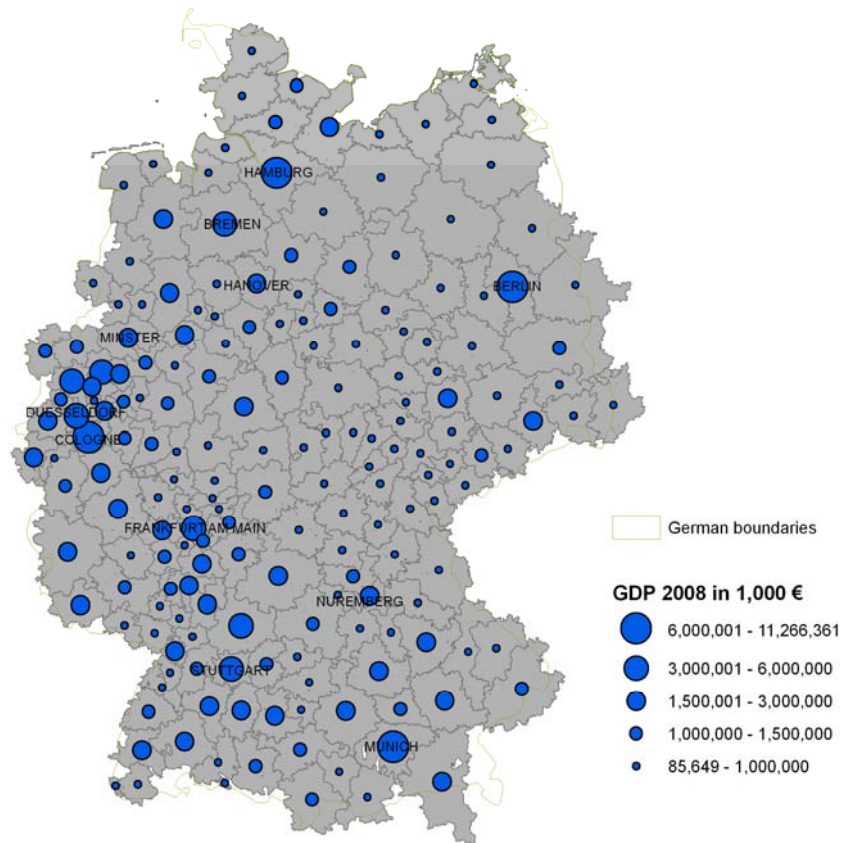


Figure 3: GDP of FUAs within Germany (source: Eurostat 2011)

Compared to the accessibility patterns of air traffic the GDP shows a similar spatial configuration. It is assumed that there is a strong interrelation between both variables. In the next section we define the non-physical interaction.

3.2 Defining non-physical interaction

The analysis of intra-firm networks is based on the methodology of the Globalisation and World Cities Study Group (GaWC) at Loughborough University. This approach estimates city connectivities from the office networks of multi-city enterprises. Intra-firm networks are spatially distributed branches of one individual corporation. The basic premise of this method is that the more important the office, the greater its flow of information to other office locations. The empirical work comprises three steps.

In the first stage of the empirical work, we had to create a reliable company database. In identifying APS- and High-Tech firms and collected information about their local and regional authorities from the websites. The result of this process was a basic set of 270 APS firms and 210 High-Tech enterprises.

In a second step we developed a so called 'service activity matrix'. This matrix is defined by FUAs in the lines, structured along the regional, national, European and global scale, and knowledge-intensive firms in the columns. Each cell in the matrix shows a service value (v_{ij}) that indicates the importance of a FUA (i) to a firm (j). The importance is defined by the size of an office location and its function. By analysing the firms' websites, all office locations are rated at a scale of 0 to 5. 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 (e.g. regional headquarter, supra-office functions) its value is upgraded to 3 or in case of even higher importance to 4. The enterprise headquarter was valued with 5. If the overall importance of a location in the firm-network is very low (e.g. small agency in a small town) the value is downgraded to 1.

In the third step, we used the interlocking network model by Taylor (2004) to estimate connectivities of FUAs (Taylor 2004). Network connectivities are the primary output from the interlocking network analysis. The measure is an estimation of 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:

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

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

$$r_{ib} = \sum r_{abj} \quad (2)$$

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

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

If we relate the interlock connectivity for a given FUA to the FUA with the highest interlock connectivity (N_h), we gain an idea of its relative importance in respect to the other FUAs that have been considered. The resulting values of relative connectivity score somewhere between 0 and 1.

$$P_a = (N_a/N_h) \quad (4)$$

4 Results

4.1 The functional urban hierarchy on the global scale

According to Kenichi Ohmae (1985), the world is essentially organized around a tri-polar macro-regional structure comprising North America, Europe and East Asia as its main economic pillars (Ohmae 1985). Looking at statistical data, Dicken (2007) shows that these three macro-regions together contain 86 per cent of both total world GDP and total world merchandise exports (Dicken 2007:38). Generally, this global triad hypothesis is supported by the findings of our interlocking network analysis, but with some striking differences between North America, Europe and East Asia.

Figure 4 shows the top 20 cities in terms of global network connectivity for APS firms: a big font size in dark red illustrates high connectivity; a small font size shows low connectivity. New York, London, Hamburg, Paris and Frankfurt indicate the highest connectivity values.

Generally, three macro-regions seem to be of particular importance for APS firms located in Germany. Firstly, there is Germany itself. Six German FUAs rank in the top 20: Hamburg, Frankfurt, Munich, Berlin, Stuttgart and Düsseldorf. These agglomerations can be regarded as a kind of 'urban circuit' that constitutes the top of the German functional urban hierarchy (Hoyler, Freytag and Mager 2008:1102). The fact that many APS networks are concentrated on the national scale might be related merely to the size of the German domestic market, which seems to create enough demand and growth potential for knowledge-intensive firms located in Germany. But also cultural and linguistic requirements as well as specific national regulations and non-tariff barriers to trade tends to hamper internationalization strategies (Thierstein et al. 2006:71).

Secondly, there is Western Europe. 14 European cities rank in the top 20. Obviously, the political and economic integration of German FUAs in Europe has had an enormous effect on the German national urban system, especially in terms of its complementary functional and sectoral specialization. Today – with the completion of the European single market – German agglomerations no longer compete among each other alone, but also with London, Paris, Milan and other European metropolises.

And thirdly, there are three highly connected cities in Asia: Hong Kong, Singapore, Shanghai, plus Tokyo as traditional global city. Taken together, they clearly catch up with North America in terms of global network connectivity. In this sense, the German space economy seems to be well equipped in its APS connections to face the challenges in the context of the raising East Asian economy, although there is still further room for improvement, especially in comparison with the High-Tech sector (see below).

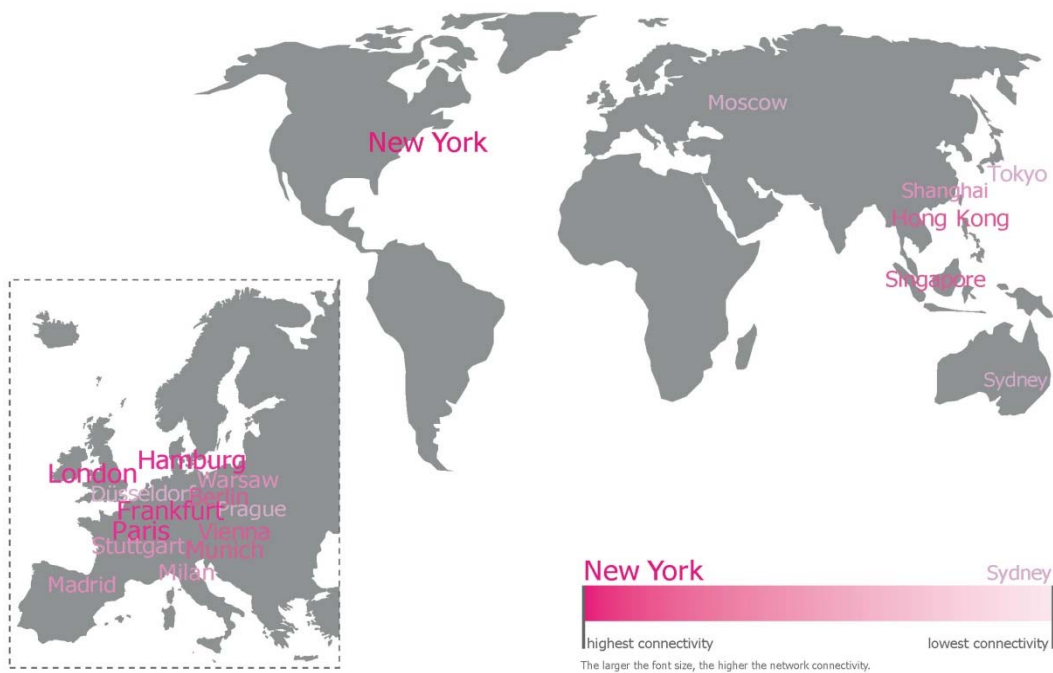


Figure 4:: Global connectivity based on APS interlocking networks (author's calculation).

Figure 5 shows the top 20 cities in terms of the interlock connectivity of High-Tech firms. In contrast to the APS sector, High-Tech firms seem to be much more networked with extra-European locations. With Shanghai, Singapore, Tokyo, Seoul, Peking, Bangkok and Hong Kong, East Asia clearly emerges as the most important economic area for High-Tech industries located in Germany. The chemicals, mechanical engineering and the electronics sectors in particular are highly represented in East Asia. In the semi-conductor industry, for example, East Asian producers have developed their own highly specialized knowledge so that firms from Europe and North America can effectively exploit not only cheap labour but also increased technical expertise in East Asian countries (Borras 2000:58).

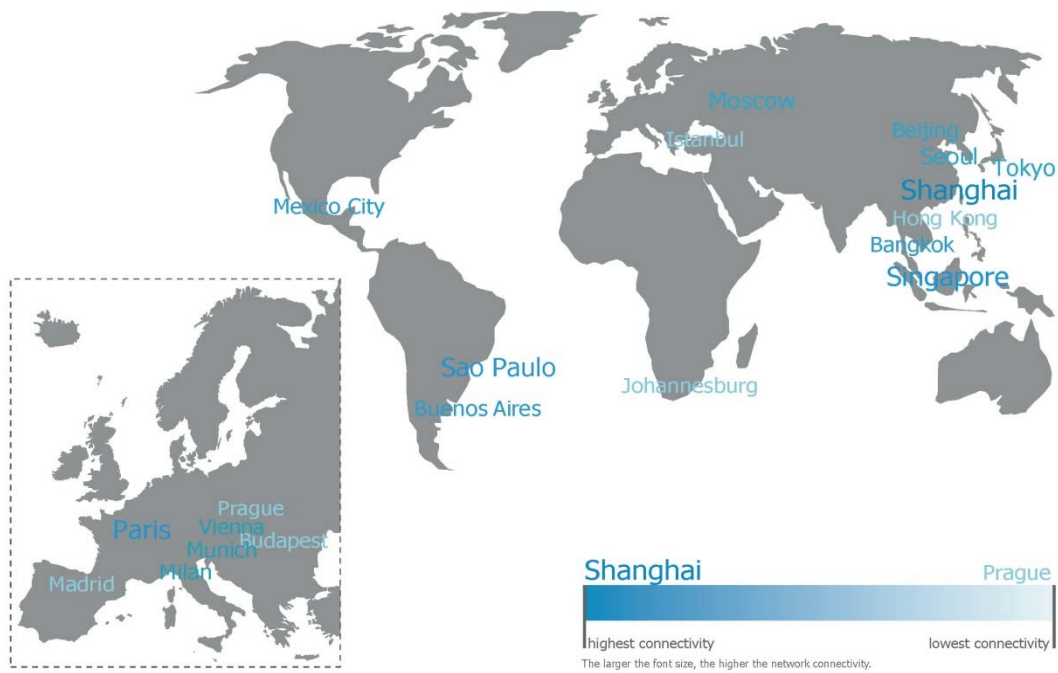


Figure 5: Global connectivity based on High-Tech interlocking networks (author's calculation).

But also three Eastern European cities – Vienna, Budapest and Prague – rank in the top 20. This means that many High-Tech firms located, for example, in Vienna also have office locations in Prague and Budapest. 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 eastward expansion of the European Union. An empirical analysis by Musil (2009), for example, confirms that Vienna derived great benefit from its geo-strategic position within the European Union (Musil 2009:263). However, it is highly questionable whether Vienna can sustain this gateway position. It can be assumed that – in the course of the economic development of Eastern Europe – many firms may re-locate their offices from Vienna to other Eastern European cities such as Budapest, Prague or Warsaw.

4.2 Economic performance from a relational perspective

Economic performance depends on various factors; one of them is the access to networks. From a relational perspective, this analysis explains the GDP of German agglomerations by the number of employment, the access via air traffic and the interlock connectivity in APS and High-Tech. We hypothesise that interlocking connectivity has a significant influence on the GDP but compared to the number of employed people its influence is less strong.

Table 1 shows the results of a multiple linear regression analysis which was calculated in three steps. The coefficient of determination R^2 in all three models reaches values of at least 0.898. The F-test statistics indicate also reliable results. They are significant in all three

models. Although there is evidence that the results of the regression analysis are trustworthy, problems of multi-collinearity might occur by dealing with absolute values. Indeed, the bigger the number of employees, the higher will be the interlock connectivity and the economic output of a spatial entity. In order to avoid a bias given by absolute values we understand regression analysis as a tool for the comparison of certain variables' influences. Thus, these regression models are not meant to make predictions about economic performance at all. Due to that, an exact estimation by using this regression equation might be impossible. All in all, the main focus is set on the influence of interlock connectivity on the size of a regional economy related to the size of employment.

The dependency of GDP can be assessed by the regression coefficients. As matter of course the size of labour force affects the economic output strongly. Consequently, employment reaches the highest value and is the most important variable in this set. The regression coefficient of access via air traffic has the lowest value and is not significant within the models two and three.

		R ²	ANOVA		Regression Coefficients	
Model	Variables		F	significance	beta	significance
1	employment	.898	1632.757	.000	.948	.000
2	employment	.903	858.217	.000	.926	.000
	Air Index				.074	.003
3	employment	.926	579.767	.000	.667	.000
	Air Index				.037	.084
	APS interlock connectivity				.177	.001
	HT interlock connectivity				.143	.014

Table 1: Regression analysis – influences of interaction (own calculation)

The coefficients of the interlock connectivity of APS and HT are significant within that analysis and they reach values of 0.177 for APS and 0.143 for HT. In comparison to employment these variables are less important. Therefore GDP depends stronger on the size of labour force than on the linking-up to non-physical networks.

4.3 Connectivity to China, India and USA

To deepen the results of the former section we hypothesis here, that the strength of the economic performance of a region depends on its relations to markets which develop very well or which are mature. Therefore we had a closer look at the relations of German agglomerations to the USA, China and India. This selection can be explained by the following arguments:

- China: During the recent decades this country reached growth rates of GDP between 8 and 14 percent a year. Even the economic crisis between 2008 and 2009 could not cause a shrinking economy (World Bank 2010). Furthermore, China is the world's largest country in terms of population and the third biggest economy in the world as well it is a strong trading partner for Germany. Thus its development will have strong influence on the German economy
- India: In the same period India had growth rates between 4 and 9 percent a year. It is also a big country in terms of population; we therefore assume, similar to China, strong influences on the German economy.
- USA: The USA is the biggest and one of the most successful economies in the world. It might be classified as a mature economy. Growth rates range between minus 3 and 4 percent. The economic crisis caused strong shrinking in the year 2009.

All in all, these countries represent prime examples of the world's economic development. Because of the economic crisis which affected the United States strongly and because of the high growth rates in China and India the relative importance of USA for the German space economy will decline whereas China and India will gain in importance.

The following results show a comparison of interlock connectivities of APS and HT firms to the mentioned countries (table 2). The most striking difference between both sectors can be observed by the significance of the variables. In the case of APS only the interlock connectivity to USA has significant influence on GDP. In contrast, only the interlock connectivity by HT to China and India firms can be considered meaningful. This result is supported by the illustrations in section 4.1. From a German perspective the centres of HT are located in South-East Asia.

Reflecting the initially stated hypothesis both APS and High-Tech firms operate in global centres. But High-Tech firms organise value chains that have high stakes in production worldwide. Thus locations tend to profit – like China and India – which manage to offer lower wages for a still better qualified workforce. The result of these worldwide operations is

“footloose” industries, such as the automotive industry (Sturgeon, Biesebroeck van and Gereffi 2008: 318). That means standardised elements of value chains, which equate codified knowledge, are often carried out in emerging countries. So, for example production plants tend to be located where production equipment, lower wages and quality management offer a positive trade-off in comparison to staying put in Germany.

	APS		High-Tech	
	Regression coefficients		Regression coefficients	
Variables	beta	significance	beta	significance
China	-.007	.974	.512	.002
India	.057	.877	.430	.002
USA	.820	.009	-.036	.697
R square	0.752		0.811	

Table 2: Regression analysis - interaction to selected countries (own calculation)

Contrastingly, APS firms have a stronger relation to the traditional centres of globalization like New York or London. Hoyler (2011) showed that in particular Frankfurt as a centre for APS firms is strongly related to these cities of “Traditional Globalism” (Hoyler 2011). One reason for this difference might be given by the fact that APS firms have to deal with complex regulations which require specific services for each country. For example, within the finance sector regulations of retirement arrangements are very specific. In the course of interviews with managers in the finance sector, many business practitioners confirmed this finding by underlining the importance of national regulations for their business activities:

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

Consequently, for some APS firms it is not possible to realize economies of scale by enlarging their markets. This evaluation is supported by findings of Thierstein (2003) who pointed out nationally oriented APS companies are indeed able to succeed (Thierstein 2003). Contrastingly, HT firms, which generate value-added by a high share of production cost cuttings of wages by producing in emerging markets carry higher weight. Finally, the question arises if HT sector acts as a cutting-edge in economic development on a whole. In the case of China this sector is used to strengthen the economic performance by adapting new technologies and to expand the domestic share of value-added. Afterwards, when the

production base is expanding and the demand for services increases APS firms will follow the locations of HT firms.

5 Conclusions

To conclude these findings we firstly have a look on our methods and secondly on our empirical results.

By using absolute values within the regression analysis the problem of multi-collinearity occurs. Therefore the regression models on a whole are not reliable anymore, but still the strength of the relative influence of the included variables can be assessed. Thus employment has the strongest influence on the size of the economy defined by the GDP. The interlock connectivity of APS and HT firms is still significant and verifies our hypothesis that linking-up to networks strengthens the economic performance. We propose that more precisely it is the level of qualification of employment – the knowledge workers – that in turn are attracted by highly connected firms and therefore more likely choose these locations to work and to live

Although physical accessibility plays a crucial role to generate and apply knowledge (Bentlage, Lüthi and Thierstein 2010), in comparison to the other variables, which indicate the size or mass of economic power it seems to be of secondary importance or to put it differently: physical accessibility is a necessary but not a sufficient condition for the knowledge creation process. Thus in order to assess the relevance of physical interaction further research with air and rail passenger data is required.

In respect of the differences between High-Tech and APS mentioned above, greater efforts should be devoted to analysing their particular network structure over time and in particular, strategic decisions in choosing locations should be considered. German manufacturing firms try to locate their economic activities close to important markets where production is done with reasonable low costs and manageable quality. Countries like India and China already offer that combination and will do so to a growing degree. The enhancing and broadening of China's and India's production bases will subsequently increase the demand for advanced producers services.

Furthermore, our cross-sectional analysis indicates that the development of China and India have strong impacts on the German economy. The growth of these economies will reinforce the trade relations with Germany and subsequently they will enforce the mutual dependency. We also assume that the economic crisis of the years 2008 and 2009 will cause a fundamental change of Germany's relations to markets abroad. The relative importance of

the USA will decline whereas countries of South-East Asia will gain in importance. Firms of the knowledge economy eventually will adjust their strategic decision making and their locational behaviour.

6 References

- Amin, Ash, and Patrick Cohendet (2004) *Architectures of knowledge. Firms, capabilities, and communities*. Oxford, New York: Oxford University Press.
- Anselin, Luc, Attila Varga, and Zoltan Acs (1997) *Local Geographic Spillovers between University Research and High Technology Innovations*. In: *Journal of Urban Economics*. 42, 422-448.
- Bartlett, Christopher A., and Sumantra Ghoshal (2002) *Managing Across Borders. The Transnational Solution*. Boston: Harvard Business School Press.
- Bathelt, Harald, and Johannes Glückler (2002) *Wirtschaftsgeographie. Ökonomische Beziehungen in räumlicher Perspektive*. Stuttgart: eugen Ulmer.
- Bathelt, Harald, and Johannes Glückler (2003) *Towards a relational economic geography*. In: *Journal of Economic Geography*. 2003, 3:117-144.
- Beaverstock, Jonathan, Richard G. Smith, and Peter J. Taylor (1999) *A Roster of World Cities*. In: *Cities*. 16, 6:445-458.
- Becattini, Giacomo (1991) *Italian industrial districts: Problems and perspectives*. In: *International Studies of Management & Organization*. 21, 1:83-90.
- Bentlage, Michael, Stefan Lüthi, and Alain Thierstein (2010) *Accessibility of German agglomerations – An approach with non-physical connectivity*. European Regional Science Association, ERSA, 20.8.2010, Jönköping, Schweden.
- Borrus, Michael (2000) *The resurgence of US electronics: Asian production networks and the rise of Wintelism*. In: Michael Borrus, Dieter Ernst and Stephan Haggard (eds.), *International production networks in Asia: Rivalry or Riches?*, London: Routledge, 56-78.
- Boschma, Ron (2005) *Proximity and Innovation: A Critical Assessment*. In: *Regional Studies*. 39, 1:61-74.
- Bottazzi, Laura, and Giovanni Peri (2003) *Innovation and spillovers in regions: Evidence from European patent data*. In: *European Economic Review*. 47, 687-710.
- Breschi, Stefano, and Francesco Lissoni (2009) *Mobility of skilled workers and co-invention networks: an anatomy of localized knowledge flows*. In: *Journal of Economic Geography*. 2009, 9:439-468.
- Castells, Manuel (2000) *The rise of the Network Society. The Information Age: Economy, Society and Culture*. 1, 2, Malden: Blackwell Publishers.
- Cooke, Philip (1992) *Regional innovation systems: competitive regulation in the New Europe*. In: *Geoforum*. 23, 3:365-382.

- Cooke, Philip (2002) *Knowledge Economies. Clusters, learning and cooperative advantage*. London: Routledge.
- Cooke, Philip, Clara De Laurentis, Franz Tödting, and Michaela Trippel (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, London: SAGE Publications.
- ESPON (2004): ESPON Project 1.1.1. Potentials for polycentric development in Europe. Project Report. Final Report. European Spatial Planning Observation Network ESPON, Luxembourg.
http://www.espon.eu/mmp/online/website/content/projects/259/648/file_1174/fr-1.1.1_revised-full.pdf. Access: 07.05.2007.
- ESPON (2009); Territorial Dynamics in Europe-Trends in Accessibility.
<http://www.espon.eu/export/sites/default/Documents/Publications/TerritorialObservations/TrendsInAccessibility/to-no2.pdf>. Access: 12.2.2011.
- Eurostat (2011): Employment and GDP.
http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database.
 Access: 24.5.2011.
- 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*, October 2005, 26, Issue:48-51.
- Friedmann, John (1986) The world city hypothesis. In: *Development and Change*. 17, 69-83.
- Hall, Peter, and Kathy Pain (2006) *The Polycentric Metropolis. Learning from Mega-City Regions in Europe*. London: Earthscan.
- Hansen, W.G. (1959) How accessibility shapes land use. In: *Journal of American Institute of Planners*. 25, 1:73-76.
- Hoover, Edgar M. (1937) *Location Theory and the Shoe and Leather Industries*. Cambridge, MA: Harvard University Press.
- Howells, Jeremy (2000) Knowledge, innovation and location. In: John R. Bryson, Peter W. Daniels, Nick Henry and Jane Pollard (eds.), *Knowledge, Space, Economy*, London, New York: Routledge, 50-62.
- Hoyler, Michael (2011) German cities. In: Peter J. Taylor, Pengfai Ni, Ben Derudder, Michael Hoyler, Jin Huang and Frank Witlox (eds.), *Global urban analysis. A survey of cities in globalization*, London: Earthscan, 224-230.
- Hoyler, Michael, Tim Freytag, and Christoph Mager (2008) Connecting Rhine-Main: The Production of Multi-Scalar Polycentricities through Knowledge-Intensive Business Services. In: *Regional Studies*. 42, 8:1095-1111.
- Jaffe, Adam B., Manuel Trajtenberg, and Rebecca Henderson (1993) Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations. In: *The Quarterly Journal of Economics*. 108, 577-598.
- Kujath, Hans Joachim (2005) Die neue Rolle der Metropolregionen in der Wissensökonomie. In: Hans Joachim Kujath (eds.), *Knoten im Netz*, Münster: Lit Verlag, 23-63.

- Kujath, Hans Joachim, and Axel Stein (2009) Rekonfigurierung des Raumes in der Wissensgesellschaft. In: Raumforschung und Raumordnung. heft 5/6, 67. Jahrgang:369-382.
- Kujath, Hans Joachim, and Suntje Schmidt (2007) Wissensökonomie und die Entwicklung von Städtesystemen. Working Paper. Erkner b. Berlin: Leibnitz Institut für Regionalentwicklung und Strukturplanung.
- Lüthi, Stefan, Alain Thierstein, and Michael Bentlage (2011) Interlocking Firm Networks in the German Knowledge Economy. On Local Networks and Global Connectivity. In: Raumforschung und Raumordnung. (in print),
- Lüthi, Stefan, Alain Thierstein, and Viktor Goebel (2010) Intra-firm and extra-firm linkages in the knowledge economy: the case of the emerging mega-city region of Munich. In: Global Networks. 10, 1:114-137.
- Maillat, Denis, Michel Quévit, and Lanfranco Senn (1993) Réseaux d'innovation et milieux innovateurs. In: Denis Maillat, Michel Quévit and Lanfranco Senn (eds.), Réseaux d'innovation et milieux innovateurs: un pari pour le développement régional, Neuchâtel: EDES, 3-12.
- Malecki, Edward J. (2000) Creating and Sustaining Competitiveness. Local Knowledge and Economic Geography. In: John Bryson, Peter Daniels, Nick Henry and Jane Pollard (eds.), Knowledge, Space, Economy, London, New York: 103-119.
- Marshall, Alfred (1920) Principles of Economics, Chapter 10 - Industrial Organization, Continued. The Concentration of Specialized Industries in Particular Localities. 8, London: Macmillian and Co.
- Musil, Robert (2009) Global capital control and city hierarchies: an attempt to reposition Vienna in a world city network. In: Cities. 26, 5:255-265.
- OECD (1996): The knowledge-based economy. <http://www.oecd.org/dataoecd/51/8/1913021.pdf>. Access: 30.04.2011.
- 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.
- Openshaw, Stan (1984) The Modifiable Areal Unit Problem. Concepts and Techniques in Modern Geography, 38/Newcastle:
- Picot, Arnold, Ralf Reichwald, and Rolf Wigand (2008) Information, Organization and Management. Heidelberg: Springer-Verlag.
- Polanyi, Michael (1967) The tacit dimension. London: Loutledge & Kegan Paul.
- Sassen, Saskia (1994) Cities in a World Economy. Thousand Oaks: Pine Forge Press.
- Sassen, Saskia (2001) The Global City: New York, London, Tokyo. 2, Oxford: Princeton University Press.
- Schamp, Eike W. (2003) Knowledge, Innovation and Funding in Spatial Context: The Case of Germany. In: Alain Thierstein and Eike W. Schamp (eds.), Innovation, Finance and

- Space, Frankfurt: Selbstverlag Institut für Wirtschafts- und Sozialgeografie der Johann Wolfgang Goethe Universität, 179-193.
- Simmie, James (2003) Innovation and Urban Regions as National and International Nodes for the Transfer and Sharing of Knowledge. In: *Regional Studies*. 37, 6:607-620.
- Sokol, Martin, Chris van Egeraat, and Brendan Williams (2008) Revisiting the 'Informational City': Space of Flows, Polycentricity and the Geography of Knowledge-Intensive Business Services in the Emerging Global City-Region of Dublin. In: *Regional Studies*. 42, 8:1133–1146.
- Sturgeon, Timothy, Johannes Biesebroeck van, and Gary Gereffi (2008) Value chains, networks and clusters: reframing the global automotive industry. In: *Journal of Economic Geography*. 8:297-321.
- 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. In: <http://www.lboro.ac.uk/gawc/guide.html>, 14.05.2010.
- Thierstein, Alain (2003) Financial places, regional production system, and the gap to bridge: considerations for a research agenda. In: Alain Thierstein and E.W. Schamp (eds.), *Innovation, Finance and Space*, Frankfurt: Selbstverlag Institut für Wirtschafts- und Sozialgeografie der Johann Wolfgang Goethe Universität, 197-214.
- Thierstein, Alain, Christian Kruse, Lars Glanzmann, Simone Gabi, and Nathalie Grillon (2006) *Raumentwicklung im Verborgenen. Untersuchungen und Handlungsfelder für die Entwicklung der Metropolregion Nordschweiz*. Zürich: NZZ Buchverlag.
- Thierstein, Alain, Stefan Lüthi, Christian Kruse, Simone Gabi, and Lars 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. In: *Regional Studies*. 42, 8:1113-1131.
- Thierstein, Alain, Viktor Goebel, and Stefan Lüthi (2007) *Standortverflechtungen der Metropolregion München. Über Konnektivität in der Wissensökonomie*. Lehrstuhl für Raumentwicklung, TU München, München.
- Torre, André, and Alain Rallet (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.
- World Bank (2011): Growth rates. <http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG/countries>. Access: 17.5.2011