EUROPEAN JOURNAL OF SPATIAL DEVELOPMENT

The European Journal of Spatial Development is published by Nordregio, Nordic Centre for Spatial Development and OTB Research Institute, Delft University of Technology

ISSN 1650-9544

Publication details, including instructions for authors: www.nordregio.se/EJSD

Human capital in the German urban system – Patterns of concentration and specialisation

Online Publication Date: 18 August 2010

To cite this article: Growe, Anna, "Human capital in the German urban system – patterns of concentration and specialisation", refereed article, August, 2010, *European Journal of Spatial Development.*

URL: http://www.nordregio.se/EJSD/refereed40.pdf

Human capital in the German urban system – patterns of concentration and specialisation[1]

Anna Growe

Contact details: Department of Spatial Planning at the Federal and Regional Levels, Faculty of Spatial Planning, TU Dortmund, D-44221 Dortmund. Phone: +49 (0) 231 755-2377, Fax: +49 (0) 231 755-4877.

E-mail address: anna.growe@tu-dortmund.de

Abstract

In the knowledge economy human capital plays a crucial role in various economic processes and thus also in spatial development. But human capital is an economic resource that is distributed unequally in space. Some regions show a higher density of human capital than others. This paper discusses questions relating to the spatial concentration and specialisation of human capital in the German urban system. Due to an increasing interest in human capital the questions are asked, where is human capital located in the German urban system and how does the distribution change over time. The paper relates to geographical theories of concentration and specialisation. It will be shown that human capital is a heterogeneous category containing different occupational groups showing different spatial patterns. Some display increasing spatial disparities; others are fairly balanced over space.

Keywords: urban system, human capital, Germany, knowledge economy, metropolitan regions

Introduction: Human Capital and the Development of Urban Systems

This article discusses the spatial consequences of the structural change within economic processes which sees a move towards knowledge-intensive activities. Recent theories of spatial development assume that a strong connection exists between these structural economic changes and the development of city-systems. The globalisation of economic processes, especially the increasing internationalisation of labour-divided processes, leads to new organisational forms of spatial development on the national, European and global scales (Friedmann 1986; Sassen 1991; Taylor 2004). The possibility of participation in these new globally interconnected economic processes is closely linked to the expansion

[1] The author wishes to thank two anonymous referees for their helpful comments on this paper. Financial support from the German Research Foundation (*Deutsche Forschungsgemeinschaft, Projekt BL 163/6-1*) is gratefully acknowledged. A different version of this paper has previously been published under the title "Concentration of knowledge-based professions in the German city-system" in: Schrenk, M.; Popovich, V.; Engelke, D.; Elisei, P. (Ed.): REAL CORP 2009: CITIES 3.0 - Smart, Sustainable, Integrative. Strategies, concepts and technologies for planning the urban future, pp. 59-72.

of knowledge-based work. Globally integrated economic activities require controlling and coordination at different scales (Sassen 1991; Kujath 2009). Consequently the existence of knowledge and the need to generate new knowledge are important elements in ensuring economic success.

In this context it is important to make a distinction between two types of knowledge: implicit and codified knowledge (Polanyi 1967). All new knowledge arises as implicit knowledge. It is a personalised type of knowledge and is based on practical experience and specific know-how (Krätke 2010: 84). Though implicit knowledge is embodied in people and organisations and can only be shared by personal interaction, human capital is one crucial resource for the knowledge economy (Amin, Cohendet 2004). The increasing importance of knowledge therefore leads to the emergence of two key issues: a concomitant increase in the importance of human capital and a similar increase in the importance of personal exchange. From a geographical perspective these developments should be analysed in items of their spatial consequences, e.g. their consequences for the development of urban systems.

Previous analysis of urban systems has in the main focused upon the spatial concentration of functions and economic activities within the urban system. This perspective has its origin in the theory of central places by Christaller (1933) and tries to identify hierarchies of cities within the urban system. Central place theory is primarily used as a framework for understanding the location of retailing activities and public services. The hierarchical patters that evolve are explained by the spatial distribution of demand. The central place theory of Christaller (1933) was further advanced by Lösch (1962). He showed that a dispersed pattern of demand leads to a dispersed pattern of supply. The latter is dependent on the interaction of economies of scale and on transport costs.

Parr, Budd (2000: 594) emphasise that these theories face some difficulties while attempting to explain recent urban system developments as the economic structure of cities is now strongly influenced by intermediate services. These services also contain about 34% of knowledge-intensive professions (Hall 2007: 12). For firms acting in intermediate services input features, e.g. knowledge as a production factor, are crucial. Parr, Budd (2000: 594) point out that in the case of financial services, as an example of intermediate services, input factors and thus costs, in respect of the provision of services, vary substantially. The development of the urban system in the knowledge-based economy is therefore strongly influenced by the existence of non-ubiquitous input factors like human capital.

The understanding of an urban network of economically linked cities with hubs of different importance is also discussed by Jacobs (1970). She stressed the importance of a functional perspective and argues that the optimal utilisation of urban structures is linked to the optimum degree of urban functional diversification. If a city is not widely diversified it will decline. As theoretical approaches based on Jacobs' assumptions stress the necessity of functional diversification and focus on urbanisation effects (also called 'Jacobian diversification externalities'), other theories focus on functional specialisation (Marshallian specialisation externalities). The question of which externalities favour

regional innovativeness and therefore shape urban systems in a knowledge-based economy remains however unanswered.

Stein (2003) pointed out that the economic specialisation of cities no longer sees the main differentiation occurring between industrial and service activities. With the increasing importance of knowledge factor in all economic processes economic activity can now be differentiated in line with the way in which knowledge (e.g. creating new knowledge or transforming knowledge) is used. Research on urban systems has thus highlighted processes of functional concentration and specialisation in cities and agglomerations. Duranton and Puga (2005) argue that a new functional labour division between cities emerges as a consequence of economic globalisation. This labour division is influenced by economic clusters across traditional economic sectors. Production sites might be relocated in peripheral regions whereas management functions concentrate within cities. The model assumes spatial specialisation on knowledge-based innovative activities in cities. Knowledge-based clusters might develop within cities and lead to a spatial specialisation of professions.

Malmberg and Maskell (2002) explain the existence of spatial clusters through processes of learning and innovation, both processes that are of particular importance within the knowledge-based economy. For Malmberg and Maskell (2002) learning processes are based on imitation and on knowledge spillover between competitors. Therefore economic actors need to observe their competitors carefully. Spatial and cognitive proximity are the supporting conditions for the fulfilment of that need. These assumptions support the expectation of increasing functional specialisation.

The increasing importance of human capital brings to prominence the question of where human capital tends to concentrate and how spatial patterns of human capital change over time. First of all, human capital is not an equally distributed resource. Theories of agglomeration suggest that, due to positive agglomeration externalities, economic resources can be used more efficiently in spaces of high density (Glaeser 2003). Cities as such work as “random generators” of contacts, information and opportunities (Läpple 2004). In consequence the level of risk associated with various working processes is reduced. A large number of studies also mention that the productivity of human capital rises according to spatial density (Moretti 2004; Lehmer and Möller 2008). Therefore the existence of human capital in agglomerations enhances the attractiveness of those agglomerations to additional human capital resources which then seek to relocate towards the agglomeration in question. Möller and Haas (2003) conclude that talented, motivated and well-educated individuals might be able to benefit more from agglomeration advantages than other workers. Therefore agglomerations might develop as “sticky places” for human capital (Markusen 1996).

The necessity of personal interaction, often in the form of face-to-face-interaction, leads to a gradual spatiotemporal process of knowledge diffusion. For this reason significant spatial disparities in the distribution of human capital can be expected (Camagni 1991; Maillait 1995). In conjunction with the necessity of the personal interaction of human capital to produce and to use knowledge, the possibility of interaction in agglomerations

has also to be differentiated (Malmberg and Maskell 2002). Agglomeration theories estimate that not only the concentration of human capital in general (functional diversification) but also the concentration of specific knowledge workers is crucial for interaction processes and therefore for the attractiveness of a city or a city-region to attract more human capital in respect of certain professions (Gertler 1995; Schamp 1996; Storper 1997; Bathelt 2000). Numerous unanswered questions nevertheless remain with regard to the ways in which new forms of spatial-functional labour division develop in the knowledge-based urban system (Kujath, Schmidt 2007: 2).

This paper seeks to interpret empirical findings about concentration processes of human capital within the German urban system in conjunction with the following research questions on the spatial patterns of human capital and the labour division:

1. Where are knowledge-based professions located and which professions show similar or different patterns of concentration?
2. Do all agglomerations show similar patterns of functional specialisation or do these patterns of labour division vary by functional specialisation.

The paper is structured into four main parts. In the introduction theoretical approaches about the role of human capital for the development of regional economies are highlighted. Two research questions were then derived from these approaches. The second section discusses methodological issues such as the definition of knowledge-based professions and the study area in which concentration processes are to be analysed. The third part of the paper presents the results of the analyses of spatial patterns and their change over time in light of the initial research questions. Finally, the paper concludes by synthesising the main findings and proposing a focus for further research.

Data

The data used in this paper has been extracted from a data-set provided by the Federal Employment Office in Germany (*Bundesagentur für Arbeit, BA*). This data includes all workers obliged to pay social insurance contributions and represents about 75% of the total workforce. Not included are civil servants, marginal employed persons, students enrolled in higher education, workers under apprenticeship, volunteers, and family workers. The data-set contains all persons who were employed on 30 June each year. As this study is interested in the development of spatial patterns in the German urban system and aims to include the development in the eastern part of Germany, only data since reunification has been used. Since an inevitable period of statistical adaptation was necessary the analysis covers the period 1997-2007. Of course a period as short as this cannot provide strong evidence for the development path of the different agglomerations but the various tendencies in respect of development can be discussed. Additional research on changes over a longer time horizon will be discussed in the conclusions section.

In this analysis workers will be differentiated by their profession (*Sozial-versicherungspflichtig Beschäftigte nach Berufsordnungen*) according to the classification of professions of 1988 (*KldB 88 BA*). The classification of workers by their profession depends on the current type of activities that are performed and not on recent

activities or on qualification. This classification enables conclusions to be made about functional spatial patterns.

The professions analysed in this paper have been selected based on the identification of occupational groups with a high share of activity in knowledge-based services and research intensive industries by Hall (2007). These occupational groups are as follows; engineers, technicians, IT-professions, scientists, management and consulting professions as well as those in the arts, media, and communications. Suitable professions had been chosen for this study on the basis of two digit occupational groups, categorised by KldB 88 BA:

- engineers (60, 61)
- technicians (62)
- finance and insurance professions (69)
- management and consulting (75)
- calculation and data processing employees (77)
- legal professions (81)
- media and communications (82)
- artists (83)
- scientists (88)

Two exceptions here include ‘advertising specialists’ and ‘estate agents’ both of which are professions within the two digit category ‘other service professions’ (70). ‘Advertising specialists’ (703) have been added to ‘artists’ while ‘estate agents’ (704) have been added to ‘finance and insurance professions’. As a regional reference the place of work principle instead of the place of residence principle has been chosen. Therefore the data refers to the location of the firm, not to the residence of the employee. This is an advantage here because the paper is interested in concentration and specialisation processes with implications for labour processes and not in living conditions.

In order to differentiate between types of regions (RT) this study uses a classification scheme promoted by the Federal Office for Building and Regional Planning (*Bundesanstalt für Bauwesen und Raumordnung, BBR*) from 2006. This scheme distinguishes between nine types of regions at NUTS-3 level (counties in Germany). The classification scheme distinguishes between areas with large agglomerations, areas with conurbation features and areas of rural character. Within those areas comprising large agglomerations, metropolitan core cities (RT1), highly urbanised districts (RT2) in the surroundings of those cities, urbanised districts (RT3) and rural districts (RT4) are differentiated. The second category contains central cities (RT5) in regions with intermediate agglomerations, their urbanised surroundings (RT6) and rural districts (RT7). In the regions of rural character a differentiation between urbanised districts (RT8) and rural districts (RT9) is made.[2]

[2] A regional classification scheme can be found in the Appendix.

The second part of the analyses focuses on agglomerations within the German urban system. In this study agglomerations relate to large areas with a dense population. In that context only aggregations of RT1, RT2, and RT3 (delimited by the black line in the following illustration) are considered and compared.

Spatial patterns of human capital in the German urban system

In order to address the question of the spatial concentration of human capital in the German urban system the location of different knowledge-based professions will be analysed. Firstly, the question of whether human capital is concentrated in agglomerations will be asked and this will be followed by a supplementary question on whether concentration patterns differ between knowledge-based professions.
The distribution of occupants, measured in absolute numbers, obviously prefers administrative units with a higher number of occupants. To eliminate this 'size effect' and to capture information about structural deviations it is useful to compare spatial patterns of location quotients (LQ). The LQ is based upon a calculated ratio between the local economy and the economy of some reference unit. In this analysis, the share of one knowledge-based profession in a part of the reference area is viewed in relation to the share of the knowledge-based profession in the reference area. Therefore the LQ is a parameter for structural deviations of a smaller area in comparison to the reference area.[3]

A value of 1 for the LQ indicates an equal share of the knowledge-based professions in the smaller area as in the reference area. A higher value shows that the share of human capital in part of the reference area is larger than in the reference area itself. A value lower than 1 here indicates a share that is smaller than in the reference area. The minimum of the LQ value is 0 while the maximum is infinite.

Figures 1 and 2 show LQ values for the two examples of 'engineers' and 'legal professions'. Dark colourings show an above average structure of the respective occupational category. Gray and white colourings show a below average structure for the respective occupational category. Comparing these visible spatial patterns it becomes clear that not all knowledge-based professions are equally located above the average in Germany.

[3] Put formally this is noted as

$$LQ = \frac{b_{tf}}{B_f} : \frac{B_t}{B}$$

where b_{tf} is the number of occupants of a certain profession t in region f. The variable B_f is the number or all occupants in region f. The number of occupants of profession t in the reference area is put as B_t and B is the number of all occupants in the reference area.

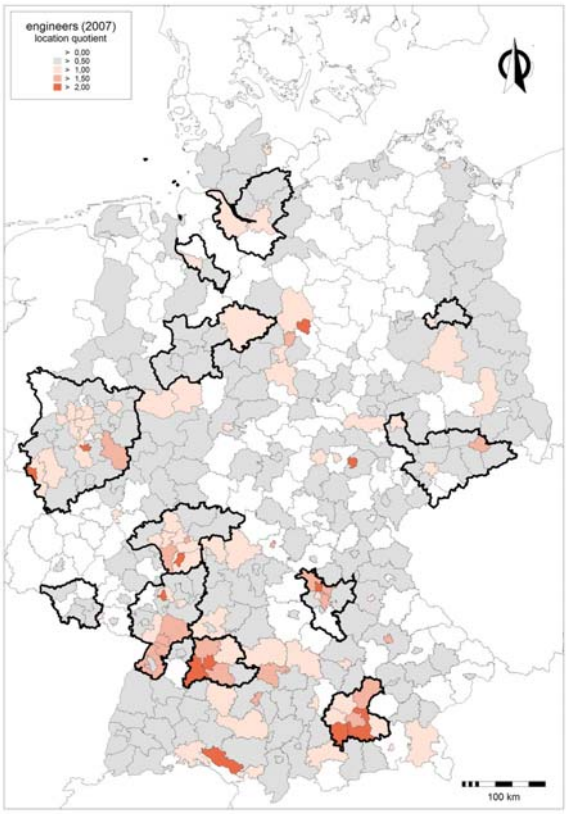

Fig. 1: Location quotient of ‘engineers’ (2007); own calculation.

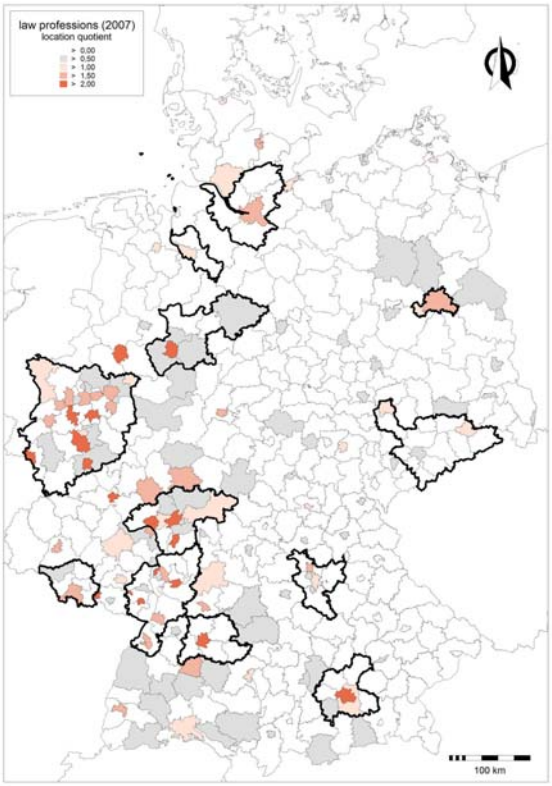

Fig 2. Location quotient of ‘legal professions’ (2007); own calculation.

First of all, both examples show an unequal distribution of employees in Germany. Second, patterns of distribution differ between knowledge-based professions. 'Engineers' are concentrated mostly in the southern part of Germany, especially in agglomerations. 'Law professions' are concentrated mostly in southern and western parts of Germany with a huge affinity towards core cities within agglomerations (RT1).

Tab. 1: LQ values for knowledge-based professions (2007); own calculation.

Occupational category	RT1	RT2	RT3	RT4	RT5	RT6	RT7	RT8	RT9
engineers	1.32	1.18	0.84	0.65	1.12	0.79	0.63	0.65	0.43
technicians	1.09	1.17	0.91	0.73	1.02	0.94	0.87	0.90	0.67
finance and insurance	1.54	0.85	0.71	0.53	1.06	0.72	0.64	0.77	0.64
management and consulting	1.34	1.11	0.86	0.78	0.96	0.77	0.68	0.75	0.67
calculation and data processing	1.40	1.18	0.77	0.72	1.06	0.71	0.59	0.63	0.56
legal professions	2.11	0.54	0.47	0.40	1.16	0.49	0.29	0.40	0.28
media and communications	1.76	0.86	0.46	0.52	1.35	0.55	0.38	0.51	0.47
artists	1.73	0.85	0.59	0.59	1.20	0.57	0.42	0.60	0.52
scientists	1.57	0.84	0.63	0.49	1.42	0.80	0.44	0.53	0.42

This raises the question of whether some professions are more highly concentrated than others or if, simply put, all patterns are different. To indentify agglomeration-orientated professions, patterns of concentration are compared by LQ values. Figure 3 shows LQ values for each occupational category (for values see tab. 1). The colours in the illustration represent different types of region, reference area is Germany. It can be seen that most knowledge-based professions are overrepresented in core cities (RT1, RT5) and highly urbanised districts (RT2) but not in rural areas (RT4, RT7, RT8, RT9).

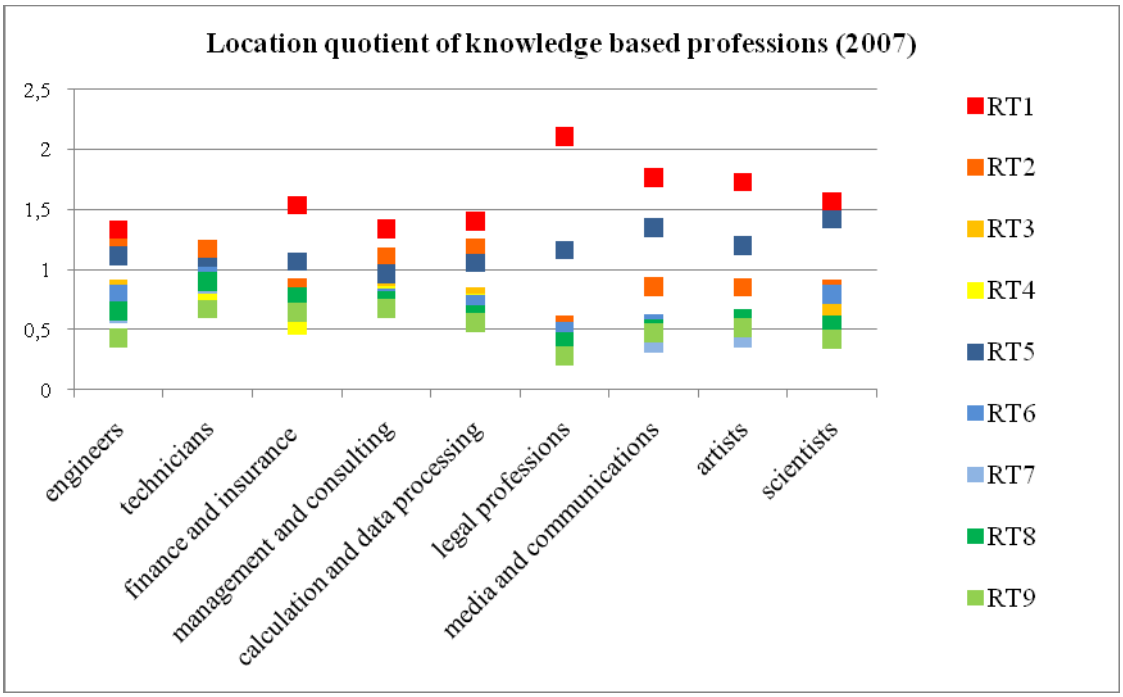

Fig. 3: Spatial affinity of human capital (2007); own calculation.

One question that has been raised in this paper is the location of knowledge-based professions. The figure above suggests that knowledge-based professions are concentrated mostly in cities and agglomerations. Only one professional category does not show an explicit above average concentration in agglomerations and urbanised areas: 'technicians'. The small number of occupational categories with no spatial affinity to agglomerations and core cities can be explained by the criteria used for the selection the professions. As an intensive use of knowledge has been a criteria for choosing the professions and an intensive use of knowledge is suggested to be easier in agglomerations and core cities (Moretti 2004; Glaeser 2003), a spatial affinity of the selected professions to agglomerations and cities might have been expected.

But not all knowledge-based professions concentrate equally within cities and agglomerations. Based on figure 3 a division into three main groups is suggested:

- professions with an affinity to agglomerations,
- professions with an affinity to core cities in general, and
- professions with an affinity to core cities in agglomerations.

The first group concentrates mostly in core cities and highly urbanised districts in regions with large agglomerations (RT1 and RT2). That group contains 'engineers', 'management and consulting professions' and 'calculation and data processing professions'. For the first group a location in agglomerated areas in general is important. It is less important to be located in core cities but there has also to be a spatial proximity to core cities.

The second group concentrates mostly in core and central cities (RT1 and RT5). The professions 'media and communication professions' and 'scientists' belong to this group. For these professions it is more important to have an urban catchment than to be located in huge agglomerations. However, these professions can also be found in agglomerations. Professions of the third group are closely related to those in the second group. They also concentrate mostly in cities (RT1). The third group clearly comprises the category 'law professions'. But 'finance and insurance professions' and 'artists' can also be viewed as being part of this group. For this group it is important to be located in cities, as the second important region type are not highly urbanised districts (RT2) but central cities (RT5). But they are noticeably more concentrated in core cities (RT1) than in central cities (RT2). It seems that for these professions an urban catchment in general in not sufficient. They have to be explicitly located in the centres of huge agglomerations.

However, these groups do not develop independently of each other but instead can often depend on each other. In this case different spatial affinities can hint at the spatial demands of the different professions in respect of their work environments. For example 'law professions' and 'finance and insurance professions' concentrate mainly in the centres of agglomerations. Closely connected to these services are 'calculation and data processing professions', but that occupational category also concentrates in highly urbanised districts, next to metropolitan core cities. A possible explanation for this could be that, on the one hand, both services depend on each other as a clients or service providers and therefore prefer a certain spatial proximity. But on the other hand, the

spatial demands of the legal or financial and insurance service professions may be rather more concerned with representativeness and accessibility whereas calculation and data services may simply look for reasonably priced sites.

The first part of the analysis undertaken here focused on spatial patterns of concentration in Germany. Concentration can also be understood as a process. The next section of the paper discusses changes in concentration. To compare the concentration of human capital in the German urban system the Hirschman-Herfindahl index (HHI) is used. This index is a measure used within economic theory to measure market concentration. The HHI measures absolute concentration and is calculated by adding the squares of firms' market shares in per cent. The strength of the HHI compared to other measures of concentration is that the index gives a more complete picture by including the information of shares of all the actors on the market and the weights according to their relative size. For the purposes of this chapter the market share of a firm is understood as the regional share of employees within each occupational category.[4]

Tab. 2: HHI values for knowledge-based professions (1997 and 2007); own calculation.

Occupational category	**HHI 1997**	**HHI 2007**
engineers	115.61	110.20
technicians	78.10	71.65
finance and insurance	153.20	168.11
management and consulting	107.66	125.65
calculation and data processing	124.37	126.78
legal professions	207.80	291.25
media and communications	246.20	260.20
artists	185.93	221.90
scientists	174.26	179.96

Figure 4 shows the change in HHI values (see also tab. 2) for all occupational categories from 1997 to 2007. The higher the value, the more concentrated this occupational category is. It becomes obvious, that the occupational categories do not only show different spatial patterns of concentration but also a different development of concentration over the decade. We do however find one category that is clearly least concentrated and may even be said to be decreasing in concentration ('technicians'). In addition this category does not show any spatial affinity towards either agglomerations or core cities (see above). We can also see a group of three rather similarly concentrated categories, namely, 'engineers', 'management and consulting professions' and 'calculation and data processing professions'. On the basis of LQ values they correspond

[4] Put formally this is noted as

$$HHI = \sum_{j=1}^{n} s_j^2$$

where s_j is the share of region j of employees, measured in percentage points. The minimum of the HHI value is $\frac{1}{n}$ where n in the number of regions (n= 439) and the maximum of the HHI value is 10,000 corresponding to a pure monopoly.

to the first group. These three groups of professions show a spatial affinity towards agglomerations and are more concentrated in Germany than ‘technicians’ which do not show a distinctive spatial affinity towards agglomerations or core cities. Furthermore there are five occupational categories that can be seen as most concentrated. These categories refer to the second and the third group (based on LQ values), which means they show a spatial affinity for cities (mainly RT1 or RT1 and RT5). Interestingly these categories are not only the most concentrated. They even display an increase in the HHI value (increase in spatial concentration).

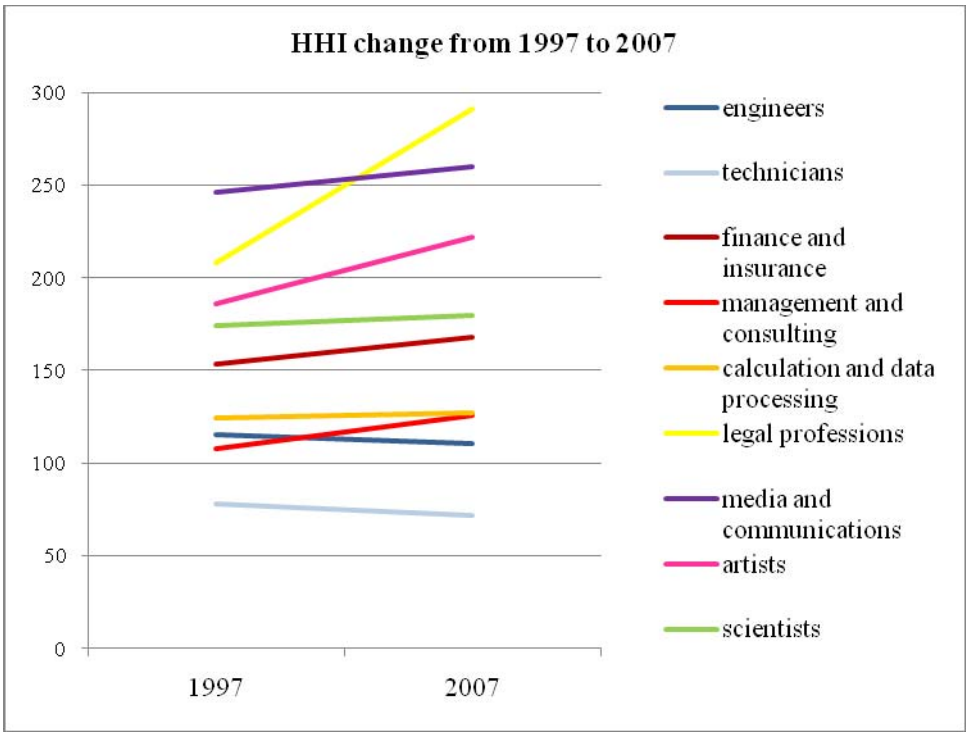

Fig. 4: Change in HHI value of professions from 1997 to 2007; own calculation.

‘Legal professions’ are the occupational category with the highest increase in spatial concentration. They are also the occupational category that is concentrated most in only one region type: core cities within agglomerations (RT1, see fig. 3). The second highest increase in HHI values can be found with the category ‘artists’, which is also an occupational category with an affinity to core cities (RT1, see fig. 3). This may hint at the fact that professions that show a distinctive affinity to cities tend to concentrate even more within cities. One reason for this development might be the explicit need by these professions for urban externalities.

Functional labour division in the urban system

The first part of this paper showed that some occupational categories show a spatial affinity to cities, some to agglomerations and some to neither. The second part of the paper discusses the question of labour division in the German urban system. The question was asked whether all agglomerations show similar patterns of functional specialisation or whether patterns of labour division through functional specialisation can be detected.

To discuss questions of functional specialisation in the German labour-divided urban system the concentration of human capital in different agglomerations was viewed in relation to the average level of human capital in Germany. Based on this calculation a surplus or deficit of functions – based on professions – can be detected.

The result of the analysis of labour division in the German urban system in 2007 is shown in figure 5. The map shows a circular chart for each agglomeration with segments for every profession. The parameter value of each chart segment is dependent on the LQ value of each profession in the specific agglomeration. The black circle in each agglomeration stands for the mean of the occupational categories, referring to Germany. Therefore a segment bigger than the circle represents a functional surplus and segments smaller than the circle represent a functional deficit in respect of the agglomeration in comparison with all German districts.

First of all, the map shows huge differences between the different agglomerations in Germany. Some agglomerations show a functional surplus for every profession (e.g. Munich) whereas other agglomerations show a functional deficit for all occupational categories (e.g. Saar). The entire functional importance of each agglomeration is shown in table 3. The values within this table are summed up LQ values and represent the size of the functional importance of each of the twelve German agglomerations. The five most important hubs within the German urban system concerning knowledge-based professions are Munich, Frankfurt, Berlin, Hamburg, and Stuttgart. As can be clearly seen there is a significant gap between Munich and the other agglomerations. The agglomerations with values above the arithmetic mean (cut-off value) are designated by the word ‘hub’.

Tab. 3: Functional strength of agglomerations, own calculation.

Agglomeration	Functional importance	Functional hub
Munich	17.93	hub
Frankfurt	13.63	hub
Berlin	13.58	hub
Hamburg	12.62	hub
Stuttgart	12.06	hub
Nuremberg	10.48	
Rhine-Neckar	10.41	
Rhine-Ruhr	9.81	
Bremen	9.08	
Leipzig - Dresden	8.80	
Bielefeld - Hannover	8.52	
Saar	7.21	

Not every agglomeration has to have strength across all functions. In respect of the question of labour division the functional strength of agglomerations has to be considered. Frankfurt shows a functional surplus for those professions dealing with financial functions, management and legal functions as well as supporting technical services. In contrast Berlin shows a functional surplus for professions dealing with

sciences, creative professions and legal services. Hamburg shows strength within the creative professions.

Other regions show specialised functional strength for professions that are important for research intensive industries ('engineers'). These agglomerations are Stuttgart and Nuremberg and they are located in the southern part of Germany. These findings confirm the important role of southern Germany as a distinctive region for technology and innovation, as Munich also has a functional surplus within this occupational group.
In order to distinguish between regions with a balanced functional surplus and regions with a specialised functional surplus the Hirschman-Herfindahl index (HHI) is used (see chapter 4). For the purposes of this chapter the market share of a firm is understood as the share of functional importance of each occupational category within each agglomeration.[5] Agglomerations with a high HHI value are structured by a concentration of functional strength and therefore are characterised by a specialised functional surplus. Agglomerations with a low HHI value are structured by a more equal distribution of functional strength and are thus characterised by a balanced functional surplus. Table 4 also contains information about the functional importance of agglomerations (see tab. 3).

Tab. 4: HHI values of agglomerations depending on the share of functional importance by occupational categories, own calculation.

Agglomeration	HHI	Functional hub
Berlin	1265.1	hub
Frankfurt	1188.2	hub
Hamburg	1184.3	hub
Nuremberg	1182.7	
Stuttgart	1170.1	hub
Rhine-Neckar	1146.0	
Saar	1140.1	
Leipzig - Dresden	1138.4	
Munich	1138.3	hub
Rhine-Ruhr	1128.1	
Bremen	1126.3	
Bielefeld - Hannover	1117.0	

Table 4 provides some interesting findings. The most important functional hubs in the German urban system are (with one exception) characterised by specialised functional surpluses. Berlin, Frankfurt, Hamburg, and Stuttgart show high HHI values and also have high values in respect of functional importance. Nuremberg and Rhine-Neckar show a

[5] Put formally this is noted as

$$HHI = \sum_{i=1}^{n} s_i^2$$

where s_i is the share of the functional strength of one profession i in each agglomeration, measured in percentage points. The functional strength of one occupational category is represented by the LQ value. The minimum of the HHI value is $\frac{1}{n}$ where n in the number of professions (n= 9) and the maximum of the HHI value is 10,000 corresponding to a pure monopoly.

distinctive strength in one occupational category (‘engineers’) and therefore are ranked middle in table 4. They are ranked slightly under the five important hubs in table 3. On the basis of these findings a differentiation between four groups of agglomerations is suggested:

Tab. 5: Functional importance and specialisation of agglomerations.

	Specialised functional surplus	**Balanced functional surplus**
High functional importance	Frankfurt, Berlin, Hamburg, Stuttgart	Munich
Small functional importance	Nuremberg, Rhine-Neckar	Rhine-Ruhr, Bremen, Leipzig-Dresden, Bielefeld-Hannover, Saar

Table 5 summarises the findings of tables 3 and 4 by intersecting the categories of strong and small functional importance with the categories of specialised and balanced functional surplus. The cut-off value of the functional importance is the arithmetic mean. The cut-off value for the functional surplus is the median value. These findings can be interpreted in the light of theories that point to the importance of functional specialisation (Duranton, Puga 2003). But on the other hand, the clearly most important functional hub within the German urban system is characterised by a mostly balanced functional surplus. These findings can be interpreted in the light of theories that focus on a functional mix in order to explain city growth (Jacobs 1970).

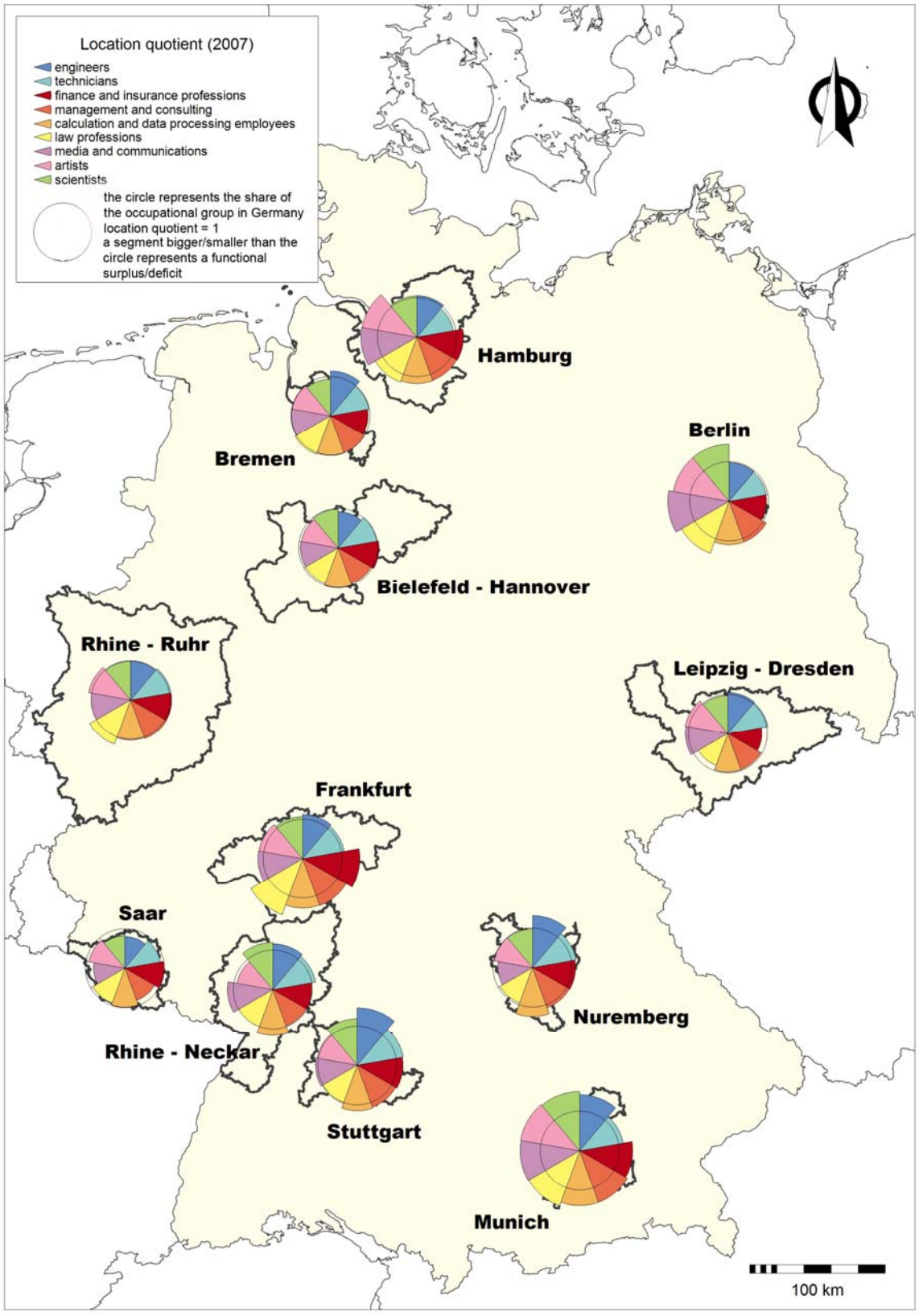

Fig. 5: Functional specialisation in the German urban system 2007; own calculation.

An initial notion of the importance of the specialisation and equalisation processes can be gained by comparing the inner functional differentiation of the five functional hubs (Munich, Frankfurt, Berlin, Hamburg, and Stuttgart) for 1997 and 2007 (fig. 6). Firstly we find an increase in functional specialisation within three agglomerations: Berlin, Frankfurt, and Stuttgart. Munich and Hamburg on the other hand show a slightly decreasing level of functional specialisation. The highest change (rise) of HHI value is showed by Berlin.

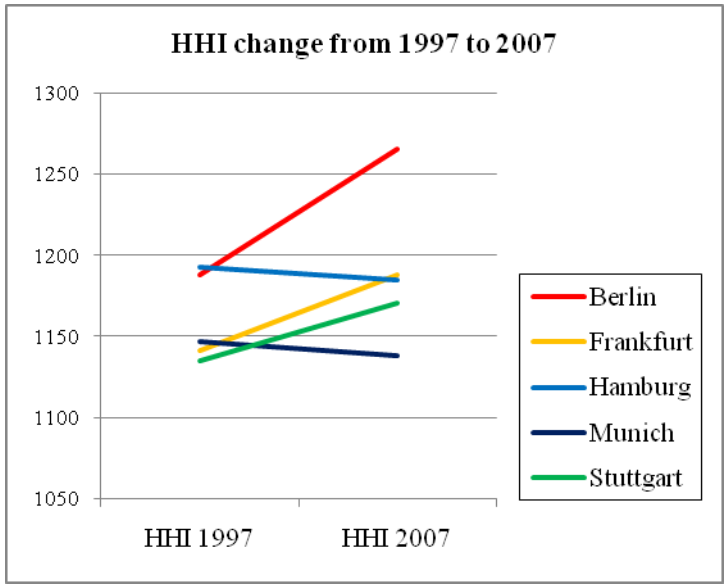

Fig. 6: Change in the HHI value of functional hubs from 1997 to 2007; own calculation.

According to theories of functional specialisation one might expect an increasing inner differentiation and a rise in the LQ values of the occupational categories that are the basis of the functional strength of each agglomeration. In the following, figure 6 is interpreted in the light of the individual agglomeration's functional emphasis. Munich, as an agglomeration with a balanced functional structure, is left out here. The other four hubs show a functional labour division. The strength of Stuttgart lies in its technical professions ('engineers'), the strength of Frankfurt is in financial, management, and legal functions. Berlin's strengths are sciences, creative and legal functions. Hamburg also shows strength within the creative functions area. Therefore Hamburg and Berlin show similar strength, whereas Frankfurt and Stuttgart show complementary strengths both toward each other and towards Berlin and Hamburg (fig. 5).

Bearing this functional strength in mind the increasing functional specialisation of Berlin, Frankfurt, and Stuttgart corresponds to their strength. The decline of inner functional specialisation in respect of Hamburg, moreover, may be caused by the significant increase of this very same functional strength in Berlin. This could then be interpreted as an illustration of the increasing labour division at the top of the polycentric German urban system.

Conclusion

In the knowledge economy human capital is a crucial resource for economic and thus for regional development. Human capital is understood as a carrier of implicit knowledge and therefore as important factor in the temporary creation of monopoly profits through the creation of new knowledge. As implicit knowledge can best be exchanged and developed by personal interaction in spaces of high density, agglomerations are more attractive for human capital than other regions. Based on the theoretical approaches outlined above two developments might occur: an increasing labour division on the basis of an increasing functional specialisation or the development of functional balanced hubs due to urbanisation externalities. The findings in this paper showed an influence of both processes on the development of the German urban system.

The primary issue discussed in this paper concerns spatial patterns of human capital. The question was thus posed, where are the knowledge-based professions located? This was followed up with a supplementary question on whether diverse professions show similar or different patterns of concentration. Based on LQ values different patterns of knowledge-based professions have been detected and diverse affinities towards cities and agglomerations in respect of each occupational category were highlighted. The division of knowledge-based occupational groups in relation to their spatial affinity into three main groups was then suggested:

- professions with an affinity to agglomerations,
- professions with an affinity to core cities in general,
- professions with an affinity to core cities in agglomerations.

Professions with affinity towards cities seem to increase their spatial concentration most. Professions with no spatial affinity increase spatial de-concentration. Therefore areas of high density are of high importance for the majority of knowledge-based professions. Professions with a more focussed concentration within cities have even increased their concentration.

The second issue discussed in this paper concerns the labour-divided urban system in Germany. The question was posed whether all agglomerations show similar patterns of functional specialisation and subsequently, whether patterns of labour division through functional specialisation could be detected.

Based on the data presented in this paper five important functional hubs within the German urban system have been identified. The most important hub (Munich) shows a balanced functional structure with the inner functional structure equalising slightly. The other four hubs are Frankfurt, Berlin, Hamburg, and Stuttgart. These hubs show complementary functional strength and their functional specialisation increases over time. Only Hamburg shows a decrease in specialisation. This development might be caused by the distinctive increase of Berlin’s specialisation over this period in the same functional areas. In consequence a further rise in the characteristic labour-division of the German urban system in favour of these agglomerations is to be expected.

Regional policy in Germany is strongly anchored within a tradition of targeting a balanced regional structure. The findings in respect of increasing labour division presented in this paper suggest that functional strength could be used as a starting point for the politics and planning associated with regional development. On the other hand the case of Munich shows that functionally balanced regions might also benefit if they provide strength within every function. This perhaps hints at the need for critical masses. Furthermore additional information on the dynamics of the overall situation could be gained by using data that is available over a longer time horizon. One disadvantage of this would be the expense of dropping agglomerations in the eastern part of Germany from that part of the analysis.

Agglomerations with distinctive functional strengths are often referred to as metropolitan regions. They are regarded as an important element of urban systems. As urban systems consist not only of hubs but also of the relations between them (Camagni 1993; Castells 1996), further research should focus not only on spatial patterns of functional concentration and specialisation but also on organisational interrelations, namely, the improvement of analytical approaches to urban network analysis.

In this context further focus on organisations may prove useful as they are the economic actors that create value on the basis of knowledge-based employees. Besides, in contrast to knowledge-based professions, such organisations might be located in more than one agglomeration or city. The sites of such organisations may therefore hint at the underlying functional networks (Taylor 2004; Hall and Pain 2006) and complement the image we already have of a labour divided urban system.

References

Amin, A.; Cohendet, P. (2004). Architectures of knowledge. Firms, capabilities, and communities. (Oxford, Oxford University Press).

Bathelt, H. (2000). ‘Räumliche Produktions- und Marktbeziehungen zwischen Globalisierung und Regionalisierung. Konzeptioneller Überblick und ausgewählte Beispiele’ [Spatial production and market relations between globalisation and regionalisation. Survey and examples], Berichte zur deutschen Landeskunde, 74, pp. 97-124.

Camagni, R. (1993). ‘From city hierarchy to city network: reflections about an emerging paradigm’, in: T. R. Lakshmanan; M. J. Beckmann (Eds.): Structure and change in the space economy. (Berlin, Springer), pp. 66–88.

Camagni, R. (Eds.) (1991). Innovation networks. Spatial perspectives, (London, Belhaven Press).

Castells, M. (1996). The information age: Economy, society and culture. (Malden, Blackwell Publishers).

Christaller, W. (1933). Die zentralen Orte in Süddeutschland. Eine ökonomisch-geographische Untersuchung über die Gesetzmäßigkeit der Verbreitung und Entwicklung der Siedlungen mit städtischen Funktionen [Central places in southern Germany. An economic-geographic survey about regularity of distribution and development of settlement with urban functions]. (Jena).

Duranton, G.; Puga, D. (2001). ‘Nursery cities: urban diversity, process innovation, and the life cycle of products’, The American Economic Review, 91, pp. 1454-1477.
Duranton, G.; Puga, D. (2005). ‘From sectoral to functional urban specialization’, Journal of Urban Economics, 57, pp. 343-370.
Friedmann, J. (1986). ‘The world city hypothesis’, Development and Change, 17, pp. 69–83.
Gertler, M. S. (1995). ‘“Being there”: Proximity, organization, and culture in the development of advanced manufacturing technologies’ Economic Geography, 71, pp. 1-26.
Glaeser, E. L. (2003). ‘The new economics of Urban and Regional Growth’, G. L. Clark et al. (Eds.), The Oxford handbook of economic geography. (Oxford, Oxford Univ. Press), pp. 83–98.
Hall, A. (2007). ‘Tätigkeiten und berufliche Anforderungen in wissensintensiven Berufen. Empirische Befunde auf Basis der BIBB/BAuA-Erwerbstätigenbefragung 2006. Studien zum deutschen Innovationssystem 3’ [Activities and requirements within knowledge-intensive professions. Empirical findings on the basis of the BIBB/BAuA-survey 2006. Studies of the German innovation system].
Hall, P.; Pain, K. (Eds.) (2006). The polycentric metropolis. Learning from mega-city regions in Europe. (London, Earthscan).
Jacobs, J. (1970). The economy of cities. (New York, Vintage Books).
Krätke, S. (2010). ‘Regional Knowledge Networks. A Network Analysis Approach to the Interlinking of Knowledge Resources’, European Urban and Regional Studies, 17, pp.83–97.
Kujath, H. J. (2009). ‘Leistungsfähigkeit von Metropolregionen in der Wissensökonomie - Die institutionentheoretische Sicht’ [Efficiency of metropolitan regions in the knowledge economy – A perspective of institutional theories], in: J. Knieling (Eds.), Metropolregionen. Innovation, Wettbewerb, Handlungsfähigkeit [Metropolitan regions. Innovation, competition, ability of action]. (Hannover, ARL), pp. 200–222.
Kujath, H. J.; Schmidt, S. (2007). ‘Wissensökonomie und die Entwicklung von Städtesystemen’ [The knowledge economy and the development of urban systems]. IRS Working Paper.
Läpple, D. (2004). ‘Thesen zu einer Renaissance der Stadt in der Wissensgesellschaft’ [Thesis of the cities’ renaissance in the knowledge society], in: N. Gestring (Eds.), Jahrbuch StadtRegion. Schwerpunkt Urbane Regionen [Yearbook cityregion. Urban regions]. (Opladen, Leske + Budrich), pp. 61–78.
Lehmer, F.; Möller, J. (2008). ‘Group-Specific Effects of Inter-regional Mobility on Earnings - A Microdata Analysis for Germany’, Regional Studies, 42, pp. 657–673.
Lösch, A. (1962). Die räumliche Ordnung der Wirtschaft [The spatial order of economy]. (Stuttgart, Fischer).
Malmberg, A.; Maskell, P. (2002). ‘The elusive concept of localization economies: towards a knowledge-based theory of spatial clustering’, Environment and Planning A, 34, pp. 429–449.
Markusen, A. (1996). ‘Sticky Places in Slippery Space: A Typology of Industrial Districts’, Economic Geography, 3, pp. 293-313.
Möller, J.; Haas, A. (2003). ‘The Agglomeration Wage Differential Reconsidered: An Investigation Using German Micro Data 1984-1997’, in: Bröcker, J.; Dohse, D.;

Soltwedel, R. (Eds.), Innovation clusters and interregional competition. (Berlin, Springer), pp. 182–217.
Moretti, E. (2004). ‘Human capital externalities in cities’, in: Henderson, J. V.; Thisse, J.-F. (Eds.): Handbook of Regional and Urban Economics. Cities and Geography. (Amsterdam, Elsevier), pp. 2243–2291.
Parr, John B.; Budd, Leslie (2000): ‘Financial Services and the Urban System: An Exploration’, Urban Studies, 37, pp. 593–610.
Polanyi, M. (1967). ‘The tacit dimension’. (London, Routledge & Kegan).
Sassen, S. (1991). ‘The global city’. New York, London, Tokyo. (Princeton, University Press).
Schamp, E. W. (1996). ‘Der Aufstieg von Frankfurt/Rhein-Main zur europäischen Metropolregion’ [The rise of Frankfurt/Rhine-Main towards a metropolitan region], Geographica Helvetica, 56, pp. 169-178.
Stein, R. (2003). ‘Economic Specialisation in Metropolitan Areas Revisited: Transactional Occupations in Hamburg’, Urban Studies, 40, pp. 2187–2205.
Storper, M. (1997). ‘Regional economies as relational assets’, in: R. Lee; J. Wills, (Eds.), Geographies of Economies (London, Arnold), pp. 248-258.
Taylor, P. J. (2004). ‘World city network. A global urban analysis’. (London, Routledge).

Anna Growe, born 1981, has worked as a Junior Research Assistant at the Dortmund University of Technology, Faculty of Spatial Planning since 2007. Since 2009 she has worked on a research project about the German labour-divided urban system. She studied Spatial Planning in Dortmund and Venice from 2000 – 2006.

Appendix

Tab. A1: Regional classification scheme.

Structural region type	Description of region type (BBR)	Region type
Regions with large agglomerations	Core cities	RT1
	Highly urbanised districts in regions with large agglomerations	RT2
	Urbanised districts in regions with large agglomerations	RT3
	Rural districts in regions with large agglomerations	RT4
Regions with features of conurbation	Central cities in regions with intermediate agglomerations	RT5
	Urbanised districts in regions with intermediate agglomerations	RT6
	Rural districts in regions with intermediate agglomerations	RT7
Regions of rural character	Urbanised districts in rural regions	RT8
	Rural districts in rural regions	RT9

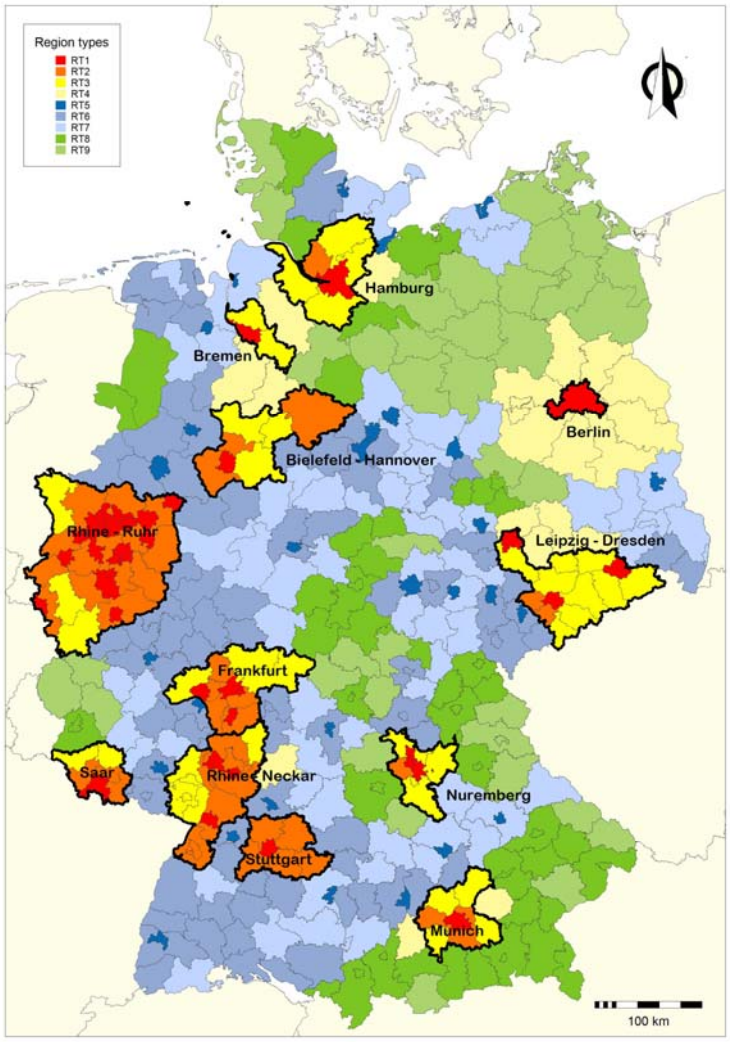

Fig. A1: Regional classification scheme.