WHERE DO KIBS WORKERS WORK IN GERMANY? SHIFTING PATTERNS OF KIBS EMPLOYMENT IN METROPOLES, REGIOPOLES AND INDUSTRIALISED HINTERLANDS

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With 2 figures and 5 tables
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Summary: In the years following reunification, the polycentric German urban system has undergone changes as regards the location of employees in knowledge-intensive business service (KIBS) professions. For the purposes of analysing functional spatial patterns, those spatial patterns exhibiting above-average increases or decreases in the numbers of employees within KIBS professions were identified on the basis of employment data. Correlations in the spatial affinities within service professions of differing compositions were mapped, leading to the identification of four patterns. Based on these patterns, spatial differentiation arising between the various services in the German urban system has been interpreted as functional specialisation. The basis of functional specialisation, with reference to the concept of knowledge bases, is differentiation into the following three service industries: technological services, consulting services and creative services.

Zusammenfassung: In den Jahren nach der Wiedervereinigung konnten im deutschen Städtesystem Veränderungen hinsichtlich der Verortung von Beschäftigten in wissensintensiven Dienstleistungen beobachtet werden. Um funktionale räumliche Muster zu analysieren werden in diesem Beitrag Räume mit überdurchschnittlichen Zu- bzw. Abnahmen der Beschäftigtenzahl in wissensintensiven Dienstleistungsberufen auf der Grundlage von Berufsdaten identifiziert. Zusammenhängende Raumaffinitäten unterschiedlicher Dienstleistungsberufe werden kartographisch dargestellt und zeigen vier Grundmuster der Veränderung. Auf der Grundlage dieser räumlichen Differenzierung wird die Herausbildung funktionaler Spezialisierung im deutschen Städtesystem diskutiert, wobei Dienstleistungen mit Hinblick auf das Wissensbasen-Konzept in drei Bereiche differenziert werden: technische Dienstleistungen, Beratungsdienstleistungen und kreative Dienstleistungen.

Keywords: Services, knowledge, Germany, urban system, occupation, concentration

1 Introduction

Our globalised economy has borne witness to an increase in the importance of knowledge within production processes, otherwise known as the 'knowledge economy'. The increasing importance of immaterial goods, such as knowledge, leads to changes in production processes and consequently to the formation of spatial structures. The aim of this paper is to explore changes in the German urban system on the basis of occupational data for knowledge-intensive business services.

Knowledge-intensive business services (KIBS) supply products which are themselves primary sources of information and knowledge, and use their specialised knowledge to produce services which facilitate their clients' activities. Consequently, KIBS are generally business-to-business services. Because they produce and deal with knowledge and information, KIBS are heavily reliant on professional expertise. As a result, their employment structures are weighted towards scientists, engineers, and other experts (Strambach 2008; Gallego and Maroto 2013). With their role of enabling and facilitating global economic processes, KIBS are seen to be at the core of the development of global cities. They are also reliant on a huge and differentiated labour market as well as accessible infrastructure (Sassen 2001; Hanssens et al. 2012).

In this context, the distinct structure of the German urban system raises the question of how KIBS develop in the polycentric urban system. Rather than a single prominent global city, the German urban system contains five to seven metropolitan regions with sectoral specialisation. The division of labour among the German metropolitan regions developed during the separation of East and West Germany as a consequence of relocating the economic functions outside of East Germany.

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A number of studies have dealt with the changes that have occurred within the German urban system since reunification (Blotevogel 2000; Klagge and Peter 2011; Hoyler 2011; Growe 2013; Lüthi et al. 2013; Growe and Volgmann 2015). With regard to regional economic development, Südekum (2006) concludes, "The main finding is that neither a general trend of regional specialisation nor one of geographical concentration can be observed" (Südekum 2006, 862). However, there are exceptions to this finding, "Only few modern sectors, notably service industries, have become more concentrated over recent years" (Südekum 2006, 862). In this context, it is significant that Südekum's analysis covered all the economic sectors.

Focusing on the service sector, Blotevogel (1998) used occupational data to identify sectoral specialisation in the German urban system for 1995. Kujath (2010) and Growe (2012b, 2012c) both analysed the post-reunification German urban system by focusing on KIBS as a subset of the service sector. The two studies diverged insofar as the type of systematisation used. Kujath differentiated services according to their use of knowledge in the production process (generation, exchange, and codification), whereas Growe applied the knowledge-base approach (analytical knowledge, synthetic knowledge, and symbolic knowledge). Both systematisations were applied prior to conducting the empirical work.

However, the explicit focus on the changes in KIBS in the post-reunification German urban system still leaves questions open. This paper discusses whether an overall process of increasing specialisation with regard to occupations in the post-reunification German urban system can be observed without the pre-sorting of occupations. KIBS constitute a highly heterogeneous sector and there is still no conclusive definition of occupations as belonging to the KIBS sector. Therefore, analysing changes in KIBS without pre-sorting occupations enables an understanding of correlating functions and of functions which develop an independent spatial pattern. This also allows conclusions to be drawn with regard to the cities that are included within the respective patterns.

The paper is organised as follows. Section 2 introduces the case study of the German urban system. Section 3 introduces KIBS as actors in the knowledge economy and presents theoretical assumptions about the locations of KIBS due to knowledge spillovers and cognitive proximity. Section 4 explains the data and methods used in the empirical analysis which follows in Section 5. In Section 6, the empirical results are interpreted on the basis of the knowledge-base approach.

2 The German urban system

The subject of this paper is the German urban system and changes within it. Unlike the French or English urban systems, the German urban system does not contain a large primate city. Instead, it has a polycentric structure of some 10–12 leading core cities with significant economic, political and cultural functions (Blotevogel 2000). However, these functions are not equally distributed among all cities; rather, they complement each other and lead to a division of labour in the urban system (Blotevogel 1998; Volgmann 2014; Growe and Volgmann 2015).

The origin of this structure dates back to the Middle Ages and continues to be reflected in the federal structure of Germany's political and administrative system (Blotevogel and Hommel 1980). In the aftermath of the Second World War, and the division of Germany and Berlin as its political sequel, the German urban system was also divided. Political/administrative and business functions were removed from West Berlin and relocated to a number of major regional centres in West Germany. Political functions were transferred to Bonn, while financial, business and air traffic functions became concentrated in Frankfurt. As a port city, Hamburg became a trade and maritime hub, while Munich developed into a centre for culture and insurance (Blotevogel 1998). In addition, the automobile and corresponding high-tech industries are located in southern Germany, particularly in the metropolitan regions of Munich and Stuttgart.

As a consequence of all these changes, West Germany's urban system developed a complex polycentric structure with complementary functional specialisation (Krätke 2002). By contrast, East Germany continued to be dominated by (East) Berlin, thereby acquiring a monocentric structure (Prigge and Schwarzer 2006).

3 Specialisation in the knowledge economy

The following section introduces KIBS as actors in the knowledge economy and present theoretical assumptions about the location of KIBS due to knowledge spillovers and cognitive proximity. However, it should be noted that KIBS are not the

only actors in the knowledge economy. Some authors also analyse high-tech industries and public actors as universities in the context of the knowledge economy (Strambach 2004; Thierstein 2006; Kujath 2010).

3.1 Knowledge-intensive business services

Intercity relations in an urban system, and changes within these relations, rely heavily on processes and on actors located in the cities, who work on these processes. KIBS are counted among these actors and carry out economic processes that deal with producing, exchanging and selling knowledge.

According to Castells (1996), knowledge has gained a fundamentally new importance in economic processes. This importance can be explained by the presence of actors dealing professionally with the creation, exchange and codification of knowledge. A heterogeneous intermediate group of actors, which produces business-to-business services, primarily information, consulting, and research and development, has come into being (Simmie and Strambach 2006; Strambach 2008; Kinder 2010).

A number of definitions of KIBS have emerged throughout the last decade (Gallego and Maroto 2013). These definitions are complementary in nature, as all of them stress their high proportion of expert labour (Miles et al. 1995; Windrum and Tomlinson 1999), their contribution to knowledge formation processes (den Hertog 2002; Toivonen 2004), and their potential facilitation of innovative changes as co-producers of innovation (Gallouj 2002).

Strambach (2008, 157) offers an approach that focuses on the production process. She points out three crucial aspects which actor-producing KIBS have in common:

- *Knowledge* is not simply an important factor of production; it is the (intangible) *commodity* that KIBS produce.
- The creation of KIBS requires *in-depth interaction* between suppliers and buyers, as KIBS are often created in cumulative learning processes.
- The output of KIBS consists primarily of consulting activities in the form of tailored problem-solving.

Both approaches demonstrate the importance of human resources and the customer service-provider relationship during the KIBS production process. They also indicate a huge range of activities, from advertising to management consultancy to software consultancy, that can be classified as KIBS. A consequence of the heterogeneity of KIBS is that they should not be analysed as one category, e.g. as one aggregated economic sector (Malerba 2007). In fact, for a differentiated analysis of KIBS, one of two possible perspectives must be chosen. A differentiated analysis can be made on the basis of corporate data (sectoral perspective) or on the basis of occupational data (functional perspective).

3.2 Specialisation of KIBS

Duranton and Puga (2005) argue that a new division of labour can be observed as a result of globalised production processes. This division is influenced by the differing levels of importance of transportation costs between the manufacturing and services industries. Accordingly, decreasing transportation costs have different consequences for choices of location for manufacturing firms, as compared with those which provide services (see also Leamer and Storper 2001). Transportation costs are more important for manufacturers than for service providers. However, even if transportation costs are low for service providers, the production of these services is based on complex interactions, and, therefore, transaction costs play a crucial role. Based on the analysis of Gaspar and Glaeser (1998) on the complementarity of ICT and face-to-face contacts, Duranton and Puga (2005) argue that great savings can be achieved if business services are concentrated in spatial agglomerations.

Duranton and Puga (2005) conclude that specialisation continues to influence the development of cities and urban systems. However, they define specialisation as function-dependent (e.g. management and control functions) rather than sector-dependent (e.g. automotive industry). The locations of manufacturing firms can be more easily transferred to small cities and due to lower land rents to surrounding regions. By contrast, management functions remain agglomerated in core cities. Thus, economic clusters evolve across traditional sectoral boundaries due to changes within the organisational structures of companies.

Although the model of Duranton and Puga (2005) is based on the US urban system, its applicability is not limited to this urban system. Duranton and Puga (2005, 347), referring to Bade et al. (2004), state that the results for the US urban system can also be confirmed for the German urban system in that study.

With regard to knowledge as a production factor, scholars still discuss whether sector-specific knowledge spillovers (Marshall 1890) or knowledge spillovers within a diversified environment (Jacobs 1970) generate more positive effects on regional economic growth (van der Panne and van Beer 2006). Recent literature, however, has introduced a differentiated view on the duality of specialisation and diversification. In order to realise and profit from knowledge exchanges, actors must be able to understand the exchanged contents with absorptive capacities (Cohen and Levinthal 1990; Nooteboom 2000; Nooteboom et al. 2007; von Einem 2011). Absorptive capacities rely on communalities in terms of technologies, knowledge bases and skills (Boschma and Iammarino 2009; Neffke et al. 2011). This hints at the differentiation of proximities, in particular the idea of cognitive proximity, introduced by Boschma (2005). In knowledge-sharing processes, the receiver must show a cognitive proximity enabling the adaptation of new knowledge.

Frenken et al. (2007) argue that complex and innovative goods are produced on the basis of related communalities (particularly skills and technologies). Therefore, it is crucial to analyse the specific composition of sectors within regional economies (Bishop and Gripaios 2010; Boschma and Frenken 2011; Boschma et al. 2012). Asheim et al. (2011) suggest using the knowledge-base approach (Asheim and Gertler 2007) to differentiate between sectors related through technology.

Kemeny and Storper (2015) remind us of the multidimensional nature of measuring specialisation by comparing the explaining effects of absolute and relative specialisation on income. They also mention the facets of specialisation quality and share by arguing, that the most significant dimension of specialisation is not the scale but the 'what'. However, despite the understandable interest of policy-makers to identify the right things to specialise in, there is little evidence what causality stands behind a correlation of, e.g., creativity and wealth in regions.

3.3 Questions

This paper discusses two questions based on the two lines of argumentation which have been introduced (increasing functional specialisation within urban systems and related activities in regional economies).

The first question addresses the composition of the spatial patterns of KIBS in the German urban system over time. Do all heterogeneous KIBS develop similarly in the same spatial units due to the importance of knowledge spillovers? If not, how are different patterns of change composed, and how can different patterns of change be explained?

The second question addresses the spatial units in which KIBS increase or decrease over time. Do all heterogeneous KIBS increase in core cities due to face-to-face contacts and the reduction of costs with regard to transactions? Or do some KIBS increase in rural areas or experience regionalisation processes within metropolitan regions? How can differences in the locations of heterogeneous KIBS be explained?

4 Data, methods and study area

The following section introduces the databases that were used to analyse KIBS in the German urban system. The methods used for detecting correlations between KIBS are also described.

4.1 Knowledge-intensive business services in Germany

Following the argumentation "from sectoral to functional specialisation", this paper uses a functional perspective (and therefore an approach based on occupational data) to analyse changes in spatial patterns of KIBS in the German urban system.

The data used in this paper have been extracted from a data set provided by the Federal Employment Office in Germany (Bundesagentur für Arbeit [BA]). The data include all employees obliged to pay social insurance contributions, representing about 75 % of the total workforce. Employees were differentiated on the basis of their occupations (sozialversicherungspflichtig Beschäftigte nach Berufsordnungen); this differentiation is based on the occupational classification of 1988 (KldB 88 BA).

Self-employed persons were not included. It should be noted that this statistical restriction might result in an underestimation of the number of professions relative to creative activities. The classification of employees by occupation depends on the type of activity currently being performed and not on recent activities or qualifications. This classification enables conclusions to be drawn regarding functional spatial patterns. Following the precedent set by Hall (2007), the occupational groups chosen were those with a high share in KIBS (see Tab. 1).

Tab. 1: Knowledge-based professions

Profession	Classification	1997	2011	Change in percentage points
Accountants (Bookkeeping)	771, 772, 773	385,137	345,546	-10.3
Advertising Professionals	703, 836	72,071	139,188	93.1
Consultants	752, 753	207,714	337,624	62.5
Data Managers	774	322,453	554,475	72.0
Engineers	601, 602, 603, 604, 605, 606, 607	635,437	714,916	12.5
Financial Consultants	691, 692	624,969	573,534	-8.2
Legal Consultants	811, 812, 813, 814	25,733	55,470	115.6
Managers	751	407,649	373,456	-8.4
Media Professionals	821, 822	55,912	75,185	34.5
Technicians	621, 622, 623, 624, 625, 626, 627, 628	792,017	772,041	-2.5
Visual Artists	833, 834, 835, 837	70,450	93,551	32.8

Source: BA, author's calculation

Two data-sets, from 1997 and from 2011, were used to enable the comparison of changes over time. These are the first and the last year, providing data within one classification for reunified Germany. The data set from 1997 covers 3,600,000 employees; the data-set from 2011, which covers 4,000,000 employees, shows a general increase in employment in KIBS. The data were provided for a NUTS-3 level, enabling differentiation between cities and their hinterlands as well as the identification of overall patterns, such as an east-west-pattern. It should be noted that within the delimited areas at NUTS-3 level some areas include one or more cities whereas other areas are more rural characterized. Functional interrelations within the areas on NUTS-3 level (Stadt- und Landkreise) cannot be analysed on this base. However, the NUTS-3 level provides occupational data that, firstly, covers Germany as a whole and, secondly, is not subject to data protection as an extent as is the more detailed LAU-2 level (Gemeinden).

4.2 Identification of correlating functions

A number of absolute and relative statistical approaches deal with questions of functional specialisation and diversification.[1)] A widely used approach dealing with change over time as well as questions of functional composition in regions is the shift-share-analysis. A shift-share analysis determines what portions of regional economic change can be attributed to national, functional (or industry mix), and regional factors. The national share effect equals the theoretical change of a region had it increased by the same percentage as the national economy. The functional (or industry mix) effect equals the theoretical change of a region had it increased by the same percentage as the function na-

[1)] Absolut indicators like the Herfindahl index show how specialised an area is. However, the indicator does not show what an area is specialised on. For example, based on the eleven KIBS, Germany displays an HHI of 1464 in 1997 and an HHI of 1322 in 2011, indicating a decreasing specialisation. But how functions change and what cities are concerned cannot be known. Relative indicators like location quotients put regional and national shares in relation and enable the identification of above or below proportional specialisation of regions on specific functions. However, location quotients are static and do not show change over time. For more information about absolute and relative approaches dealing with questions of functional specialisation and diversification in the German urban system see Growe (2012b).

tionwide, minus the national share effect. The local share effect equals the actual change of a region, minus the previous two effects. The following table 2 shows examples of a shift-share-analysis, displaying results for the biggest German cities and one rural county neighbouring Munich.

Results for the selected spatial units indicate that the number of KIBS employees do not only increase above the average national change in big core cities. Berlin, for example, gains 5,109 KIBS employees less than expected, had it increased by the same percentage as the German number of KIBS employees (also indicated by the index of national share effect < 1.00). In contrast, the rural country of Munich gains 12,368 KIBS employees more than expected (also indicated by the index of national share effect > 1.00). However, the identified index values do not show what cities and counties undergo similar gains or losses in the same KIBS functions.

This paper is focusing on relative changes to understand shifting positions of cities and regions in a national urban system, based on correlation of gains and losses of different KIBS between all counties in Germany. Data from all 402 counties for 1997 and 2011 ("Stadt- und Landkreise" in German) were compared on the basis of relative changes. The first step was a calculation of the percentage share of a county in Germany, in relation to all employees occupying a single function. The second step involved calculating the change in a county's share, in relation to all employees occupying a single function, from 1997 to 2011, in percentage points. The third step involved the z-standardisation of the changes, in percentage points. This permitted verification of whether the increase in the importance of a spatial unit as a location for employees in KIBS is above or below average in Germany.[2]) An example of the calculation is shown for Hamburg in table 3.

The average of the z-standardised values was 0 with a standard deviation of 1 and -1. The z-standardised change in importance (hereinafter referred to as CI values) can therefore be interpreted as follows:

- CI values of between − 1 and 1 indicate a small change,
- CI values of between − 2 and − 1 and between 1 and 2 indicate a medium change, and
- CI values of >+ 2 or <− 2 indicate 'exceptional change' in statistical terms.[3])

Using this method, eleven CI-values were calculated for each of the 402 counties, one for each of the professions. In order to gain an understanding of the correlations between all of the professions, a principal component analysis (PCA) was performed on the basis of CI values. The PCA is an abstract approach that can be used to detect patterns of similar development. Taylor and Walker (2001) use a PCA for analysing relational changes in urban networks and argue that the main advantage of this method is its "parsimony" as it reduces multiple indicators (the 11 KIBS functions in this paper) to few components (four components in this paper): "In effect, these rotated components are new 'supervariables' and as such they can be defined in terms of the original objects over which the input variables were measured" (Taylor and Walker 2001, 27; see also Taylor 2005; Taylor et al. 2014a; Taylor et al. 2014b).

In order to better understand patterns of similar development, a structural PCA (based on occupation percentages of each county in 1997) and a dynamic PCA (based on relative changes of importance of each county from 1997–2011) has been made. The structural PCA helps to interpret patterns detected by the dynamic PCA, using the same method for changes and the starting point. This analysis enabled verification of whether above or below average changes in German professions correlate throughout Germany.

5 Correlation of KIBS professions in Germany

As the first step, a PCA was performed for all professions in 1997. The result of this analysis is one component explaining almost 93 % of the variance (see Tab. 2). Therefore, in 1997 all KIBS professions are strongly correlated. This is also shown by the very high loadings of the different professions on the extracted component (see legend in Fig. 1).

Figure 1 shows the geographical locations of positive scores for the extracted component. The geographical pattern mirrors the distribution of large

[2]) Note, that a loss of relative importance still can go along with an increase of employees in absolute numbers (and vice versa). This is the case, when the share of occupants in a subregion changes in relation to Germany as a whole. The following examples illustrates this effect: The number of advertising professional increases in Germany as a whole (see Table 1) and in the city on Hamburg between 1997 and 2011. However, the share of advertising professionals in Hamburg in relation to all advertising professionals in Germany decreases from 7.8 % in 1997 to 7.6 % in 2011. In that context, the importance of Hamburg as KIBS location in Germany slightly decreases.

[3]) This approach is based on a method developed by Derudder et al. (2010) to calculate changes within organisational firm networks over the course of time.

Tab.2: Selected examples of a shift-share-analysis

	Number of KIBS employees in 1997	Number of KIBS employees in 2011	national share effect (absolute number of employees more/less than expected)	index: industry mix effect (m)	index: local share effect (c)	index: national share effect (t = m * c)
Berlin	168,682	183,979	-5,109	1.01	0.97	0.97
Munich	156,289	187,386	12,190	1.06	1.00	1.07
Hamburg	134,626	167,979	17,067	1.06	1.05	1.11
Cologne	79,026	90,336	1,750	1.05	0.97	1.02
Munich, rural county	36,911	53,744	12,368	1.07	1.21	1.30

Source: BA, author's calculation

Tab. 3: Calculation example of change in importance (CI), example of Hamburg

	Share of employees in Hamburg of employees in Germany 1997 (first step)	Share of employees in Hamburg of employees in Germany 2011 (first step)	Change in in percentage points (second step)	z-standardisation of changes (= CI values, third step)
Accountants	4.22 %	4.78 %	0.56	5.04
Advertising Professionals	4.07 %	3.93 %	-0.14	-2.67
Consultants	5.22 %	5.11 %	-0.11	-0.94
Data Managers	3.15 %	3.40 %	0.25	2.12
Engineers	3.10 %	3.71 %	0.61	4.98
Financial Consultants	3.93 %	4.27 %	0.34	3.07
Legal Consultants	9.09 %	8.29 %	-0.80	-4.22
Managers	4.99 %	6.17 %	1.18	4.90
Media Professionals	2.68 %	2.74 %	0.05	0.68
Technicians	7.80 %	7.60 %	-0.21	-0.86
Visual Artists	6.73 %	7.08 %	0.35	4.08

Source: BA, author's calculation

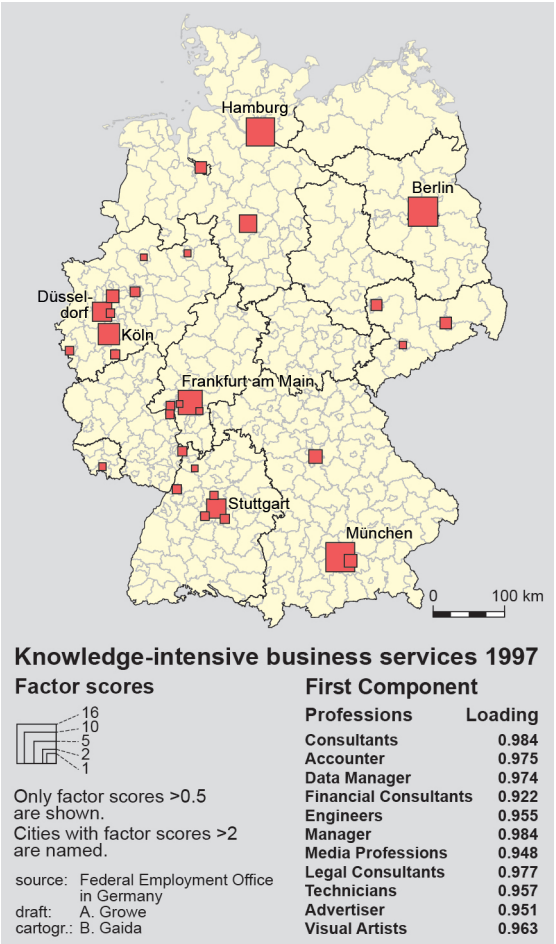


Fig. 1: One component (1997) Source: author's diagram (author's idea, illustration: B. Gaida), data: BA, author's calculation

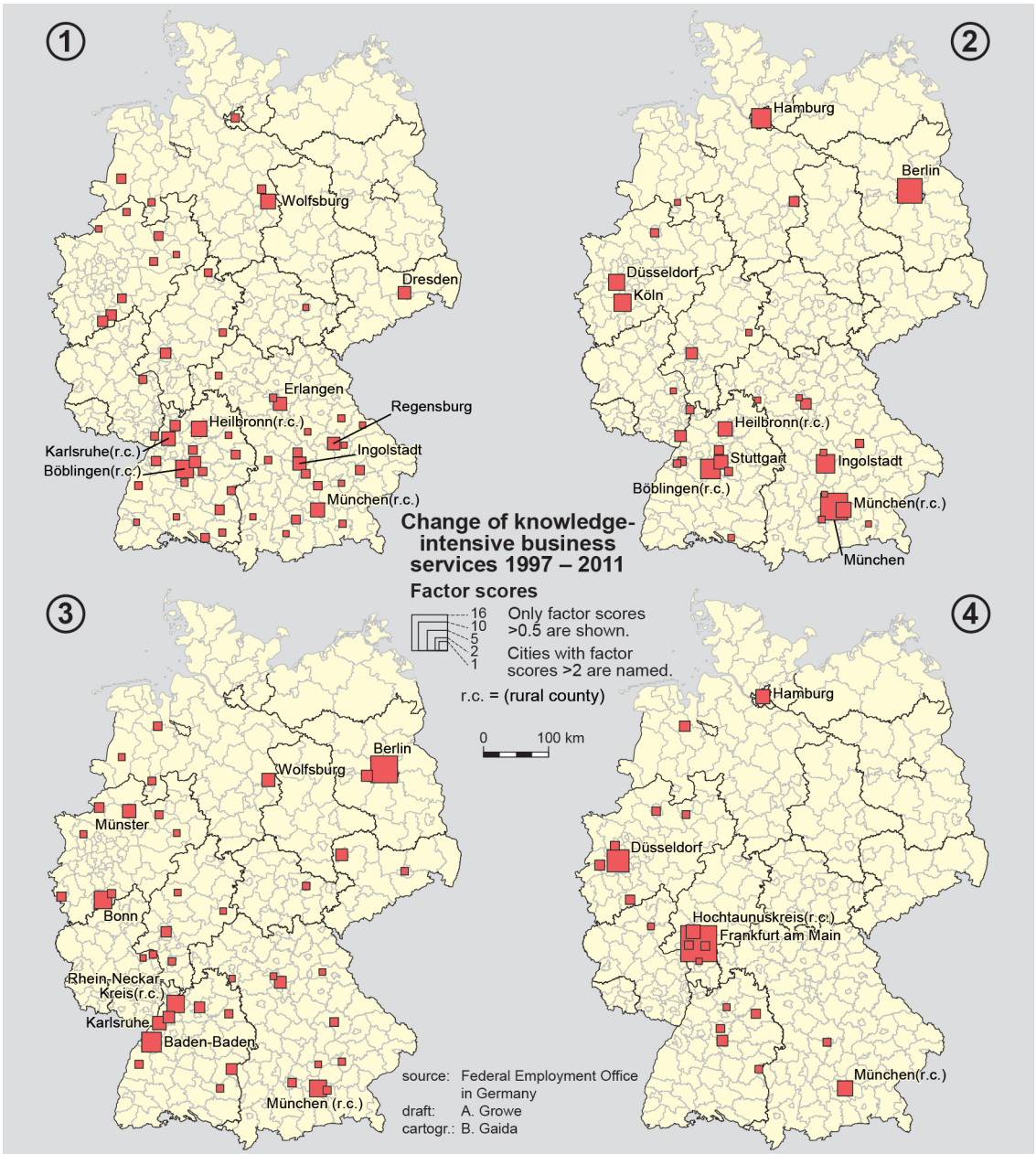
cities in Germany. Munich, Berlin and Hamburg, the biggest cities in Germany, each with more than 1 million inhabitants, exhibit the highest factor scores. Based on their factor scores, the polycentric regions of Rhine-Ruhr, Rhine-Main and Stuttgart can also be recognised on the map. The result is not surprising, as the largest cities also include the largest numbers of employment. However, the focus on KIBS occupants leads to relatively high scores in second-tier cities in polycentric metropolitan regions like Stuttgart or the Ruhr area. Either an urban context or an industrialised region seem to be important for KIBS in 1997. With regard to the research questions, figure 1 provides two types of information. Firstly, it shows that in 1997 KIBS occupations correlate strongly. Secondly, in 1997 KIBS occupants are mainly located in large cities, which is the basis for a comparison of the changing patterns shown in figure 2.

In order to detect correlated changes in KIBS professions, a PCA was used for the z-standardised changes of percentage points (CI values). This enabled the identification of KIBS professions exhibiting above or below average changes in the same spatial units (see Tab. 4). In contrast to the first PCA, four components were extracted for the relative changes (see Tab. 5). This demonstrates that the observed KIBS professions do not change equally in all locations.

The **first component** correlates positively with a positive relative change in the following professions: technicians, engineers, and accountants. Component 1 is influenced by above-average changes in employees with technical affinities. Spatial units gaining importance as locations of technical activities simultaneously show negative relative changes with regard to creative activities. Figure 2 shows locations where technical activities grow concurrently at an above average rate over time. Locations with factor scores of > 2 are named on the map. Disparities between East and West Germany are immediately apparent. In East Germany, a positive relative change with respect to technically-based activities can be observed only in Dresden. In Southern Germany, locations with existing strengths in automobile and high-tech industries are also increasing in importance as locations for technology-oriented professions.[4)]

A second pattern is apparent in the relationships between core cities and the surrounding districts. In southern Germany, positive scores can be found primarily in the surrounding districts and to a lesser extent in the central cities. This observation suggests a regionalisation process (e.g. in the Munich region (Growe 2012a), in the Stuttgart region with the surrounding Böblingen district,

[4)] A reading example shall illustrate how to understand figure 2. The four components identify counties with similar developments. In component one cities and rural counties in southern Germany show high scores, for example Heilbronn, Böblingen and the rural county of München. This suggest that all three counties undergo a similar development pattern in the sense that all three counties increase their importance for the functions technicians, engineers, and accounters. The finding implies that percentage share of technicians, engineers, and accounters in the three counties (of all technicians, engineers, and accounters in Germany) increase in comparison to the percentage share of technicians, engineers, and accounters in other counties. Therefore we can observe a relative shift of technicians, engineers, and accounters in Germany in favour of the counties with high scores in component one. At the same time counties with high scores in component one will lose percentage shares for functions with negative loadings, e.g. legal consultants.



1 First Component

Professions	Loading
Technicians	**0.883**
Engineers	**0.870**
Accounter	**0.746**
Manager	0.250
Data Manager	0.198
Consultants	0.085
Financial Consultants	-0.063
Visual Artists	-0.253
Media Professions	-0.442
Advertiser	-0.509
Legal Consultants	-0.562

2 Second Component

Professions	Loading
Manager	**0.864**
Consultants	**0.839**
Legal Consultants	**0.624**
Visual Artists	**0.608**
Advertiser	0.415
Media Professions	0.203
Accounter	0.148
Engineers	0.088
Financial Consultants	0.050
Technicians	-0.125
Data Manager	-0.126

3 Third Component

Professions	Loading
Data Manager	**0.862**
Media Professions	**0.670**
Advertiser	0.380
Accounter	0.272
Legal Consultants	0.176
Visual Artists	0.149
Technicians	-0.034
Consultants	-0.054
Manager	-0.091
Financial Consultants	-0.100
Engineers	-0.208

4 Fourth Component

Professions	Loading
Financial Consultants	**0.951**
Legal Consultants	0.294
Consultants	0.273
Engineers	0.139
Accounter	-0.033
Technicians	-0.056
Data Manager	-0.083
Media Professions	-0.120
Manager	-0.164
Visual Artists	-0.258
Advertiser	-0.527

Fig. 2: Four components, based on relative changes (1997–2011). Source: author's diagram (author's idea, illustration: B. Gaida), data: BA, author's calculation

Tab.4: Principal components in 1997

Component	Initial eigenvalues			Sum of squared factor loadings for extraction		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	10.198	92.712	92.712	**10.198**	**92.712**	**92.712**
2	.287	2.611	95.323			
3	.212	1.924	97.247			
4	.096	.875	98.122			
5	.076	.694	98.816			
6	.039	.355	99.172			
7	.028	.258	99.430			
8	.023	.212	99.642			
9	.016	.147	99.789			
10	.013	.123	99.912			
11	.010	.088	100.000			

Source: BA, author's calculation

Tab.5: Principal components of relative change from 1997 to 2011

Component	Initial eigenvalues			Sum of squared factor loadings for extraction			Rotated sum of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	3.392	28.264	28.264	3.392	28.264	28.264	**3.158**	**26.320**	**26.320**
2	2.514	20.948	49.212	2.514	20.948	49.212	**2.598**	**21.649**	**47.969**
3	1.835	15.292	64.504	1.835	15.292	64.504	**1.636**	**13.637**	**61.606**
4	1.135	9.456	73.960	1.135	9.456	73.960	**1.482**	**12.354**	**73.960**
5	.942	7.853	81.813						
6	.544	4.532	86.346						
7	.451	3.760	90.105						
8	.398	3.319	93.425						
9	.248	2.066	95.490						
10	.210	1.750	97.240						
11	.197	1.643	98.883						

Source: BA, author's calculation

and within the polycentric Rhine-Neckar region). Central cities with high scores are primarily centres for the automotive industry (Audi in Ingolstadt, VW in Wolfsburg and BMW in Regensburg) as well as IT clusters (Dresden).

The **second component** is strongly correlated with positive relative changes in management, consultancy and creative activities. The literature attests to a strong urban affinity for management and control functions as well as creative activities

(Sassen 2001). The spatial pattern in figure 2 confirms this supposition. Management, consultancy and creative activities were well represented in big cities in 1997 (starting year, see Fig. 1). However, these areas are still increasing in importance as locations for these same activities, suggesting that these KIBS professions are undergoing a concentration process in core cities.

Observing an increase of relative importance of technicians and engineers in small cities in metropolitan hinterlands in southern Germany (first component) and an increase of management activities in big metropolises (second component) invites to think of shifting patterns of rather production-linked and rather strategical knowledge-based services in a more abstract way. The argument of increasing functional specialisation is based on locations of headquarters and production plants (Duranton and Puga 2005), which is not measured in this paper. However, shifting patterns of production-linked services and strategical services can hint on different spatial affinities of these activities and on increasing functional specialisation. In that context, the first and the second component can be understood as two sides to the story of functional specialisation.

The **third component** correlates positively with positive relative changes in activities in the field of data management and with some creative activities (media and, to some extent, advertising). Spatially, Component 3 exhibits a pattern which is complementary to the two principal components. The spatial pattern of the third component focuses on smaller cities in West Germany (Münster, Bonn, Karlsruhe and Baden-Baden) and some cities in Eastern Germany (Berlin and, although not shown on the map by name, Potsdam, Leipzig and Dresden). As they are neither large metropolitan areas nor part of an industrialised hinterland, the cities included in the third component can be discussed in the light of the concept of regiopoles (Aring and Reuther 2008). Following Aring and Reuther (2008, 23) regiopoles are cities with more than 100.000 inhabitants, a certain amount of metropolitan functions according to the index of metropolitan functions of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (at least a university or university of applied sciences) and not located within a metropolitan region. The idea of regiopoles responds to the political concept of metropolitan regions. Therefore, regiopoles can be understood as a normative concept. However, there is empirical evidence used in the process of identifying possible regiopoles, e.g. the metropolitan functions index. Given that context, the spatial pattern of the third component can be used as a starting point to discuss the role of regiopoles within an increasingly knowledge-based economy.

The functional composition of the third component mirrors that of the urban type. Neither exclusively technological professions (as in Component 1) nor explicitly metropolitan services (as in Component 2) contribute to Component 3. Rather, the intersection of consultancy and technical activities (specifically, data management) as well as creative activities show a positive relative change in the smaller cities.

The **fourth component** correlates positively with positive relative changes in financial consulting. Positive relative changes in numbers of employees are found almost exclusively in large core cities, most notably in Frankfurt, but also in Hamburg and Dusseldorf. Thus, as with Component 2, the spatial pattern of Component 4 reveals a strong urban affinity. However, Component 4 exhibits a pattern which is much more polarised and strongly focused in the Frankfurt region (primarily the core of the city as well as some surrounding areas such as the Hochtaunuskreis district). In addition to the existing concentration of important sites for financial activities in Frankfurt (e.g. the location of the German Stock Exchange, the locations of many of the major German banks such as Deutsche Bank and Commerzbank, and the locations of the German Federal Bank and the European Central Bank), financial consultancy represents yet another spatial concentration.

Changes in KIBS Professions in the German Urban System

The analysis of relative changes in KIBS professions in the German urban system reveals four functional patterns with different compositions reflecting four distinct spatial patterns. In terms of composition, the four components reflect

- technology-based KIBS professions (Component 1),
- KIBS professions based on management, consulting, and creative activities (Component 2),
- hybrid composition of consultancy and technical activities (specifically, data management) as well as creative activities (Component 3) and
- financial consulting (Component 4).

In terms of spatial patterns the four components reflect

- high-tech industrialised hinterlands of metropolitan areas in Southern Germany (Component 1)
- five to seven large metropolitan centres (Frankfurt not included) (Component 2),

- mid-sized cities or regiopoles, being neither metropolitan centres nor industrialised hinterlands (Component 3)
- Frankfurt (Component 4).

The results demonstrate that not all relative changes in the heterogeneous spectrum of KIBS professions encompass the same locations for all professions. However, the relative changes in some professions correlate systematically in the German urban system. In the context of discussing relative variety, Asheim et al. (2011) suggest using the knowledge-based approach. Applying the knowledge-based approach (in the sense of differentiating between technology-based activities, consulting activities, and creative activities) gives clues as to the spatial affinities of various KIBS professions.

Overall, we can differentiate between an affinity towards cities (differentiated into an affinity towards (i) metropolitan cities, (ii) regiopoles and (iii) Frankfurt) and an affinity towards industrialised hinterlands. An affinity towards cities can be identified predominantly for the creative activities as well as for different types of consulting activities (e.g. management consulting, legal consulting, financial consulting and others). An affinity towards industrialised hinterlands can be identified predominantly for technical activities (e.g. engineers, technicians, accountants and others).

In Section 5 the findings for the first and the second pattern have been discussed in connection with the functional specialisation argument. Technical activities as being rather production-orientated gain importance in industrialised hinterlands whereas consulting and creative activities as being rather strategical-orientated activities stay important within metropolitan cores. Based on the knowledge base approach also the fourth pattern (financial consulting, mainly in Frankfurt) can be counted as consulting activity within cities and therefore supports the assumption of increasing functional specialisation within different KIBS in the German urban system.

In a nutshell, we can observe different development patterns between different KIBS. The KIBS developing in similar spatial patterns can be counted to similar activities according to the knowledge base approach, namely to form a metropolitan pattern (creative and consulting activities) or to form a small city and hinterland pattern (containing technical activities). The identified spatial patterns can be discussed in the context of the knowledge base approach and in the context of the idea of functional specialisation. On the basis of the knowledge base approach the patterns can be explained by the different knowledge bases that are important for the respective activities and that can be exchanged between actors differently simple. In that context activities relying strongly on face-to-face contacts would be located in dense areas, which can be seen in component two and four. On the bases of the idea of functional specialisation manufacturing orientated activities are expected to relocate in smaller cities with lower land rents whereas strategic activities stay in urban centres. This assumption explains component one, two and four.

The third component raises questions about the role of mid-sized cities in urban systems within the knowledge economy. As Aring and Reuther (2008, 23) put it, the focus on regiopoles enables a "new reading of the German urban system". Regiopoles or the so called "small big cities" appear to represent spatial patterns of their own which neither correspond entirely with the technology-based KIBS professions nor with the metropolitan KIBS professions. Given, that the rising knowledge economy will not limit its effects on metropolitan regions, more research needs to be done about the role of "small big cities" in the knowledge economy. What role do they play in the context of an urban system in the rising knowledge economy? What is the interplay between "small big cities" outside metropolitan regions and small and big cities within metropolitan regions? A possible starting point can be the analysis of inter-city-relations that has been done with a focus on polycentric metropolitan regions (Hall and Pain 2006). However, these studies focus on inter-city-relations within metropolitan regions and can be extended on relations including "small big cities" outside metropolitan regions in a national urban system.

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