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Hoyler, Michael; Freytag, Tim; Mager, Christoph

Postprint / Postprint
Zeitschriftenartikel / journal article

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Empfohlene Zitierung / Suggested Citation:
Hoyler, M., Freytag, T., & Mager, C. (2008). Connecting Rhine-Main: The Production of Multi-Scalar Polycentricities through Knowledge-Intensive Business Services. *Regional Studies*, *42*(8), 1095-1111. https://doi.org/10.1080/00343400701874230

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https://nbn-resolving.org/urn:nbn:de:0168-ssoar-133591

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Journal:	*Regional Studies*
Manuscript ID:	CRES-2006-0303.R1
Manuscript Type:	Main Section
JEL codes:	L22 - Firm Organization, Market Structure: Markets vs. Hierarchies; Vertical Integration < L2 - Firm Objectives, Organization, and Behavior < L - Industrial Organization, L84 - Personal and Professional Services < L8 - Industry Studies: Services < L - Industrial Organization, R12 - Size and Spatial Distributions of Regional Economic Activity < R1 - General Regional Economics < R - Urban, Rural, and Regional Economics
Keywords:	Polycentricity, city-region, connectivity, knowledge-intensive business services, Rhine-Main

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Connecting Rhine-Main: The Production of Multi-Scalar Polycentricities through Knowledge-Intensive Business Services

MICHAEL HOYLER,* TIM FREYTAG† and CHRISTOPH MAGER†

* Department of Geography, Loughborough University, Loughborough, LE11 3TU, UK. Email: m.hoyler@lboro.ac.uk

† Geographisches Institut, Universität Heidelberg, Berliner Straße 48, 69120 Heidelberg, Germany. Emails: tim.freytag@geog.uni-heidelberg.de; christoph.mager@geog.uni-heidelberg.de

First received : December 2006

Accepted : August 2007

Paper prepared for *Regional Studies*

Special issue 'Globalisation, City-Regions and Polycentricity in North West Europe'

Final Version, August 2007

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Abstract

Most of the literature on polycentric urban regions has focused on the analysis of intra-regional rather than external linkages, while research on the emergence of a 'world city network' has analysed external city-relations without explicitly addressing city-regional contexts. This paper aims to bring both perspectives together. Drawing on Taylor's interlocking network model, it presents a first analysis of multi-scalar inter-city connectivities within a specific city-regional context. Central to the analysis is the question how knowledge-intensive business service firms in Rhine-Main connect this multi-nodal metropolitan region to other cities within Germany and beyond. The result is a detailed mapping of the business service connectivities of a major European city-region.

Key words: Polycentricity, city-region, connectivity, knowledge-intensive business services, Rhine-Main

JEL classification: R12, L22, L84

Liaison Rhin-Main: La production de polycentricités multiscalaires via des services commerciaux basés sur le savoir

MICHAEL HOYLER TIM FREYTAG et CHRISTOPH MAGER

Résumé

La majeure partie de la littérature sur les régions urbaines polycentriques s'est axée sur les liaisons intrarégionales plutôt qu'aux liaisons externes alors que la recherche

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sur l'émergence d'un réseau de villes mondiales a analysé les relations entre villes extérieures sans traiter de façon explicite du contexte des villes-régions. Cet article vise à réunir ces deux perspectives. S'appuyant sur le modèle de maillage de Taylor, il présente une première analyse des connectivités intervilles multiscalaires dans un contexte de villes-régions spécifiques. La question du raccordement des entreprises de services commerciaux basés sur le savoir de la région métropolitaine multinodale Rhin-Main avec les autres villes d'Allemagne et d'ailleurs est au centre de cette analyse. Le résultat est une carte détaillée des connectivités des services commerciaux d'une grande ville-région européenne.

Mots-clés : polycentricité, villes-régions, connectivité, service basé sur le savoir, Rhin-Main.

JEL classification: R12, L22, L84

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German Abstract

Forschungsarbeiten über polyzentrische Metropolregionen haben bislang zumeist intraregionale Strukturen und Prozesse untersucht und nur selten externe städtische Verflechtungen thematisiert. Dagegen analysieren neuere Forschungen zur Herausbildung eines globalen Städtesystems interurbane Vernetzungen ohne den metropolitanen Raum als Kontext explizit zu berücksichtigen. Dieser Aufsatz verbindet beide Perspektiven. Unter Bezugnahme auf Taylors Netzwerkmodell wird eine erste Analyse interurbaner Verflechtungen für eine spezifische Metropolregion auf verschiedenen Maßstabsebenen vorgenommen. Im Zentrum der Untersuchung steht die Frage, wie wissensintensive Dienstleistungsunternehmen das Rhein-Main Gebiet als multinodale Metropolregion an andere Städte in Deutschland und darüber hinaus anbinden. Das Ergebnis ist eine detaillierte Kartierung der Dienstleistungsverflechtungen einer bedeutenden europäischen Metropolregion.

Polyzentrizität, Metropolregion, Konnektivität, wissensintensive Dienstleistungsunternehmen, Rhein-Main

Conectando la región Rin-Meno: la producción de policentralidades multiescalares a través de servicios comerciales con alto nivel de conocimientos

MICHAEL HOYLER TIM FREYTAG and CHRISTOPH MAGER

Abstract

La mayoría de literatura sobre las regiones urbanas policéntricas se ha ocupado principalmente de analizar los vínculos intrarregionales en vez de externos mientras que en la investigación sobre la aparición de una 'red de ciudades mundiales' se han analizado las relaciones externas entre las ciudades sin abordar explícitamente los contextos de regiones metropolitanas. En este artículo reunimos ambas perspectivas. Basándonos en el modelo de redes entrelazadas de Taylor, presentamos un primer análisis de conectividades multiescalares interurbanas dentro de un contexto específico de región metropolitana. El enfoque de este análisis es plantearnos cómo las empresas de servicios comerciales con alto nivel de conocimientos en la región Rin-Meno conectan esta región metropolitana multinodal a otras

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ciudades en Alemania y otros sitios. El resultado es un representación pormeronizada de las conectividades de servicios comerciales de una importante región metropolitana europea.

Key words:
Policentralidad
Región metropolitana
Conectividad
Servicios comerciales con alto nivel de conocimientos
Región Rin-Meno

JEL classification: R12, L22, L84

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INTRODUCTION

In many of the current policy discourses on cities in globalization, city-regions rather than individual cities are being identified as the new key arenas for the generation of economic growth (HERRSCHEL and NEWMAN, 2002; BRENNER, 2004). For the largest and economically most important of these metropolitan areas, new concepts such as 'global city-region' (SCOTT, 2001) or 'mega-city region' (HALL and PAIN, 2006) suggest a complex interrelationship between their role as nodes in the global economy and their polycentric, multi-clustered spatial form.[1] However, most of the literature on polycentric urban regions has so far focused on the analysis of internal regional structures (KLOOSTERMAN and MUSTERD, 2001; KLOOSTERMAN and LAMBREGTS, 2001; BAILEY and TUROK, 2001; MEIJERS 2005) rather than external interregional and international linkages (PARR, 2004, 238). At the same time, a growing body of research (summarized in TAYLOR, 2004; GaWC, 1999-2007) has analysed the external relations of cities to sketch out the contours of a 'world city network', but has focused mainly on the globally most important core cities without explicitly addressing their city-regional context (see, however, TAYLOR *et al.*, 2006a, b). This paper aims to bring the two perspectives together. Drawing on a revised GaWC[2] methodology, initially specified to investigate inter-city linkages on a global scale (TAYLOR, 2001), the paper presents the first empirical analysis of multi-scalar inter-city connectivities within a specific city-regional context. At the centre of the analysis is the question how advanced producer service firms use the morphologically multi-nodal metropolitan region Rhine-Main within their intra-firm business networks to service not only the region itself but other cities nationally and transnationally. The result is a detailed mapping of advanced producer service connectivities of a major European city-region.

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The argument proceeds in five stages. First, we place Rhine-Main within the polycentric German urban system and review the evidence available so far on the region's external economic relations. We identify an increase in studies that investigate the national and transnational linkages of the metropolitan region Rhine-Main, but note a lack of comparable data on external linkages of individual cities within the polycentric region. Section two addresses this shortfall by adopting and extending an approach developed in the study of 'world cities' that conceptualizes cities as (global) business service centres. Section three outlines the methodology and sampling procedures that form the basis of our empirical investigation. Section four describes and interprets the multi-scalar geographies of connectivity of Rhine-Main, produced through the intra-firm networks of eight knowledge-intensive business services. These are explored more in-depth in two related mappings of Rhine-Main's integration into national intra-firm business service networks. The concluding section discusses the implications of the empirical results for the conceptualization of polycentricity.

PLACING RHINE-MAIN: A POLYCENTRIC CITY-REGION IN A POLYCENTRIC URBAN SYSTEM

In Germany, both historical territorial fragmentation and contemporary decentralized organization of political power have contributed to the development of a polycentric system of cities and metropolitan regions with complementary functional and sectoral specialization (BLOTEVOGEL, 2000, 2002). Metropolitan functions are distributed across a series of major and mid-size German cities, none of which has managed to achieve dominance as a national metropolis (BBR, 2005, 177-190). Consequently,

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clusters of knowledge-intensive business services can be found in varying constellations in the core cities of all major metropolitan regions and other urban centres (KRÄTKE, 2004, 2005). Within this division of labour, Rhine-Main, Germany's second biggest metropolitan region after Rhine-Ruhr, has long been identified as the country's most globalized urban agglomeration, not least due to the evolution of its core city, Frankfurt am Main, into Germany's undisputed financial centre (GROTE, 2004) and leading international logistics hub (SCHAMP, 2001). The region's rising trajectory as 'emerging node in the global economy' (FELSENSTEIN *et al.*, 2002; ESSER and SCHAMP, 2001) has led to a number of recent studies of Rhine-Main that investigate the external relations which link the region into wider economic networks (e.g. HEINRICH, 2001; KUJATH *et al.*, 2002). These have used a range of variables such as foreign direct investment or foreign trade to assess Rhine-Main's integration into international economic flows. While these data can provide an insight into the comparative position of Rhine-Main as a region (or rather the position of the state of Hesse for which most of these statistics are available), they are of little help in assessing the external linkages of individual cities within the polycentric region.

CITY-REGIONS IN MULTI-SCALAR CITY NETWORKS

In this paper, we adopt an alternative approach to evaluate both internal and external (or rather multi-scalar) linkages of cities in Rhine-Main, building on TAYLOR's (2001) interlocking network model of inter-city relations. This was developed initially as a methodology for systematically describing and analysing inter-city relations on a global scale. TAYLOR (2001) follows SASSEN's (1991) work on advanced producer service firms as key actors in world city network formation. These firms have become

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a major driving force in the economic development of urban and metropolitan regions in globalization. In order to offer a seamless service to their corporate customers, many business service firms (for example in accountancy, advertising or law) have created global networks of offices. Each office network is the outcome of a firm's locational strategy and links the cities in its network through flows (of information, ideas, people etc) between offices. The resulting inter-city network forms part of CASTELLS' (1996) 'space of flows', which he interprets as new spatial logic of the information age. In the absence of comprehensive and comparative inter-city flow data, a quantitative analysis of office networks, based on data on size and function of individual offices, can provide a surrogate measure of the intensity of knowledge-based flows between office locations and, more generally, between places in the world economy (TAYLOR, 2004). As the focus is on advanced producer rather than consumer services, the assumption of intensive flows between offices is inherently plausible on the global scale – these firms tend to operate across rather than through segmented markets to provide a specialized seamless service (SASSEN, 1991), albeit to different degrees depending on sectoral and firm-specific differences. Knowledge and expertise in project teams, for example, are often drawn from several office locations in a firm's transnational network (FAULCONBRIDGE, 2006, 2007).

In principle, the application of the interlocking network model is not restricted to the global scale, but can be adapted to explore inter-city relations at all scales from global to intra-regional (TAYLOR *et al.*, 2006a, b). However, there are potential conceptual implications to consider. One concerns the ambiguous nature of flow data derived from office locations, especially at the regional and national scale. Multiple office locations in different cities can either indicate intensive intra-firm relations or possibly signal a subdivision into separate markets that are serviced by different

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office locations. The degree to which one or the other is the case will vary between sectors and firms. Evidence from qualitative interviews with advanced producer service firms in Rhine-Main suggests that in this case the assumptions of the model are robust and meaningful to support a transfer from the global to other scales of analysis (FISCHER *et al.*, 2005b; FREYTAG *et al.*, 2006). The second implication is related and concerns the relative importance of intra-firm relations at different scales. While these office linkages may be a dominant process for strategic advanced producer services at the global scale, regional intra-firm linkages may be much less important in the constitution of flows than relations to customers, other firms and suppliers. While this may well be the case, we do not aim to comprehensively measure all types of flows in this study but focus on one key process – intra-firm relations – across multiple scales. In this respect, the paper provides an exploratory analysis that complements studies of intra- and inter-regional flows that are concerned with inter-firm and customer relations (e.g. HEINELT *et al.*, 2007).

The shift from global to multiscalar analysis focused on one region also requires some methodological adjustments to data collection: Whereas data for the analysis of the world city network consisted of a sample of globally operating business service firms (TAYLOR *et al.*, 2002), a regionally-based approach must take as its starting point a sample of multi-locational firms with at least one office in the region. The geographical scope of firms will therefore vary much more than in the global scale data. A second modification relates to the exact location of firms included in the sample. Whereas data collection on the global scale adopted a pragmatic approach to office location (i.e. location listed on the corporate website; TAYLOR *et al.*, 2002), data collection for a specific city-region requires exact details of all locations. This is important as corporate websites may list the location of the internationally best known

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core city rather than the actual office location in a smaller municipality or neighbouring city to increase visibility.

METHODOLOGY

The data collection for this study was undertaken as part of the INTERREG IIIB NWE research project POLYNET (HALL and PAIN, 2006; TAYLOR *et al*., 2006a). Eight knowledge-intensive service sectors were included in the analysis: accountancy, advertising, banking/finance, design consultancy (architecture, civil engineering, planning), insurance, law, logistics (supply chain management, global integrated freight etc.) and management consultancy (including IT consultancy). Design consultancy and advanced logistics were added to the six other sectors previously studied at the global level (TAYLOR, 2004) as these are closer related to manufacturing and basic infrastructure, two variables SASSEN (2001, 80) identifies as characteristic for the regional scale in her comparison of global city vs. global city-regional processes. Data were collected on the offices of a sample of firms from these eight sectors, following a joint but locally adaptive strategy between all research teams (TAYLOR *et al*., 2006a). The creation of the sample for Rhine-Main proceeded in three steps.

Data collection – Creating an inventory of advanced producer service firms

The first empirical step was to create an inventory of service firms for each of the six 'functional urban regions' (FURs) that constitute Rhine-Main.[3] The main source used

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was the Hoppenstedt firm database, which in 2003 contained information on about 160,000 businesses in Germany with an annual turnover of at least one million Euro and/or more than twenty employees. For each firm, the database lists office location(s), contact details, website, business sector, names of senior management, number of employees, annual turnover and other key data. Compared to the total number of firms liable to tax, advanced producer service firms are only marginally underrepresented in this database, which tends to record businesses engaged in trans-regional marketing activities more comprehensively than others (KRÄTKE, 2005, 166). This makes the database particularly suited to identify multi-locational firms. Furthermore, the comprehensive spatial coverage of the database permits representative analyses of the economic profiles of cities and regions in Germany (KRÄTKE, 2004, 2005).

Firms were selected for inclusion in the inventory of service firms according to their assigned NACE Rev. 1.1 codes (Appendix 1). The initial data collection resulted in a list of 3,560 APS firms. Their geographical distribution reflects differences in the size and economic structure of the FURs of Rhine-Main (Figure 1, Table 1; FREYTAG *et al.*, 2006). The sectoral distribution of firms among the eight defined advanced producer service sectors showed a dominance of banking/finance (46%), followed by management consultancy (27%), advertising (12%), design consultancy (10%) and insurance (4%).

FIGURE 1 – INSERT APPROXIMATELY HERE

TABLE 1 – INSERT APPROXIMATELY HERE

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There were, however, limits to the database. Use of the NACE classification led to an underreporting of accountancy firms (1%) as many of these also act as management consultancies and were classified as such in the database. The near-absence of the law sector reflects the late emergence and low overall number of large German law firms (MORGAN and QUACK, 2005). Logistics services were not selected on the basis of Hoppenstedt as the NACE classification was too general to allow the identification of knowledge-intensive third-party or fourth-party logistics and freight forwarding, the focus of this study. Because of these limitations of the Hoppenstedt database, information on accountancy, law and logistics firms was additionally collected from branch directories, city websites, and international firm rankings (including the GaWC 100: TAYLOR *et al.*, 2004, Appendix A).

Data reduction – Creating a sample of networked advanced producer service firms

The second empirical step was to identify and remove all purely local firms from the inventory. This was achieved through a three-stage procedure. First, wherever possible, a firm's website was identified based on information given in the Hoppenstedt database and through complementary web-based research. If no corporate website could be found, the firm was removed from the inventory. Second, if a firm had no other office either in another FUR of Rhine-Main or elsewhere in the world, it was classified as a purely local firm and also removed. For all remaining firms, information provided on their corporate websites was used to confirm or change their sectoral allocation. If, after reclassification, a firm did not belong to any of the eight sectors included in this study, it was also removed. The result of this

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exercise in data reduction was a sample of 457 non-local firms that form the basis for further analysis (Table 2).

TABLE 2 – INSERT APPROXIMATELY HERE

Office classification and data matrix creation

In a third empirical step, office locations were identified for each remaining firm, and information was gathered on office size and importance of a firms' presence in a city (e.g. number of practitioners working in an office, number of offices in a city). In addition, extra-local functions of an office within a firm's office network were also recorded (e.g. headquarter, research). To ensure comparability within the POLYNET project, the information gathering was restricted to an agreed list of key regional, national, European and global cities (TAYLOR *et al.*, 2006a, b; Appendix 2). The regional list comprises the six FURs of Rhine-Main; the list of 33 German cities contains all those with over 100,000 social security contributors in 2000 (BBR, 2002). Cities at the European and global scales were chosen because of their high rankings in previous GaWC analyses of global connectivities (TAYLOR, 2004).

In order to be able to make comparisons across firms, each firm was allocated a service value for each of its office locations. The service value indicates the importance of a particular city office within a firm's overall office network. Service values were allocated on a scale from 0 (no presence of a firm in a city) to 3 (superior office, i.e. headquarter, regional headquarter, high number of employees). All cities in which a firm was present initially scored 2 (standard office); information from

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corporate websites and company reports was used to lower (to 1 – sub-office, i.e. representative office, very small number of employees) or raise the service value if appropriate.[4] Overall, 73% of the offices located in the given cities were coded as standard offices, 10% as sub-offices and 17% as superior offices.

The result of this classification exercise are four service value matrices that array firms against cities at different scales: a regional matrix of 457 firms x 6 cities (FURs), a national 457 x 36 matrix (33 top national cities plus Darmstadt, Aschaffenburg and Hanau), a European 457 x 30 matrix (25 European cities, including Frankfurt, plus the five other FURs of Rhine-Main), and a global 457 x 30 matrix (25 world cities, including Frankfurt, plus the five other FURs of Rhine-Main).

Calculating network connectivities

Following TAYLOR's (2001; TAYLOR, *et al.*, 2002; TAYLOR, 2004) inter-locking model of inter-city relations, the four matrices were used to calculate measures of regional, national, European and global connectivity for each of the six FURs of Rhine-Main:

First, a universe of *m* advanced producer service firms located in *n* cities is defined. The service value of a firm *j* in city *i* indicates the importance of its office(s) in the city within the firm's office network; it is represented by v_{ij}. An *n* x *m* array of all service values defines the service value matrix V.

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For each pair of cities in the service value matrix V, the basic relation is defined as an *elemental interlock* between city a and city b in terms of firm j:

$$r_{ab,\,j} = v_{aj} \cdot v_{bj}$$

Summation of all products for a pair of cities defines an aggregate *city interlock*:

$$r_{ab} = \sum_{j} r_{ab,\,j}$$

For each city there are n - 1 such links; the summation of these links defines the *interlock connectivity* of city a:

$$N_a = \sum_{i} r_{ai} \quad (\text{where } a \neq i)$$

As N_a varies with size of the matrix, TAYLOR (2001, 2004) calculates the proportion to highest interlock connectivity recorded (N_h) to ease interpretation:

$$P_a = \frac{N_a}{N_h}$$

This measure will be employed below to assess city network connectivities for the FURs of Rhine-Main at different scales.

Mapping national connectivity profiles

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To further explore the business service integration of Rhine-Main within Germany, city interlocks were used as a basis for two complementary mappings. The first mapping shows a series of six FUR-specific connectivity profiles; the second mapping consists of a series of eight sector-specific connectivity profiles for the Rhine-Main metropolitan region.

Both mappings follow the same principle, which is outlined here for the FUR-specific connectivity profiles:

- City interlocks are calculated for each FUR in Rhine-Main with each of the 30 top cities in the national matrix (excluding intra-regional linkages within Rhine-Main).
- The contribution of each FUR to the national interlock connectivity of Rhine-Main is calculated (Table 3).
- For each national city, the sum of all city interlocks with FURs in Rhine-Main is calculated.
- For each national city, the expected interlock connectivity (in relation to a FUR's share of the total national connectivity of Rhine-Main) is calculated by multiplying the sum of all city interlocks with FURs in Rhine-Main with the contribution of each FUR to the national interlock connectivity of Rhine-Main.
- For each national city, the absolute difference between actual and expected interlock connectivity is calculated. The result can be positive (over-linked) or negative (under-linked).
- For each national city, the relative difference between actual and predicted interlock connectivity is calculated (i.e. percentage over-linked or under-linked).

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- For each FUR, the mean of the relative differences is calculated.
- Relative differences are classified for each FUR by standard deviation from the mean. The resulting maps show both the strength (ranked) of interlock connectivity between a FUR in Rhine-Main and all other 30 German cities mapped (graduated symbol), and indicate over- or under-linkage compared to the overall connectivity of Rhine-Main (grey scale).

Similarly, sector-specific national connectivity profiles are calculated and mapped, which show the strength of interlock connectivity between the Rhine-Main region (combined six FURs) and all other 30 German cities for each of the eight business service sectors studied.

TABLE 3 – INSERT APPROXIMATELY HERE

CONNECTING RHINE-MAIN: MAPPING THE GEOGRAPHIES OF ADVANCED PRODUCER SERVICE RELATIONS

Scales of connectivity

The initial aggregate analysis of network connectivities confirms Frankfurt's dominant position as the major cluster of knowledge-intensive business services in Rhine-Main. The city and the surrounding municipalities in the FUR Frankfurt show the highest degree of connectivity at all scales. Note however, that the relative importance of Frankfurt increases with geographical scale (Table 4). Intra-regional network connectivities of Wiesbaden, Mainz and Darmstadt score between 61 and 44 per

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cent of Frankfurt's value, i.e. a number of service firms operate offices in more than one of these FURs. The smaller FURs of Aschaffenburg and Hanau are less well connected but still relatively well-integrated into intra-firm business networks of regional scope.

TABLE 4 – INSERT APPROXIMATELY HERE

However, even within the region, aggregated intra-firm office linkages show a clear radial pattern connecting each FUR to the 'First City' Frankfurt (Figure 2). Connectivities are highest between Frankfurt and the FURs of the two *Länder* capitals Wiesbaden (the 'prime link', see TAYLOR *et al.*, 2006a, 62) and Mainz, followed by Darmstadt. The strength of these linkages and the relatively low connectivities with Hanau and Aschaffenburg reflect the longstanding West-East disparities in tertiary employment in the region (BÖRDLEIN and SCHICKHOFF, 1998) and the closer association of business service firms in Wiesbaden, Mainz and Darmstadt with the financial sector cluster in Frankfurt. A secondary triangle of interconnections exists between the FURs of Wiesbaden, Mainz and Darmstadt that confirms the relative strength of inter-FUR connectivities in the western part of Rhine-Main. However, the linkages that bypass Frankfurt are relatively weak. Frankfurt appears as primate in relation to all other cities in the region, despite the – compared to other scales – high average regional network connectivity (43%) of all other FURs in Rhine-Main (Table 4).

FIGURE 2 – INSERT APPROXIMATELY HERE

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The comparatively strong functional polycentricity at the regional scale drops substantially to 16% for the national servicing strategy of knowledge-intensive business services (Table 4). Compared to all other European city-regions analysed in the POLYNET project, this is by far the lowest degree of polycentricity measured for the national scale (TAYLOR *et al.*, 2006b, Table 7)[5]. Mainz and Wiesbaden only score between a fourth and less than a fifth of Frankfurt, while Aschaffenburg and Hanau fall clearly behind the other FURs. A strong primacy pattern emerges, in which Frankfurt constitutes the preferred location of choice for business networks of national scope.

This pattern is reinforced at European (7%) and global (6%) scales. Frankfurt stands out as First City and gateway into Rhine-Main for business networks of transnational scope. The connectivity scores reported here reflect Frankfurt's post-WW II rise as international financial centre (GROTE, 2004) and as Germany's premier location of internationally-oriented advanced producer services (BEAVERSTOCK *et al.*, 2006; FREYTAG *et al.*, 2006). Frankfurt's dominance among the FURs of Rhine-Main and the resulting lack of polycentricity at both European and global scales is in part due to the comparatively small size of the metropolitan region: 84% of all firms studied maintain only one office location in Rhine-Main; in the majority of cases this is located in the FUR Frankfurt. As the strength and direction of Frankfurt's global connectivities has been analysed previously (e.g. BEAVERSTOCK *et al.*, 2001, 2006; TAYLOR, 2003), the remainder of the paper focuses on the integration of different parts of Rhine-Main into national servicing strategies of knowledge-intensive business services. This will be achieved through two complementary mappings of disaggregated connectivities for Rhine-Main's six FURs and for eight business service sectors.

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FUR-specific national connectivity profiles

Frankfurt, the global node of Rhine-Main, is also particularly well-connected to other major cities in Germany (Figure 3a). It is part of and gateway to the 'urban circuit' of those German cities that have long constituted the apex of a polycentric national configuration of cities and metropolitan regions, characterized by complementary functional and sectoral specialization (BLOTEVOGEL, 2000, 2002). Knowledge-intensive business service firms with national ambitions tend to have multiple office locations across all of these major cities (Frankfurt, Hamburg, Munich, Düsseldorf, Berlin, Stuttgart and Cologne). These are also Germany's best connected cities globally (in the same order, see BEAVERSTOCK *et al.*, 2001, 5). Within Rhine-Main, the FUR Frankfurt is the preferred location for service firms with national scope – it is the only FUR that is overlinked to all other major German cities.

Wiesbaden and *Mainz*, respective capitals of the states of Hesse and Rhineland-Palatinate, also show high interlock connectivities with other major cities in Germany, but these remain below average compared to the total connectivity of Rhine-Main, especially for Mainz (Figure 3a). Wiesbaden's intra-firm linkages are comparatively strong with mid-size cities such as Aachen, Karlsruhe, Kiel and Magdeburg, mainly due to high connectivities in management consultancy. Mainz shows a similar overall pattern; however, connectivities above average are dominated by the banking/finance sector (Augsburg, Münster) and by advertising (Bonn, Bochum, Kiel), the latter related to the presence of one of the main public national broadcasting companies in the city.

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Darmstadt, a city with a strong IT sector and technical university, is more intensively linked with the major German cities than Mainz or Wiesbaden although these linkages remain average compared to Rhine-Main's total connectivity (Figure 3a). The FUR shows a clear pattern of business service connectivity with other cities that share a strong technological focus (Aachen, Braunschweig, Karlsruhe). Other linkages above average to Magdeburg, Erfurt and Bochum are mainly due to insurance firms and design consultancies.

Aschaffenburg and *Hanau*, two smaller FURs in eastern Rhine-Main that have retained a higher percentage of their industrial workforce, possess connectivity profiles that are dominated by linkages of average intensity to many of the major and medium-sized cities in Germany (Figure 3b). Aschaffenburg shows overlinkage to Mannheim, a major port and logistics node in the metropolitan region Rhine-Neckar, and to Duisburg, Bochum and Wuppertal in Rhine-Ruhr. The connectivity profile of the neighbouring FUR Hanau is characterized by an even stronger focus on cities in the Ruhr area including Essen. This reflects the specialization of local service firms in logistics and design consultancy with strong ties to industrial production. Overlinkage to Bielefeld and Halle is mainly due to interlocks generated by insurance firms.

The comparison of FUR-specific national connectivity profiles for Rhine-Main shows distinctive variations that reflect the functional and sectoral specialization between the cities that constitute the region (see also FISCHER *et al.*, 2005a). Frankfurt clearly acts as 'First City' for internationally and nationally active business service firms and constitutes a key gateway to the other major nodes of the German economy. However, the mapping also suggests the complementary role played by

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other FURs in Rhine-Main and their ability to bypass Frankfurt, especially in developing links with other smaller urban centres in Germany.

FIGURE 3a – INSERT APPROXIMATELY HERE

FIGURE 3b – INSERT APPROXIMATELY HERE

Sector-specific national connectivity profiles

A second mapping disaggregates the national connectivity of Rhine-Main by business service sector. The eight service sectors studied contribute to a different degree to the overall network connectivity of Rhine-Main: Banking/finance with its large national office network clearly dominates (40.2%), followed by insurance (26.7%). All other service sectors contribute less than 10% to Rhine-Main's overall network connectivity: Management consultancy (8.4%), Logistics (8.0%), Accountancy (6.6%), Design consultancy (4.3%), Advertising (3.6%) and Law (2.0%). Each sector varies considerably in the way it links Rhine-Main to other German cities.

Banking and finance: Rhine-Main's connectivity profile for banking/finance shows a geographically balanced national pattern (Figure 4a). The strongest links exist with Germany's other major cities, led by Berlin, Munich, Hamburg and Düsseldorf. However, most of these remain below average compared to overall sector connectivity. Above average connectivities with Bochum, Duisburg, Halle and a number of smaller cities are due to the relative strength of the banking/finance sector in these cities compared to other business services included in the analysis.

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Insurance: As a specialist financial service, the insurance sector in Rhine-Main (located mainly in Wiesbaden and Frankfurt) shows highest absolute linkages with Berlin, Munich and Hamburg, followed by Stuttgart and Cologne (Figure 4a), all cities with an above average specialization of their workforce in insurance (BLOTEVOGEL, 2002). Of these, Rhine-Main connects only to Cologne above average but the connectivity profile for insurance reveals a strong over-linkage to a range of secondary insurance centres, many of which house headquarters or regional headquarters of insurance firms (e.g. Hanover, Nuremberg, Dortmund, Karlsruhe, Mannheim).

Management consultancy: In contrast to banking and insurance, management consultancy connectivity of Rhine-Main displays a clear pattern of over-linkage to all major German cities (Figure 4a). Munich, Berlin, Düsseldorf, Hamburg and Stuttgart lead in terms of absolute and relative connectivity; Dresden and Aachen are both also linked above average to Rhine-Main. This connectivity profile of Rhine-Main for management consultancies reflects the increasing urban concentration of the sector (GLÜCKLER, 2004a, 149). The FUR Frankfurt contributes most to sectoral connectivity for management consultancy, followed by Darmstadt's strong contribution through its IT-sector (for example with linkages to Aachen).

Accountancy: Although a relatively ubiquitous business service sector on the global scale (TAYLOR, 2004, 81), accountancy only contributes a small percentage to Rhine-Main's overall connectivity. Nevertheless, the sector connects Rhine-Main to all national cities included in the analysis (with the exception of Bochum) (Figure 4a). Over-linkage occurs primarily with major cities that show the highest absolute

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connectivity, while smaller cities are under-linked to Rhine-Main in accountancy. Two regional concentrations of above average connectivities stand out: Rhine-Ruhr and major cities of the 'Saxon Triangle', Leipzig, Dresden and Chemnitz.

Logistics: The knowledge-intensive logistics service sector in Rhine-Main is the only sector in which Aschaffenburg and Hanau contribute more to Rhine-Main's connectivity than Mainz and Wiesbaden, although less than Frankfurt (with most firms located in the rings of the FURs rather than the cores). The connectivity profile for logistics highlights Germany's major transport nodes such as port cities, locations of major airports and rail freight nodes: Hamburg, Nuremberg, Munich, Stuttgart, Bremen, Mannheim and Duisburg (Figure 4b; see also HESSE, 2006, 46). Rhine-Ruhr is connected through all of its major cities; however East German cities are less intensively linked to Rhine-Main in this sector.

Design consultancy: the connectivity profile for design consultancies (architecture, civil engineering, planning) diverges significantly from all other profiles (Figure 4b). Berlin clearly dominates in absolute terms, followed by Munich, Leipzig, Stuttgart and Dresden. In contrast to other business services, this sector shows a strong over-linkage to East German cities. The sector-specific geography reflects the expansion of German and international firms into East Germany after unification and the considerable market potential in terms of brownfield site redevelopment, and building and infrastructure projects. In West Germany, Karlsruhe and Braunschweig stand out as technology-driven cities that show above average connectivities with Rhine-Main, especially with Frankfurt, Darmstadt, Wiesbaden and Mainz.

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Advertising: the advertising sector contributes little to the overall connectivity of Rhine-Main and focuses geographically on the major German cities and centres of advertising, Munich, Berlin, Hamburg and Düsseldorf (Figure 4b). As Germany's leading advertising centre with regard to turnover (BATHELT and JENTSCH, 2004, 47), Rhine-Main is linked to many of the *Länder* capitals and to the past federal capital Bonn, but a third of all German cities with more than 100,000 social security contributors does not show any advertising connectivities with Rhine-Main and will be serviced through either local advertising agencies or larger groups that bypass Frankfurt. Reflected in the mapping are locational strategies of major advertising networks, with national headquarters in Rhine-Main or one of the other leading advertising centres and smaller branches and subsidiary network offices in a restricted range of other places (THIEL, 2005, 573).

Law: the law sector is the most concentrated of all the studied eight sectors (Figure 4b). Rhine-Main's national connectivity in this sector is almost completely due to law firms located within the FUR Frankfurt, Germany's premier centre for corporate legal work and the preferred point of entry for US and UK law firms seeking access to the German legal market. The corporate law sector connects the region primarily to other major cities; over half of all cities studied are not connected through offices to law firms in Rhine-Main. This reflects the general tendency of corporate law firms to cluster in leading cities nationally and globally (TAYLOR, 2004, 85) as well as the late abolishment of legal restrictions that prevented the creation of 'supra-local partnerships' between German business law firms before the 1990s (MORGAN and QUACK, 2005, 1772). In the period of merger and consolidation that followed, legal firms with national and international ambitions first established or acquired offices in the top-tier of German cities.

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The comparison of sector-specific national connectivity profiles for Rhine-Main shows distinctive variations for each sector that reflect both the functional and sectoral specializations of cities in Germany and sector-specific organizational and locational strategies.

FIGURE 4a – INSERT APPROXIMATELY HERE

FIGURE 4b – INSERT APPROXIMATELY HERE

CONCLUSION

This paper has employed an interlocking network model to explore the question how knowledge-intensive business services link the metropolitan region of Rhine-Main intra-regionally and externally across multiple scales. The result is a first detailed mapping of the integration of a functionally multi-nodal city-region into wider business service networks. This quantitative analysis provides new insights into the outcomes of locational strategies of multi-locational professional service firms that operate to varying degrees from Rhine-Main.

First, the functional primacy of Frankfurt as First City of Rhine-Main emerges as much stronger than the morphological polycentricity of the region would suggest. It is only at the regional scale that Rhine-Main appears functionally polycentric as business service node, albeit much less pronounced than most other city-regions in the POLYNET study, particularly Rhine-Ruhr and Randstad Holland (TAYLOR *et al.*,

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2006b). At all other scales, multi-locational advanced producer service firms clearly prefer Frankfurt over any of the other FURs that constitute the region. This makes Rhine-Main a special case among the eight city-regions studied in POLYNET: The comparative POLYNET finding that 'office networks that are regional are also national in scope' (TAYLOR *et al.*, 2006b) does not apply to Rhine-Main, where degrees of polycentricity are similarly low for the national, European and global scale. The large differences in functional polycentricity between regional and global scale support SASSEN's (2001) identification of distinctive global city vs. global city-regional processes. The global 'space of centrality' is clearly focused on the FUR Frankfurt, i.e. core city and surrounding municipalities rather than the wider Rhine-Main region.

Second, despite the low overall degree of functional business service polycentricity in Rhine-Main, there is clear evidence for the development of FUR-specific national connectivity patterns. These point to complementary relations between the six FURs of Rhine-Main and the ability of the non-leading FURs to bypass Frankfurt, especially in their respective sectoral niches, although the gateway role of Frankfurt across all scales remains undisputed.

Third, the patterns of connectivity mapped for Rhine-Main reflect to a substantial degree the characteristics of the polycentric German metropolitan system, in which no single city or urban region achieves dominance across all service sectors (BLOTEVOGEL, 2000, 2002; BBR, 2005). This 'division of labour' in advanced producer service provision between the major German cities is one of the underlying reasons for the intensive inter-city linkages that connect Rhine-Main nationally. How this compares to city-regions in more centralized urban systems where most higher-

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order business services cluster in one or two 'global cities', remains to be seen (WOOD, 2006). Furthermore, the processes that drive the decision-making that underlies the identified inter-urban functional linkages differ between service sectors and require additional analysis that engages with actors, practices, and complementary inter-firm networks through more intensive methodologies (for Rhine-Main, see for example FISCHER *et al.*, 2005b; BATHELT and JENTSCH, 2004 for advertising; GLÜCKLER, 2004b for management consultancy; SCHAMP *et al.*, 2004 for investment banking and automobile design).

Finally, the findings of this paper challenge notions of polycentricity that focus on spatial form rather than function. In the perspective adopted here, polycentricity emerges as a scale-dependent phenomenon based on the coming together of various business service networks of different organizational architecture and scalar reach. This poses significant challenges for policy makers who, despite attempts to develop extended institutional frameworks for metropolitan regions, often remain caught in the territorial logic of administrative boundaries and spatial planning competences (HOYLER *et al.*, 2006). The exploratory mapping of inter-urban business service linkages in this paper visualizes one aspect of the 'relational complexity' of urban regions in globalization. As HEALEY (2006) suggests, this requires the development of a new 'scalar consciousness' among policy-makers and planners rather than a continued reliance on traditional spatial imaginations that centre on urban form and physical structure.

Acknowledgements – The research for this paper was undertaken as part of the INTERREG IIIB North West Europe project 'POLYNET – Sustainable Management of

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European Polycentric Mega-City Regions'. We acknowledge funding by the European Union, the Ministry of Science, Research and the Arts of the State of Baden-Württemberg, and the University of Heidelberg. We would also like to thank Christian Fischer for valuable research assistance, and Peter Taylor and four anonymous referees for helpful comments on an earlier version of this paper.

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Table 1. Social security contributors, inventory of firms, and firm offices studied by FUR

FUR	Social security contributors (2001)		Initially recorded firms (2003)		Firm offices studied (2003)	
Frankfurt	1,063,137	(63%)	2299	(65%)	388	(68%)
Wiesbaden	162,696	(10%)	359	(10%)	52	(9%)
Mainz	162,102	(10%)	241	(7%)	42	(7%)
Darmstadt	158,132	(9%)	337	(10%)	55	(10%)
Aschaffenburg	77,348	(5%)	228	(6%)	19	(3%)
Hanau	58,590	(4%)	96	(3%)	16	(3%)

Sources: Statistical Offices of Hesse, Bavaria and Rhineland-Palatinate (2004); Hoppenstedt firm database (2003).

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Table 2. Distribution of firms studied by sector

Accountancy	26	(6%)
Advertising	56	(12%)
Banking/Finance	147	(32%)
Design Consultancy	47	(10%)
Insurance	55	(12%)
Law	28	(6%)
Logistics	22	(5%)
Management Consultancy	76	(17%)

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Table 3. Contribution to national network connectivities of Rhine-Main

FUR	
Frankfurt	58%
Wiesbaden	12%
Mainz	13%
Darmstadt	9%
Aschaffenburg	4%
Hanau	4%

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Table 4. Multi-scalar network connectivities of FURs in Rhine-Main

FUR	regional	national	European	global
Frankfurt	1.00	1.00	1.00	1.00
Wiesbaden	0.61	0.22	0.13	0.11
Mainz	0.57	0.24	0.09	0.06
Darmstadt	0.44	0.17	0.08	0.06
Aschaffenburg	0.27	0.07	0.04	0.03
Hanau	0.25	0.08	0.03	0.02
Average for non-leading FURs in Rhine-Main	0.43	0.16	0.07	0.06

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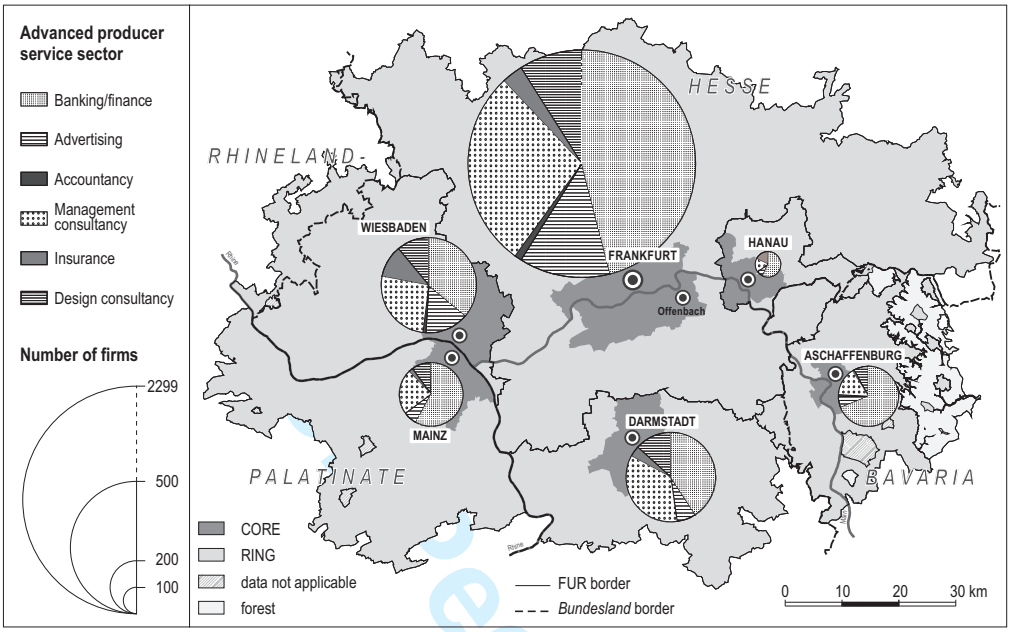
Fig. 1. APS firms in the FURs of Rhine-Main (selected sectors)



Source: Hoppenstedt firm database 2003

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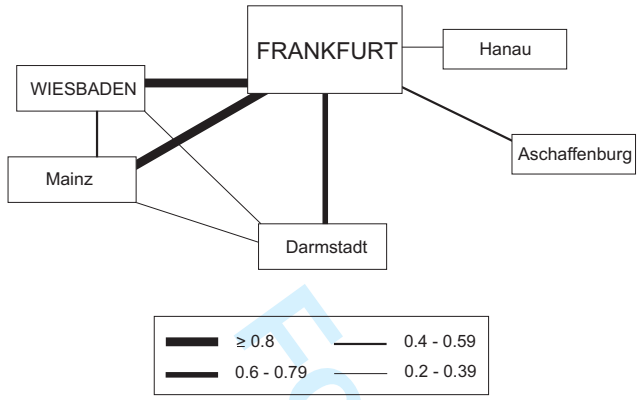
Fig. 2. Intra-regional business service linkages in Rhine-Main



Note: Values are calculated as proportions of the prime link (Wiesbaden-Frankfurt).

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Fig. 3a. National connectivity profiles of Frankfurt, Wiesbaden, Mainz and Darmstadt

(for legend and city codes, see Fig. 3b)

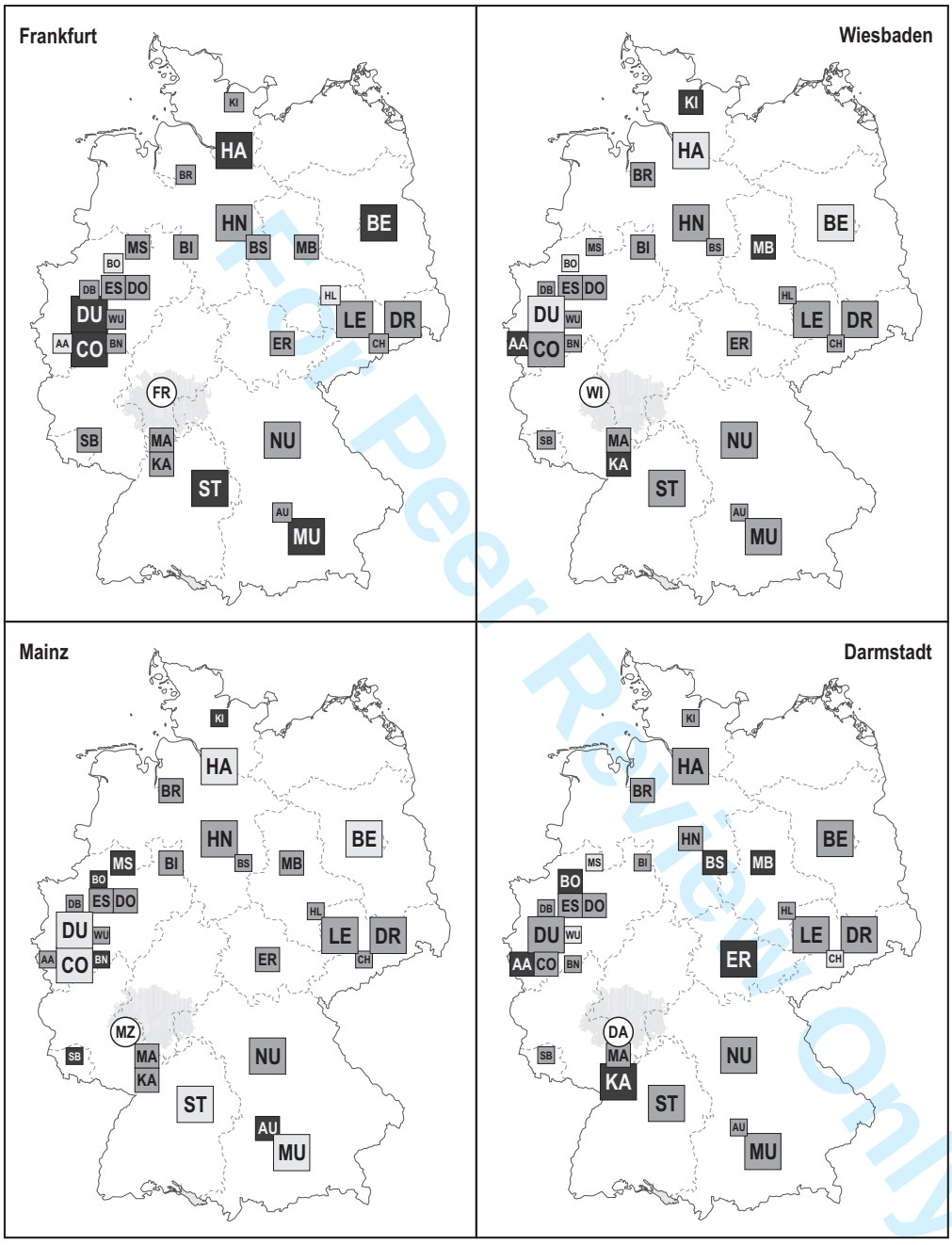

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Fig. 3b. National connectivity profiles of Aschaffenburg and Hanau

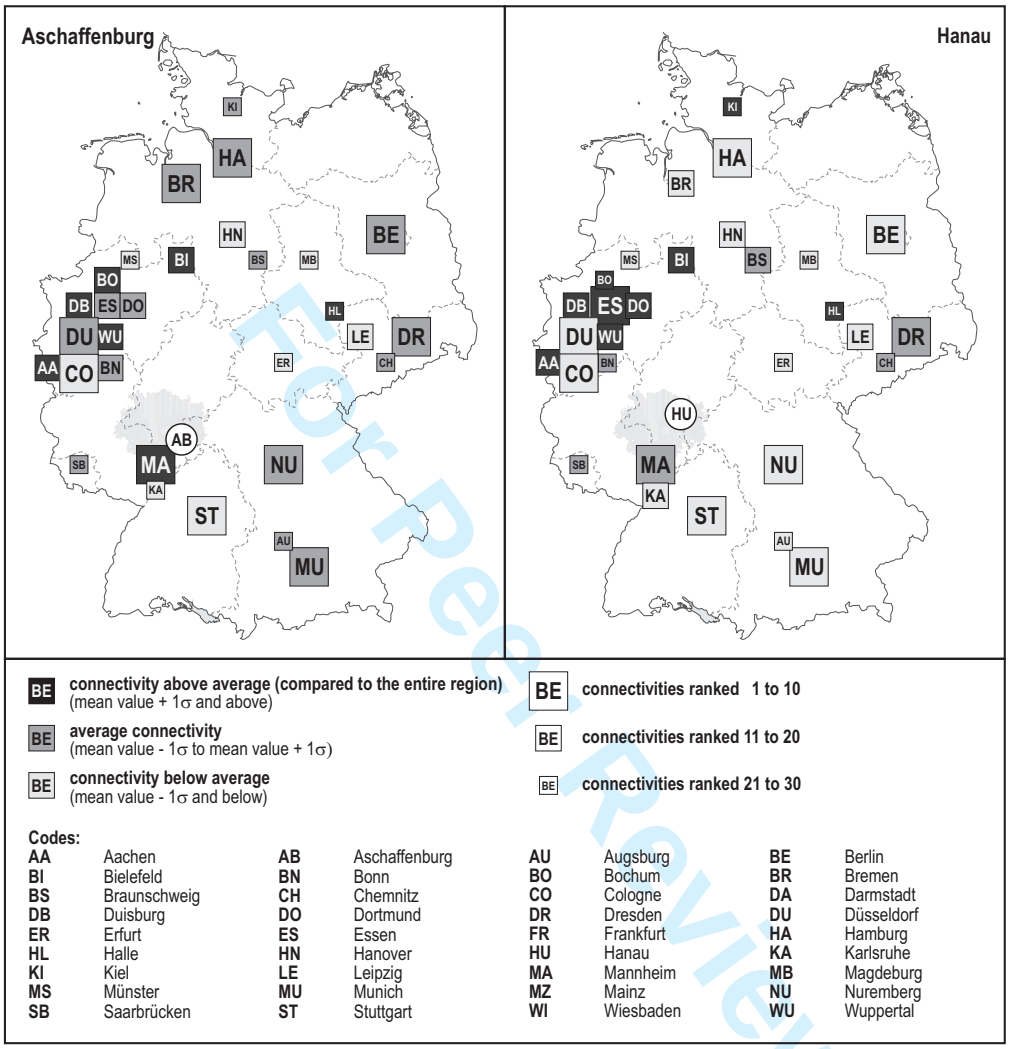

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Fig. 4a. Sectoral connectivity profiles of Rhine-Main (for city codes, see Fig. 3b)

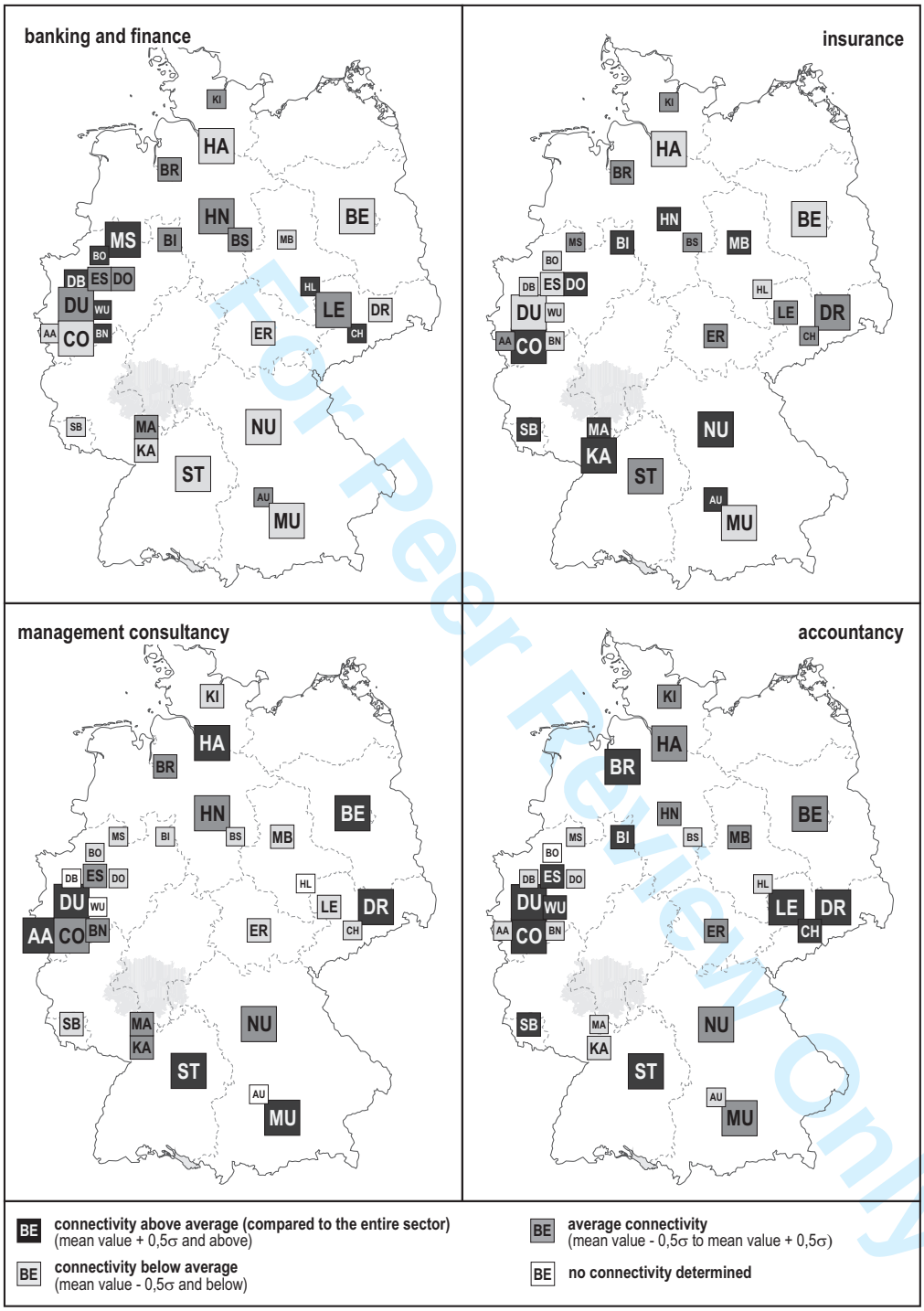

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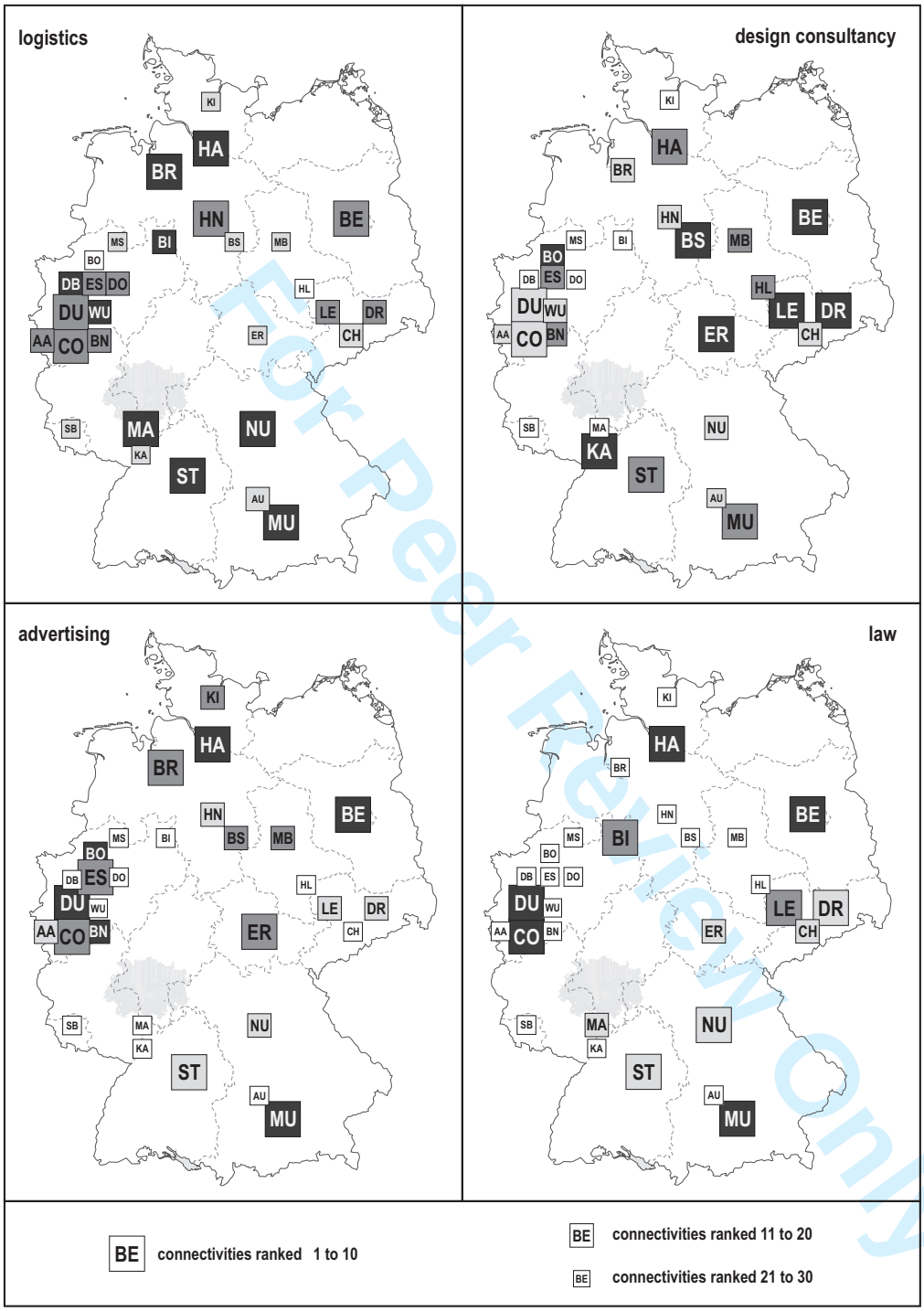
Fig. 4b. Sectoral connectivity profiles of Rhine-Main (for city codes, see Fig. 3b)



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Appendix 1. Codes used to allocate firms to sectors

Accountancy	74121, 74122, 74123, 74124, 74125
Advertising	74401, 74402
Banking/Finance	65*, 67110, 67120, 67130
Design consultancy	74201, 74202, 74203, 74204, 74205, 74206, 74207, 74208, 74209
Insurance	66*, 67201, 67202, 67203
Law	74111, 74112, 74113, 74114, 74115
Logistics	not allocated on the basis of NACE in this study
Management consultancy	72100, 72221, 72222, 74141, 74142

Source: German Classification of Economic Activities (*Wirtschaftszweige*; WZ 2003), based on NACE Rev. 1.1 (2002) (NACE: *Nomenclature statistique des Activités économiques dans la Communauté Européenne*).

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Appendix 2. List of cities chosen for study

Regional (FURs)	National	European	Global
Aschaffenburg	Aachen	Amsterdam	Amsterdam
Darmstadt	Augsburg	Athens	Brussels
Frankfurt/Main	Berlin	Barcelona	Buenos Aires
Hanau	Bielefeld	Berlin	Chicago
Mainz	Bonn	Brussels	Frankfurt
Wiesbaden	Bochum	Budapest	Hong Kong
	Braunschweig	Copenhagen	Jakarta
	Bremen	Dublin	London
	Chemnitz	Düsseldorf	Los Angeles
	Cologne	Frankfurt	Madrid
	Dortmund	Hamburg	Melbourne
	Dresden	Istanbul	Mexico City
	Duisburg	Lisbon	Miami
	Düsseldorf	London	Milan
	Erfurt	Madrid	Mumbai
	Essen	Milan	New York
	Frankfurt/Main	Moscow	Paris
	Halle	Munich	Singapore
	Hamburg	Paris	Taipei
	Hanover	Prague	Tokyo
	Karlsruhe	Rome	Toronto
	Kiel	Stockholm	San Francisco
	Leipzig	Vienna	Sao Paulo
	Magdeburg	Warsaw	Sydney
	Mainz	Zürich	Zürich
	Mannheim		
	Munich		
	Münster		
	Nuremberg		
	Saarbrücken		
	Stuttgart		
	Wiesbaden		
	Wuppertal		

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NOTES

[1] The latter concept explicitly builds on the former (HALL and PAIN, 2006, 12; see also HALL, 2001, for an earlier formulation).

[2] The Globalization and World Cities Study Group and Network based at Loughborough University, UK. See http://www.lboro.ac.uk/gawc/

[3] There is no generally agreed delimitation of Rhine-Main as the contemporary structure is the result of different processes of regionalization in history (HOYLER *et al*., 2006). The use of administratively or morphologically defined units for analysis proves to be problematic, as functional intra- and interregional relationships cannot be described adequately by reference to built-up areas or administrative borders. Based on previous studies (HALL and HAY, 1980; GEMACA, see IAURIF, 2002), we employ the concept of functional urban regions to demarcate Rhine-Main in terms of areas that show regular daily relationships with core cities. The metropolitan region is delimitated by the borders of contiguous FURs, each comprising a single FUR core, defined in terms of employment size and density, and its associated ring, defined in terms of regular daily journeys (Figure 1). FUR cores are single municipalities (NUTS 5 units) or sets of adjacent municipalities with more than six workers per hectare and a minimum of 20,000 employees. FUR rings are defined on the basis of 10 per cent or more residentially-based employees commuting daily from a contiguous municipality to a core. The data used for this analysis cover contributors to the German social security system but exclude for example civil servants and self-employed persons (BUNDESANSTALT FÜR ARBEIT, 2004). The resulting regionalization provided a working definition of Rhine-Main for the collection of data on advanced producer service firms in Rhine-Main in 2004 (FREYTAG *et al*., 2006).

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[4] This is a modified version of TAYLOR *et al.*'s (2002) six-point scale. A similar four-point scale was used in an earlier pilot study by TAYLOR and WALKER (2001). The advantage of the simpler scale in the context of the POLYNET study lies in the reduction of potential inter-team variability in allocating scores.

[5] Measured by the average percentage of network connectivity of the five non-leading cities in each city-region. Of all city-regions in the POLYNET study, Germany contains the city-region with the highest (Rhine-Ruhr, 75%) and lowest degree of polycentricity (Rhine-Main, 16%) at the national scale (TAYLOR *et al.*, 2006b).

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