EMERGING POLYCENTRIC CITY-REGIONS IN GERMANY. REGIONALISATION OF ECONOMIC ACTIVITIES IN METROPOLITAN REGIONS

Anna Growe

With 8 figures and 2 tables
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Summary: Over the last decades the hierarchical understanding of the relationship between cities and their hinterlands has been replaced by a network-based understanding. In the context of this development, the emergence of polycentric network structures in urban regions is discussed, with a focus on qualitative changes in the relationship between cities and their hinterlands. This paper analyses the extent to which the emergence of polycentric regions can be observed in the German urban system. Using commuting data and employment data with a focus on knowledge-based services it is analysed what centres besides core cities are becoming primary hubs to enable processes of regionalisation in three metropolitan regions in Germany. The results indicate that, in spite of an affinity of knowledge-based services to core cities, processes of regionalisation can also be observed with these activities. However, due to the importance of transaction costs a location in other cities in polycentric regions can be expected to be more attractive than a location in the suburbanised or rural hinterland.

Zusammenfassung: In den letzten Jahrzehnten ist das vormals hierarchische Verständnis von Beziehung zwischen Städten und ihrem Umland durch die Annahme einer Netzwerkstruktur ersetzt worden. Im Zusammenhang mit dieser Weiterentwicklung wird die Entstehung polyzentraler Netzwerkstrukturen in Stadtregionen diskutiert, wobei insbesondere ein Fokus auf die qualitative Veränderung der Beziehung von Städten zu ihrem Umland gelegt wird. In diesem Beitrag wird anhand von Pendlerdaten und Beschäftigtendaten analysiert, inwieweit die Herausbildung polyzentraler Stadtregionen im deutschen Städtesystem beobachtet werden kann und welche Zentren in den Regionen – neben den traditionellen Kernstädten – sich zu neuen ökonomischen Zentren entwickeln und Ankerpunkte für Prozesse der Regionalisierung werden. Dabei wird ein Fokus auf wissensintensive Dienstleistungen gelegt. Die Ergebnisse zeigen, dass – trotz einer Affinität dieser Tätigkeiten für hochverdichtete Räume – auch Regionalisierungsprozesse für wissensintensive Dienstleistungen beobachtet werden können. Aufgrund der großen Bedeutung von Transaktionskosten für diese Tätigkeiten kann jedoch vor allem eine Verlagerung in Umlandstädte festgestellt werden und keine Verlagerung wissensintensiver Dienstleistungen in das periphere oder suburbane Umland.

Keywords: Germany, metropolitan areas, regionalisation, polycentricism, knowledge-based services

1 Introduction

Cities cannot be understood in separation from their hinterlands. Changes in a city always have impacts on the surrounding regions and vice versa. Over the course of time, the notion of the relationship between cities and their hinterlands has changed. Taking as an example the development of regional economic theories these changes can be followed.

The idea of *one* central city, surrounded by a hinterland with agrarian functions (von Thünen 1875) has been replaced by the idea of an urban system consisting of different hierarchical layers (Christaller 1933). Within this system, higher-order cities are surrounded by a greater hinterland than lower-order cities. Smaller towns can also be part of a bigger city's hinterland. Part of this theory is the idea that smaller towns provide less goods and services than bigger cities. Therefore supplies of specialised goods and services in smaller towns have to be supplemented by supplies in bigger cities.

Over recent decades, the hierarchical understanding of the relationship between cities and their hinterlands has been replaced by a network-based understanding (Sassen 1991; Taylor 2004). In this development it is supposed that the functional enrichment of the hinterland leads to a shift in the relationship between city and hinterland. It is assumed that these shifts lead to the emergence of smaller towns as new economic hubs in the surrounding regions. This process is discussed as the formation of polycentric structures within urban regions (Hall and Pain 2006).

The emergence of polycentric network structures in an urban region therefore hints at qualitative changes in the relationship between cities and regions. The increasing importance of the surrounding region does not result only from relocations of large-scale commerce and industries, for example at motorway exits, or of places of residence of employees working in the core cities, but from a qualitative enrichment of the region with economic activities where smaller towns become hubs and lose their primary function as living sites (Meijers 2005, 773).

This paper analyses whether the development of polycentric regions can be observed in the German urban system and what centres, besides core cities, are primary hubs to enable the processes of regionalisation. Changes in the German urban systems are analysed due to two reasons. First, the urban system in Germany is polycentric and there are about 8 to 12 agglomerations where economic activities and especially knowledge-based activities are concentrated. In this regard the German urban system offers the possibility to compare developments in monocentric and polycentric metropolitan regions within one national urban system. Second, the German urban system has been influenced by huge transitions through the German reunification. The time span used in this analysis enables a comparison of East and West German metropolitan regions after reunification.

The paper is structured as follows: Part 2 describes the links between two strands of research: polycentric urban regions and knowledge economy. It is discussed, whether locational choices of knowledge-based activities contradict regionalisation processes. The first hypothesis, developed in this part, is that in spite of an urban affinity of knowledge-based services, processes of regionalisation can also be driven by stakeholders of the knowledge economy if secondary centres in the region serve as anchors within the hinterland. The second hypothesis assumes that in prospering regions radial patterns of flows are replaced by network patterns of flows.

Part 3 introduces three study areas in the German urban system and presents data and methods of analysis. To compare changes in locations of different occupational groups within metropolitan regions occupational data is used in the analyses. Commuting data is used to analyse changes of flows within metropolitan regions. Part 4 presents empirical results from the analyses and Part 5 contains a conclusion and discussion of the research questions.

2 Theory

This paper aims to combine two strands of current research: the discussion of polycentric urban regions and the discussion of the knowledge economy.

The discussion of polycentric regions is closely related to discussion of urban systems. Both approaches consider the functional relationships between separately located cities (De Goei et al. 2010, 1152). The structure of urban systems can range from monocentric systems to polycentric structured networks.

The discussion of the knowledge economy is related to the discussion of changed economic processes, caused for example through the decrease of transportation costs, and the necessity of knowledge use and creation to gain competitive advantages (Castells 1996).

2.1 Elements of a polycentric region

When discussing polycentric regions, a lot of authors differentiate between morphological and functional structures (Parr 2004; Meijers 2005; Lüthi et al. 2011; Münter 2011). Differentiation between these structures is important, especially in the context of polycentric regions. In these regions, economic structures and settlement structures may diverge, much more than in monocentric regions.

In discussing the *morphological structure*, the focus is on physical elements of the urban region, e.g. the number of cities in a given territory (Nordregio 2004, 3). In morphologically monocentric regions, an explicit decrease of density can be observed with increasing distance from the centre of the core city. This differs in polycentric regions. In polycentric regions cities of similar size can be located close to each other (Burger and Meijers 2012). Davoudi (2007, 66) specifies morphological aspects of polycentric urban regions on the inter-urban scale as follows: "three or more cities that are historically and politically separate, have no hierarchical ranking, [and] are in reasonable proximity from each other". This structure also leads to an integration of rural spaces and green spaces, deserving protection (Kloosterman and Musterd 2001, 626). These spaces of in-betweenness may be a potential for further developments on the one hand but can also shift into problematic leftover areas on the other hand.

The *functional structure* of an urban region is focused on by looking at the location of economic activities within the region and at the flows that

indicate relations between locations in a given metropolitan region (Nordregio 2004). The concentration of a huge share of all economic activities within the business centre of the core city are a sign of a functionally monocentric urban region. Functionally polycentric regions are determined by the distribution of economic activities in a lot of hubs in the region.

Functionally polycentric regions can be broken down into labour-divided regions (e.g. the polycentric region of Randstad, where Amsterdam is the financial centre, Rotterdam is the trading centre due to its harbour, and The Hague is the political centre) and into functionally-balanced regions. An example of a functionally-balanced polycentric region is the Ruhr area. Here we find several cities of similar size and – due to historic reasons – also with similar economic functions (Kloosterman and Musterd 2001; Parr 2004).

2.2 The development from monocentric to polycentric regions

De Goei et al. (2010, 1152) explain the development of polycentric regions, starting from monocentric structured systems. The concept of a monocentric region is based on one central unit, usually the central business district or the historic centre of a large core city surrounded by radial residential areas (step 1 in Fig. 1). Different functions, such as working or living, are organised within the city by reasons of efficiency. The basic idea is that most economic activities are located in the centre of the core city, due to location rents. Within the suburbs of the core city mainly reproductive functions are located, and suburbs are primarily used as living areas.

Processes of regionalisation start, when former suburban locations with a primary residential function change into independent, secondary employment centres (step 2 in figure 1). To foster this development, it is crucial that economic activities start to develop in former living centres so that either the population of these centres can work at their places of residence or incoming commuters can use the new centre as a place of work. These two parallel processes lead to the increased importance of former suburban locations: firstly, the former smaller hubs become attractive for incoming commuters from other suburban areas or the core city (Anas et al. 1998) and, secondly, the former suburban centres become more independent of the core city because the population of the secondary employment centres can be supplied with working sites in the smaller hubs themselves. Following their employers, more employees may move into the secondary centres. These processes are often supported by cheap land prices and high living quality in the suburban regions (van der Laan 1998).

After a time, the secondary centres develop to increasingly independent employment centres within a growing city region. The consequences are the development of polycentric cities and – later – the development of polycentric regions (step 3 in figure 1), in which commuting patterns are no longer centralised but criss-cross entire regions in a decentralised manner (Kloosterman and Musterd 2001; De Goei et al. 2010, 1152). In regions with a high density and in combination with high development pressure, the network structure can cover more than one large core city and their suburban surrounding regions and form a mega-city region (Anas et al. 1998; Lüthi et al. 2010).

An explanation for the unusual higher importance of smaller cities within metropolitan regions than in self-standing cities of similar size can be found in the concept of regional externalities, introduced by Parr (2002). The concept is traced back by Meijers and Burger (2010) to the concept of 'borrowed size', invented by Alonso (1973).

As a result of these processes, competition between core cities and the suburban centres may occur and the relationship between these different types of location in the urban region changes. The more employees commute between the new centres of the region and bypass the core city, the more decentralised are the flows of goods, services, and people (De Goei et al. 2010, 1152). Once a decen-

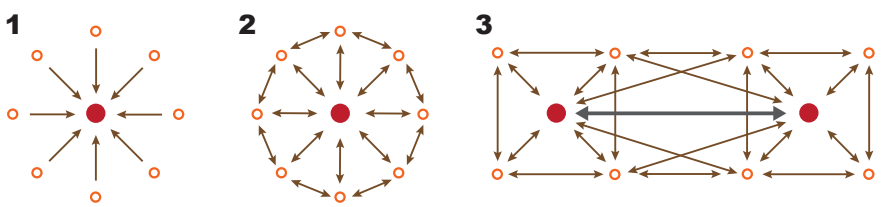

Fig. 1: From monocentric to polycentric regions

tralised network structure has developed in the region, economic development is no longer dependent on the central business district in the core city, but may also be based on the development of smaller centres in the region. In this context, different centres may specialise in different economic functions and lead to a labour-divided, complementary structure within the polycentric region (De Goei et al. 2010, 1152).

2.3 Reasons for the development of polycentric regions

A number of reasons may lead to the relocation of firms and households into secondary employment centres. Most reasons can be summarised as economic, for example cheaper land sites in the surrounding region. Other reasons can be traced back to changes in technology or society (Kloosterman and Musterd 2001, 624).

One example of change due to technological reasons is the change to traffic infrastructure and the corresponding costs of transportation. The shift from using railway systems – as an ideal means of transport for monocentric cities – to individual transport by car and lorry has led to a decrease in the importance of radial transport systems and to the possibility of using new settlement areas in urban regions that were previously too remote. A network structure of the transport system, however, results in intensive commuting patterns between all towns in the region and not only radial commuting patterns centred on one core city. Therefore the whole region can be used as a potential location for living and working (Oostendorp 2011, 114).

An example of changing societal values and their consequences for settlement structures is the development of new lifestyle designs. The Fordist lifestyle model characterised by the separation of living and working sites is increasingly losing importance. Boundaries between work and leisure activities as well as traditional role models – with one main wage earner – are displaced by double incomes and more flexible spatial organisation of everyday life (for example with regard to child care and leisure organisation). Such changes result in new expectations with regard to the place of residence that can be fulfilled either by combining working and living within one large core city (Growe and Münter 2010, 58–59) or within dense urban regions with many hubs (Kloosterman and Musterd 2001, 625–626).

Beside cheaper land in surrounding areas, structural economic reasons can also be found to explain regionalisation processes. Modifications in economic processes are important drivers of regionalisation and can lead to changed patterns of production, for example in form of altered patterns of economic specialisation. Duranton and Puga (2005) argue that with improved organisation in economic processes sectoral specialisation – characterised by core-peripheral patterns – is displaced by functional specialisation and characterised by different economic specialisation of cities. The development of specialised urban locations leads to an increase of interaction and flows between these different sites. In regions where former secondary hubs can complement huge core cities polycentric metropolitan regions arise.

Changes in the spatial organisation of economic activities do not only explain the development of polycentric urban regions but connect also the discussion of spatial structures with the formation of the knowledge economy.

2.4 Polycentric metropolitan regions and metropolitan service activities

Over the last decades, not only geographical reference areas of economic production changed, but also the methods and products of economic activities (Drucker 1969; Ohmae 1996). In this context, especially the qualitative shift of the role of knowledge within economic processes is discussed (Piore and Sabel 1985; Bell 1989; Stehr 2001).

Knowledge is regarded as a crucial factor in economic processes, both as a tradable product and as a production factor. The increasing importance of knowledge within economic processes, for example within global control of economic activities, leads to an increase in the importance of places where such knowledge can be produced and used most effectively, especially by knowledge-based services (Kujath 2009, 201; Growe and Blotevogel 2011; Hanssens et al. 2012).

According to Dunning (2002), the increased importance of knowledge-based economic activities leads to an increased importance of large core cities and agglomerations: "To minimise distance-related transaction costs, and to maximise the benefits of dynamic learning economies, it frequently pays firms to concentrate their activities within a limited spatial area" (Dunning 2002, 15). The observation of a concentration of knowledge-based services in large

core cities and agglomerations, especially in industrialised countries, is confirmed by a number of authors (Sassen 1991; Sassen 1997; Senn 1993; Taylor et al. 2002; Krätke 2007).

To sum up, due to high transaction cost sensitivity, knowledge-based work is assumed to show a certain urban affinity. Cities offer the necessary face-to-face contacts and a broad variety of interaction partners to prevent lock-in effects. Therefore, at first sight, the urban affinity of knowledge-based economic activities may seem to oppose regionalisation processes that lead to polycentric regions.

Then again, the increasing density of metropolitan regions can also be understood as supporting factor for the attraction of knowledge-based activities in metropolitan regions (Krätke 2007; Blotevogel and Schulze 2009). Lüthi et al. (2012, 4) developed a mega-city-region model that – by systematically combining local agglomeration economies and global network economies – derives the evolving of polycentric urban regions from the need of the knowledge economy to local as well as global accessibility and integration. Therefore metropolisation and regionalisation can also be understood to be complementary processes.

Based on these approaches, this paper discusses two questions.

1. Are knowledge-based activities affected by processes of regionalisation to the same extent as economic activities in general? Processes of regionalisation are analysed by studying changes of locations of different occupational groups within metropolitan regions.
2. Can we observe a development from radial patterns of flows into network patterns of flows within metropolitan regions in Germany? To answer this question changes of commuting patterns have been analysed in monocentric and polycentric metropolitan regions.

To sum up, this paper aims to subsume two research strands (the discussion of polycentric metropolitan regions and the discussion about the increasing importance of knowledge-based activities in metropolitan regions) and asks if these processes oppose or support each other.

3 Study area, data and method

To analyse whether processes of regionalisation can be found in German metropolitan regions and if knowledge-based activities show a stronger affinity towards core cities or show a similar extent of regionalisation as economic activities in general, the relocation of employees within metropolitan regions is analysed. The following sections introduce the three sample regions, the data used and the methods used.

3.1 Study area

The bases of the analyses are three metropolitan regions: Berlin, Munich, and Rhine-Main (surrounding the large core city of Frankfurt), that show complementing morphological and functional structures (see Tab. 1). By choosing Berlin, changes in a morphological and functional monocentric region can be observed. Rhine-Main shows changes in a morphological and functional polycentric structured region. Whereas the Munich case offers the observation of changes in a region, that is characterised by both structures: monocentrism and polycentrism.

In the following analyses, statistical data of employees at county (LAU 2, local administrative unit 2) level is used. The delimitations of the metropolitan regions are based on the boundaries of political cooperation. In the choice of these boundaries, no analyses of political spheres of activities are intended. Rather, these choices aim to analyse intra-regional, local changes in the context of a broader region than – for example – the density criteria of the BBSR (Federal Institute for Research on Building, Urban Affairs and Spatial Development) suggests.

However, to analyse whether changes within the metropolitan regions occur in favour of large core cities, in favour of secondary centres or in favour of other counties, the classification of counties of the BBSR is used and aggregated to five different regional types (Tab. 2).

The spatial patterns of core cities, of secondary centres, and of other counties are shown in the maps in figure 2.

Tab. 1: Morphological and functional structure of three metropolitan regions

Structure	Berlin	Munich	Rhine-Main
morphological	monocentric	monocentric	polycentric
functional	monocentric	polycentric	polycentric

Tab. 2: Aggregated typology of counties (LAU 2)

New typology	Typology of the BBSR
Core cities (1)	(1) large core cities in agglomerations, (2) core cities in agglomerations, (9) core cities in urbanised regions
Secondary centres in urbanised areas (2)	(3) centres of medium and upper centrality in areas of high density in agglomerations, (5) centres of medium and upper centrality in dense areas in agglomerations, (7) centres of medium and upper centrality in rural areas in agglomerations, (10) centres of medium and upper centrality in dense areas in urbanised regions, (12) centres of medium and upper centrality in rural areas in urbanised regions
Other counties in urbanised areas (3)	(4) other counties in areas of high density in agglomerations, (6) other counties in dense areas in agglomerations, (8) other counties in rural areas in agglomerations, (11) other counties in dense areas in urbanised regions, (13) other counties in rural areas in urbanised regions
Secondary centres in rural areas (4)	(14) centres of medium and upper centrality in rural areas of higher density, (16) centres of medium and upper centrality in rural areas of lower density
Other counties in rural areas (5)	(15) other counties in rural areas of higher density, (17) other counties in rural areas of lower density

3.2 Data

The territorial data used in this paper are 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 70% of the total workforce. Employees are differentiated on the basis of their occupations (sozialversicherungspflichtig Beschäftigte nach Berufsordnungen), and this in turn is based on the occupational classification of 1988 (KldB 88 BA). The classification of employees by occupation is based on the current type of activity performed and not on recent activities or on qualifications. This classification makes it possible to draw conclusions about functional spatial patterns.

With regard to questions concerning knowledge-based activities, the choice of occupational groups is based on the identification of knowledge-based professions of Hall (2007). Hall (2007, 46) systemises occupants according to the research intensity of the labour and according to the share of highly qualified personnel which results in a differentiation of six occupational groups: engineers, technicians, IT-related jobs, consulting, creative and media jobs, and other knowledge-intensive jobs.[1)]

To enable a comparison of changes over time and therefore processes instead of status, two data sets from 1997 and from 2007 are used. By choosing this period, a comparison of the results of this paper with other studies, concerning changes in the German urban system, should be enabled (c.f. Krätke 2007; Krätke 2010; Blotevogel and Schulze 2010; Growe and Blotevogel 2011; Knapp and Volgmann 2011; Growe 2012b).

In addition to the location-related data of the employment statistics, commuting data are also used. These data are also based on workers who pay social insurance contributions. In this respect, the commuter statistics are not complete, but it is sufficient to reproduce the essential spatial labour market linkages. To analyse regionalisation processes, these flow data (including information about living and working location) play an important role. On the basis of such data it is possible to analyse not only changes in working locations but also changes in interaction networks within the region.

In this paper, commuting balances (balance of inbound commuters and outbound commuters) are analysed as well as commuting flows within the region. Based on the balances of commuters, changes in the integration of a county as a working location and therefore as a potential hub within an urban region can be detected. On the basis of commuter flows, changes with regard to the

[1)] Occupations that are aggregated as "knowledge-based professions" – the Kldb 88 BA code is shown in brackets: accountancy (753, 771, 772), advertising (703, 833, 834, 835, 837), architecture (603, 604, 623, 624), consulting (752), consultant engineers (611, 612, 626), data management (774), finance (691, 692), ICT services (602, 622), insurance (693, 694), law (811, 812, 813, 814), management (751), media (821, 822), real estate (704).

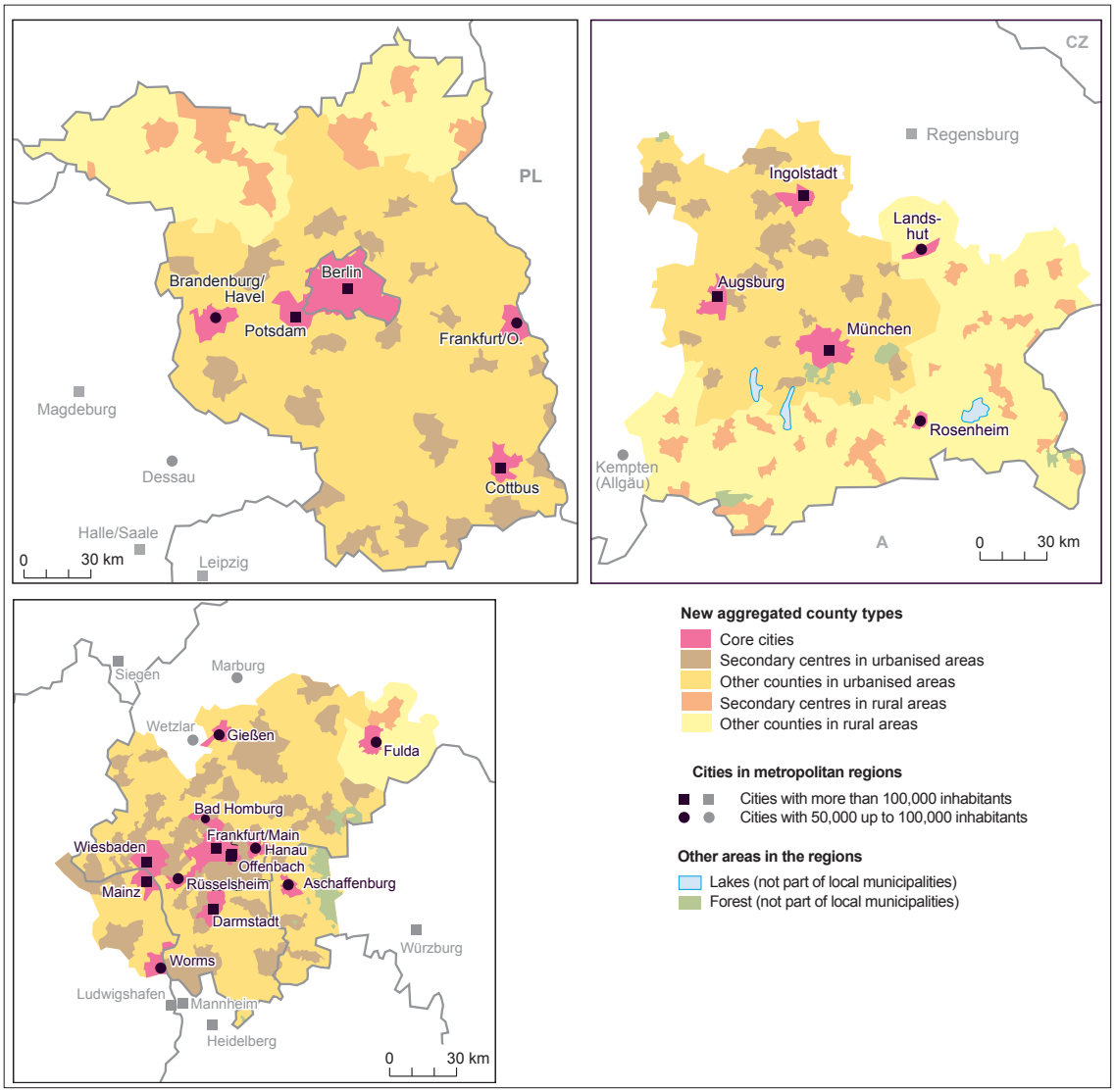

Fig. 2: Spatial patterns of county types in three metropolitan regions

development of radial structures towards network structures can be identified.

To sum up, occupational data enables conclusions about locations and processes of relocations of knowledge-based services within metropolitan regions and commuting data enables conclusions about flows between different cities within metropolitan regions. Therefore, occupational data are used to discuss whether knowledge-based activities show similar processes of regionalisation as economic activities in general (question 1). Commuting data are used to analyse the emerging network patterns of flows (radial or network patterns that hint on mono- or polycentric regions) with regard to question 2.

3.3 Method

Processes of regionalisation not only affect different places in an urban region by themselves, but most notably the relationship between locations within a region. Changes within a region must therefore be understood to be relative changes and the measurement of hubs within networks must refer to the relative nature of these changes. In this paper, changes in professions from 1997 to 2007 are measured by the (relative) change in the importance of an individual city in the network of cities.

- First, the importance is measured by the percentage share of each county in the overall network at different points in time.

- Second, the change between the percentage shares of each city at both times is calculated.
- Third, z-scores of the percentage change are calculated. This is carried out to show whether the change in importance (CI) is above average or below average.

CI values between -1 and 1 are considered to be a small change, CI values between -2 and -1 and CI values between 1 and 2 are considered to be a medium change, and CI values > +2 or < -2 indicate 'exceptional change' in statistical terms.[2)]

4 Results

The following sections show empirical results with regard to the question as to whether processes of regionalisation can be observed in the German polycentric urban system and if knowledge-based activities are affected to the same extent as economic activities in general. To discuss these questions, firstly processes of regionalisation are analysed by studying changes in locations of workplaces with regard to the new typology of core cities, centres of medium and upper centrality in the region and other locations. Secondly, spatial patterns of the places with changing importance as a location for work within the metropolitan regions are taken into consideration.

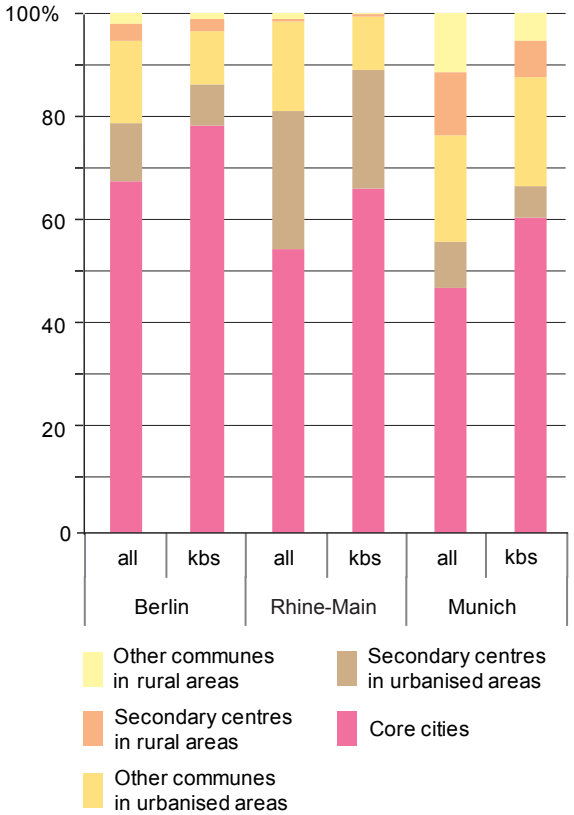

Fig. 3: Distribution of all employees (all) and of employees in knowledge-based services (kbs) according to new county types. Source: BA, own calculation

4.1 Polycentrism in the three metropolitan regions and processes of regionalisation

Figure 3 shows the proportional distribution of all employees and of employees working in knowledge-based services with regard to the newly aggregated county types at baseline (1997). The figure shows that the region of Berlin is strongly monocentric. In Berlin, almost 70% of all employees and nearly 80% of employees working in knowledge-based services are located in the few core cities of the region of Berlin.

The regions of Rhine-Main and Munich are much less monocentrically structured as the share of the core cities relative to the distribution of employees is much smaller. However, the localisation of the workforce differs in these two regions. In the Rhine-Main region, the employees are – apart from in the core cities – located in further centres in the surrounding area. In the Munich region a very large proportion of employees are located in other counties, in the urban hinterland.

After all it is important to consider that this structure is not static but changes over time. So what parts within the metropolitan regions gain in importance over time? Do changes happen in favour of core cities or in favour of smaller centres within the region? Figure 4 shows the percentage change in number of employees for all three metropolitan regions according to the new types of counties. Figure 5 shows the percentage change in number of employees working in knowledge-based services.

First of all, figure 4 shows a difference between Berlin and the other two regions. The region of Berlin as a whole is characterised by a decrease in employment: the number of employees decreased in all county types, but the decrease in the core cities is smaller than in other county types. Therefore, the changes lead to in-

[2)] 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. However, the outlined calculation used in this paper has been modified. Instead of calculating z-standardised changes on the basis of z-standardised values in this paper, z-standardised changes on the basis of percentage shares are used to facilitate the understanding of the calculation and the interpretation of data.

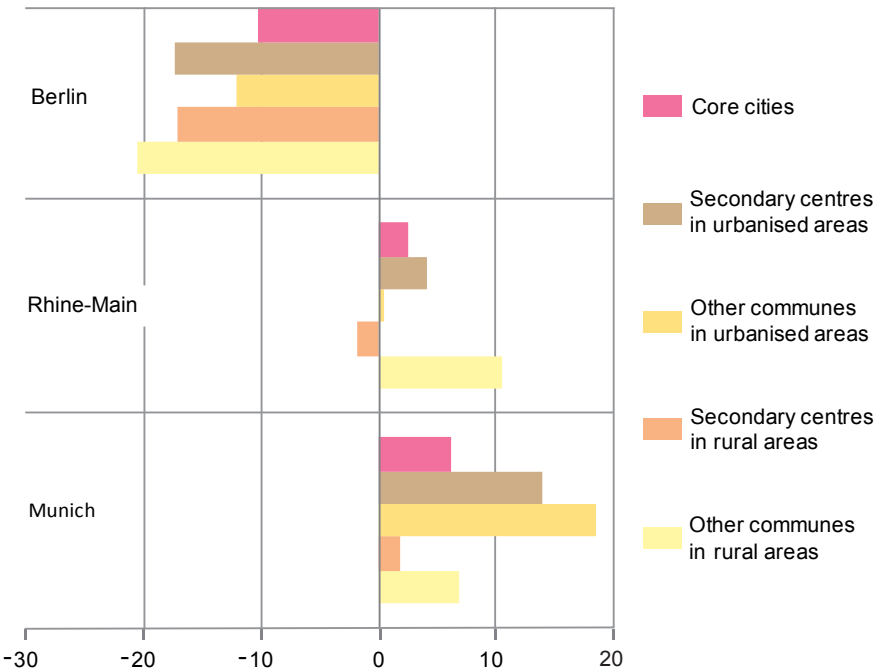

Fig. 4: Percentage change (1997–2007) in all employees according to new county types. Source: BA, own calculation

direct concentration processes. In contrast, the regions of Rhine-Main and Munich are defined by growth processes in all types of municipalities (with the exception of centres of medium and upper centrality in rural areas in the region of Rhine-Main) and in both cases the growth is bigger in centres in the urban hinterland than in the core cities themselves. Therefore in both regions processes of regionalisation can be observed.

A similar process can be observed with regard to the change in employees in knowledge-based services (see Fig. 5). Due to the shrinking processes in the hinterland of Berlin and the growing processes in the core towns of Berlin, concentration processes can be detected in the region of Berlin. In contrast, regionalisation processes can be identified in Rhine-Main and in Munich in which different county types are favoured. In Rhine-Main, regionalisation processes favour centres of medium and upper centrality in urbanised areas. Catching-up processes can be observed with regard to rural areas. In Munich, regionalisation processes in favour of urbanised areas without centres can be observed.

To sum up, Berlin is determined by concentration processes whereas Rhine-Main and Munich are determined by regionalisation processes. The latter are, however, favouring different parts of the metropolitan region: in Rhine-Main the secondary centres are favoured and in Munich suburban areas without specific centres are favoured.

4.2 Spatial patterns of the centres changing in importance within metropolitan regions

In the following sections, spatial patterns are analysed to understand these processes. Four maps are presented for each region and relative changes are shown on these maps. With regard to the method of changes in importance (CI values) presented in section 3, positive relative changes are shown in red and negative relative changes are shown in blue.

Berlin

The major employment losses in Berlin (see Fig. 4 and 5) have also been discussed by other authors (c.f. Krätke and Borst 2000; Geppert 1999; Reissert and Schmid 1999; Geppert et al. 2005) and are concluded to result from the special initial conditions of the city after German reunification. With the reunification of Berlin, two previously separate labour markets with a very atypical employment structure were reunified. After the reunification of Berlin, the reduction in overstaffing in the public sector as well as the process of de-industrialisation led to a massive decline in employment in Berlin. The empirical results of this study suggest that the convergence of Berlin's economic structure with

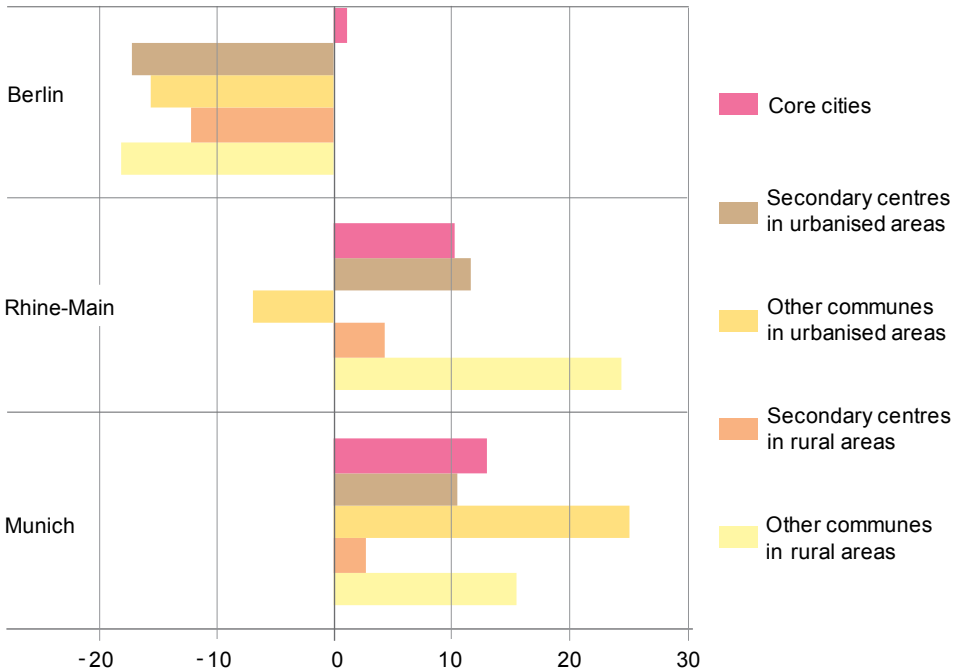

Fig. 5: Percentage change (1997–2007) in employees in knowledge-based services according to new county types. Source: BA, own calculation

the structure of West Germany has not yet been completed. Intra-regional variations must therefore be interpreted in relation to a reduction in employees in the region.

The maps in figure 6 show the relative change in the importance of all municipalities in the Berlin region as locations of economic activity between 1997 and 2007. The concentration processes of employees and employees in knowledge-based services (already discussed on the basis of figures 4 and 5) can be recognised in the upper maps in figure 5, too. Berlin and Potsdam are marked with dark red colours that indicate an exceptional relative increase in importance. Even cities like Frankfurt (Oder) and Cottbus lose in relative importance as locations of economic activities (dark blue colours).

Several aspects may be discussed as reasons for this development (Krätke and Borst 2000; Geppert et al. 2005; Growe 2012a, 192):

- The core city of Berlin is – compared to the national average – still relatively inexpensive.
- The core city of Berlin provides – unlike the cities of Munich and Frankfurt am Main – a broad and comprehensive range of building areas.
- Negative agglomeration effects are not very influential in Berlin (e.g., residential and commercial space is not as scarce and expensive as in the cities of Frankfurt and Munich).
- However, positive agglomeration effects (e.g., infrastructure and a minimum density of economic subjects) lead to significant locational advantages over the surrounding countryside.

Taken together, these factors do not represent pressure towards an expansion of economic activities from the core city into the hinterland.

Munich

By contrast, the Munich region is determined by processes of regionalisation. These processes have been discussed on the basis of figures 4 and 5 and their spatial patterns seen in the maps in figure 7.

The difference between the increase in employees, both in general and also in knowledge-based services (see Fig. 4 and 5), and the relative loss of importance of the core city of Munich in the upper maps in figure 7 indicates a strong positive economic dynamic within the region. Consequently, this dynamic leads to high expansion pressure and to above-average employment growth in surrounding areas, supported by a lack of building areas within the city of Munich.

On the one hand, the expansion pressure favours other core cities (Ingolstadt) and secondary

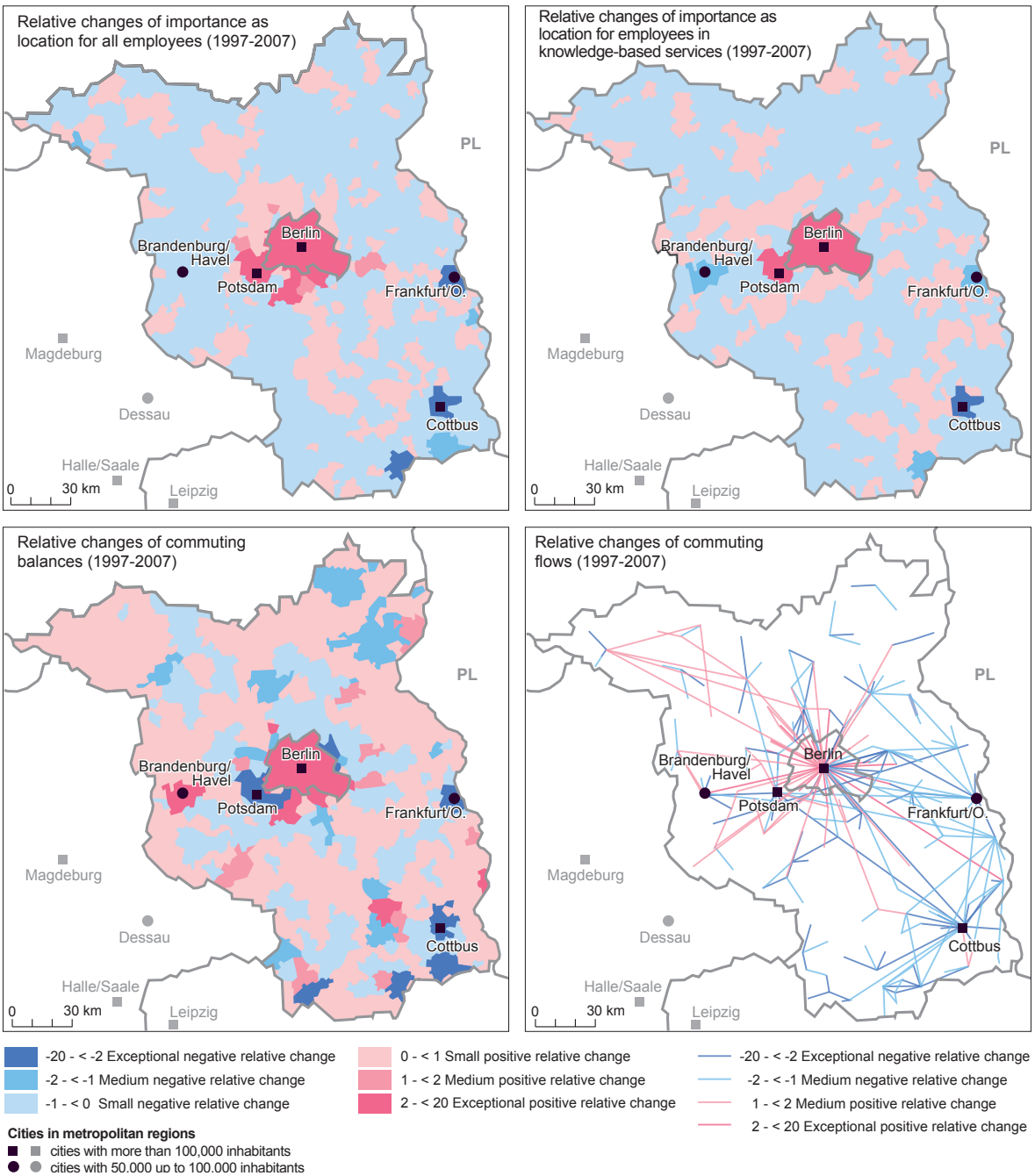

Fig. 6: Relative changes in importance as location for economic activities in the Berlin region. Source: BA, own calculation

employment centres (Donauwörth, Vilsbiburg, Penzberg). On the other hand, also suburban areas without a distinct centre are favoured. The spatial patterns reveal that these are mainly areas in the corridor between the central core city of Munich and Munich Airport. Due to the particular dynamics of this corridor, changes in importance of this county type can be put into perspective.

The maps in figure 7 below show relative changes in commuting patterns. The relative changes of commuting balances show an increasing independency of the surrounding secondary centres (e.g. Freising and Erding) as the location of working places as the relative positive balance increases. The relative change in commuting flows indicates a growing network of interaction between

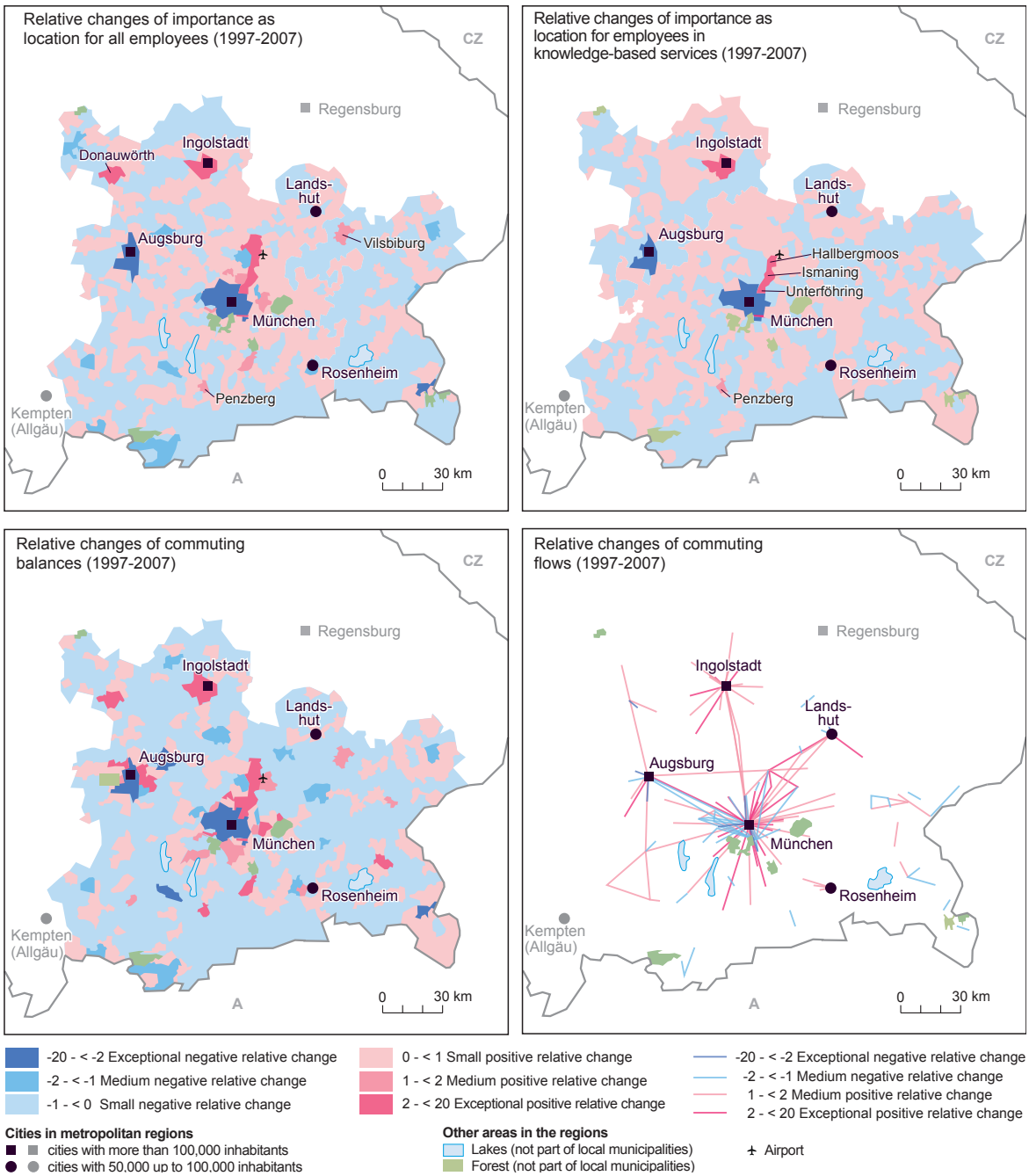

Fig. 7: Relative changes in importance as the location of economic activities in the Munich region. Source: BA, own calculation

Munich itself and the surrounding cities. However, between the cities, for example between Augsburg and Ingolstadt, the flows do not increase. The final step of increased criss-crossing interaction therefore does not seem to have been accomplished yet. An interesting exception is the increase in commuting flows between the airport location, the core city and neighbouring municipalities.

Rhine-Main

As in the Munich region, processes of regionalisation can be observed in the Rhine-Main region. The maps indicate strong regionalisation processes for economic activities and simultaneous growth of the core cities, from which only the industrial areas in the region are excluded (Rüsselsheim, Hanau and

Mühlheim am Main, which are the industrial axis along the Main, indicated by the dark blue colour in the upper maps in figure 8).

Comparing regionalisation processes of all employees and of employees in knowledge-based services, slight differences can be detected. The development of all employees indicates a general growth process: an exceptional relative change can be observed in the large core city as well as in the surrounding cities and secondary centres.

The regionalisation process of employees in knowledge-based services shows slight negative rela-

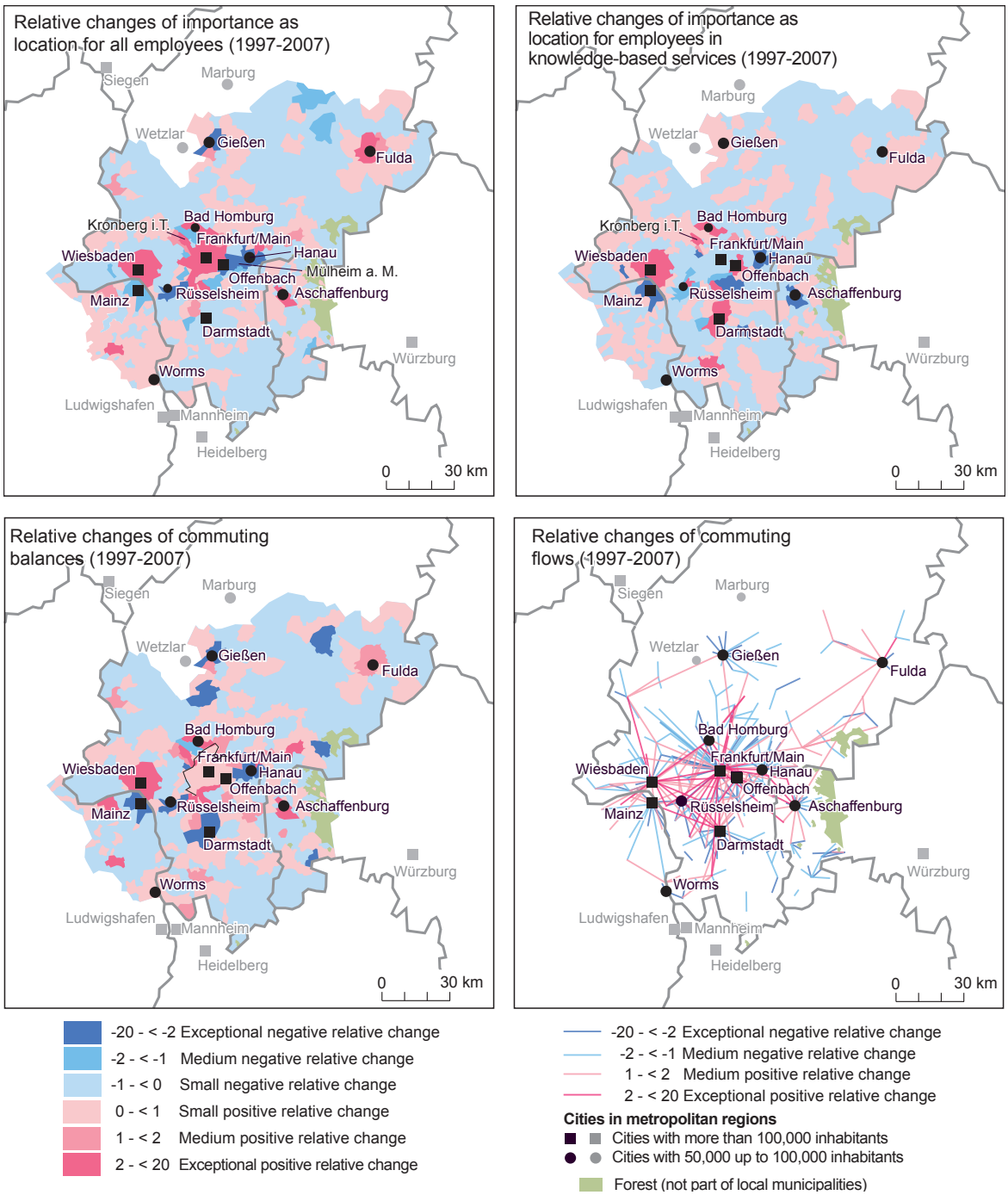

Fig. 8: Relative changes in importance as the location of economic activities in the Rhine-Main region. Source: BA, own calculation

tive changes in the large core city of Frankfurt. The percentage change (see Fig. 5), however, indicates an increasing number of employees in the core city. Therefore the exceptional relative change in the surrounding cities (e.g. Kronberg and Bad Homburg) does not indicate a change at the expense of the core city, but a general growth with distinct catching-up processes in the surrounding areas.

A positive relative intra-regional change with regard to employees in knowledge-based services can be identified especially in Wiesbaden, in the big cities in Southern Hesse (Darmstadt and Bensheim) and in the Taunus (Bad Homburg and Kronberg). It can be assumed that the growth in importance of these locations can also be explained by the accessibility of the core city as well as the airport.

In comparison to the Munich region, it is striking that the locations in the region of Rhine-Main close to the airport show a less exceptional development. Firstly, Frankfurt airport is located on the territory of the city of Frankfurt and secondly, Frankfurt airport is – in comparison to Munich airport – significantly better accessible.

The relative changes in commuting balances show increasing independency of the surrounding secondary centres from the core city so that inhabitants of these centres do not rely on commuting to the core city. The relative importance of the core city decreases. At the same time the surrounding centres develop into important locations for workplaces and gain importance within the region. Notable examples of this process are the exceptional positive relative changes of commuting balances in Kronberg and Bad Homburg. As a result of these overlapping processes we can observe an increase of miscellaneous dependent relations within the region. The map of the relative changes of commuting patterns also shows an increasing criss-crossing interaction and therefore an increasing network structure.

5 Conclusion

According to Taylor (2004), relations between cities take two major forms: reciprocal and equal exchange between cities and a relationship characterised by dependent exchanges between cities and their hinterlands. According to this classification, local relations between cities and their surrounding secondary centres in metropolitan regions would be characterised by hierarchical dependencies. However, the location of economic activities and – correspondingly – flows of people, goods and services may change within a metropolitan region. In this regard it can be asked if relations between large cities and secondary centres within the region also change.

The *first question*, discussed in this paper, deals with changed relations between large cities and secondary centres in the knowledge economy. It has been asked whether knowledge-based activities are affected by processes of regionalisation to the same extent as economic activities in general. Processes in the three sample regions show that – in prospering regions like Munich and Rhine-Main – processes of regionalisation can also be detected for knowledge-based activities.

According to Kloosterman and Musterd (2001) a relocation of economic activities from the core cities to larger cities in the regional hinterland can be expected as a result of these lower transport costs in general and negative agglomeration effects within dense urban cores. By relocating their sites to new centres, companies can save costs and still have access to qualitative urban infrastructure and participate in positive agglomeration economies. However, due to the importance of transaction costs for many economic activities, especially in the knowledge-based services sector, a location in other *cities* in polycentric regions can be expected to be more attractive than a location in the suburbanised or rural hinterland.

The empirical results of this paper do support these assumptions. In particular the case of the Rhine-Main region shows the growth in the economic importance of surrounding cities by increasing positive relative changes and catching-up processes of smaller cities within the region. Also the explicit increase in positive commuting balances in surrounding centres and the relative increase in criss-crossing commuting patterns support the assumption of regionalisation in favour of smaller cities within the region.

Also processes in the Munich region support this idea. In this region the relative change in the importance of locations as economic centres and the relative changes of commuting networks reveal another crucial development. Airport locations play a special role in the regionalisation process in metropolitan regions (c.f. Bontje and Burdack 2005; Witlox and Derudder 2007; Haas and Wallisch 2008; Dross and Thierstein 2011; Thierstein and Dross 2010). In the example of the Munich region, this special role is particularly evident. The development of the municipalities of Hallbergmoos, Ismaning and Unterföhring in the Munich region serve as an outstanding example of the emergence of new centres in the vicinity of airports. The maps in figure 7 show that these and other communities (c.f. Dross

and Thierstein 2011) along the local railway line to the airport have been monitored to experience significant job gains after the relocation of the airport in 1992 to its present location.

The airport's economic importance within the metropolitan region can be explained not only by international accessibility and its transportation function. Through convention and meeting facilities at the airport itself and within airport hotels (Castells 1996; McNeill 2009) as well as through the adjacent office sites, the airport itself becomes a place of face-to-face interaction. Expressed in the terminology of Bathelt et al. (2004) airports are not only parts of the *global pipelines*, but also form an important part of the *local buzz*.

The case of the metropolitan region of Berlin, however, hints on special preconditions that enable regionalisation processes in metropolitan regions. The decrease in economic activities and low expansion pressure due to cheap and adequate building sites has led to a concentration within the region.

To summarise, if metropolitan regions are determined through economic prosperity, processes of regionalisation can take place. Such processes lead to an enrichment of the region with economic activities, including knowledge-based activities, in which secondary centres are favoured.

The *second question*, discussed in this paper, asks whether a change from radial patterns of flows into network patterns of flows can be observed in metropolitan regions in Germany. Changes of commuting patterns in the three sample regions show varying results. First, in the Berlin case, no change towards a network pattern can be observed. On the contrary, the radial pattern even increases. However, Berlin is the monocentric sample region and economically less prosperous than the other two sample regions. A possible simple explanation therefore would be that Berlin – due to less development pressure – doesn't develop into a polycentric urban region.

Changes of commuting patterns in the other two regions are more complex. In the Rhine-Main region commuting patterns relate to a morphological and functional polycentric region. The patterns already show a network pattern, even at the beginning of the analysed time span. However, the visualisation of relative changes of commuting flows indicate, that the network structure expands by increasing relations that bypass the biggest city (Frankfurt). Examples of these relations are the exceptional positive relative changes of flows between Bad Homburg and Wiesbaden, between Hanau and Aschaffenburg or between Darmstadt and Mainz.

In the Munich region we find an interesting case of transition. The commuting pattern is still visibly influenced by a radial structure. However, new hubs, bypassing the core city of Munich are developing. Interestingly, these new hubs are not located in other core cities but in the secondary centres Freising and Erding, close to the airport.

To conclude, the changes of commuting patterns teach us two things. First, there is no explicit either radial or network structure but an infinite number of possible transition patterns, floating between theoretically defined extremes. Second, anchor points in evolving networks tend to be cities (e.g. Wiesbaden, Mainz, and Darmstadt in Rhine-Main or Augsburg and Ingolstadt in the Munich region). However, also smaller secondary centres may work as anchors within evolving networks, when infrastructure facilitates accessibility (e.g. the Munich airport and the close by secondary centres Freising and Erding). Especially with regard to requirements of the knowledge economy, the question of accessibility is crucial (Bentlage et al. 2012) and may hint towards new network formations within polycentric urban regions.

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Author

Dr. Anna Growe
Institute of Cultural Geography
Albert-Ludwigs University of Freiburg
79085 Freiburg
anna.growe@geographie.uni-freiburg.de