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METROPOLISATION THROUGH REGIONALISATION? SPATIAL SCOPE AND ANCHOR POINTS OF METROPOLITAN FUNCTIONS IN GERMAN URBAN REGIONS

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ABSTRACT

Based on topics of research examining how metropolisation processes affect the areas surrounding metropolitan centres and change the locations of metropolitan functions in urban regions, this article examines: (i) how pronounced the process of the regionalisation of metropolitan functions is; (ii) in which sub-areas of a surrounding region the regionalisation of metropolitan functions can be observed and (iii) which places are anchor points of metropolitan regionalisation. The regionalisation processes are studied using a municipal-level dataset of metropolitan functions from German urban regions. The findings indicate that centrifugal forces distribute metropolitan functions across the surrounding region around one or more metropolitan core cities, and that this is, for the most part, linked to medium-sized cities and to the complementary areas of metropolitan centres.

Key words: metropolisation; metropolitan functions; regionalisation; urban regions; polycentric regions; Germany; surrounding area

INTRODUCTION

Intensive changes in metropolises and their surrounding areas can result from both concentration and parallel regionalisation processes. In 1933, Colby already characterised agglomeration processes in modern cities as an interplay between centrifugal and centripetal processes, using the example of American metropolises during the economic boom of the 1920s and early 1930s (Colby 1933). While the inner-city becomes a centre of attraction for complex functions, new qualities develop in the outer areas. Centrifugal forces lead to a regionalisation of various urban functions surrounding the core city (Volgmann *et al.* 2022). Changes relate not only to the location of the

population or jobs, but also to the location of high-ranking functions that decisively characterise the significance of the metropolis (Meijers *et al.* 2016). It is undisputed in the literature that both a process of concentration (in favour of large agglomeration areas) and, in parallel, a process of deconcentration into the region (within the agglomeration areas) can be observed (Cardoso & Meijers 2021; Volgmann & Münter 2022).

It has not been conclusively clarified, however, how strong and how far the centrifugal forces act into a region. Questions regarding the newly emerging spatial structure are also still open (Growe 2012; Cardoso & Meijers 2021). Will polycentric structures emerge as a result of centrifugal forces within the agglomeration

areas, oriented towards existing or new centres? Or will dispersed inter-urban landscapes emerge, their peri-urban structures leading to a further blurring between centres and the landscape?

In order to understand how strongly, and where, surrounding regions are urbanising, this analysis is based on metropolitan functions (Volgmann 2014; Growe 2018). Metropolitan functions are the features of cities of particular size and importance, which can be differentiated into sub-functions, to conceptualise how comprehensively and well certain tasks can be fulfilled by cities (Blotevogel & Schulze 2009). Indicators, such as the locations of economic and political organisations, the location of innovation and knowledge actors or the location of communications and transportations hubs, can be used to analyse whether and to what extent sub-areas can fulfil special urban tasks through metropolitan features.

The aim of this paper is thus to address the following questions:

1. How pronounced is the regionalisation of metropolitan functions? In which sub-areas of a surrounding region can the regionalisation of metropolitan functions be observed?
2. Does the intensity of regionalisation differ for different metropolitan sub-functions? Do changes in the locations of metropolitan functions differ for the various metropolitan sub-functions?
3. Which places are the anchor points for metropolitan regionalisation? Can scattered metropolitan dispersion be observed to start at the centre, or is there polycentric metropolitan development, linked to existing or new centres in the surrounding region?

By providing information using small-scale data at the municipal level, this paper complements the body of literature on the results of centrifugal forces distributing various metropolitan functions across city regions, and on how far the effects of a metropolis reach across a region.

This paper is structured as follows: the *introduction* is followed by the *theoretical foundation* of the study (Section 2), which presents the various strands of argumentation on *metropolisation as a result of concentration processes*, *metropolisation*

as a result of regionalisation processes and *metropolitan functions*. Presenting the *research design*, Section 3 details the *study region* and the procedure of *measuring metropolitan functions* used in *constructing metropolitan indices*. Section 4 contains the *analyses and empirical results* in response to the three research questions. The paper concludes with a *discussion* (Section 5) that summarises the results and provides suggestions concerning further research needs.

THEORETICAL FOUNDATION

The focus on agglomeration processes in larger cities, and the changing relation between such cities and their surroundings, has been subsumed under the term ‘metropolisation’¹ (Meijers *et al.* 2014; Cardoso & Meijers 2021). While this work addresses the broad topic of metropolisation, it also focuses on the development of new anchor points in metropolitan regions through the localisation of metropolitan functions in the surrounding regions. As metropolisation refers to complex, interlinked processes, including various scales, such as cities, their surroundings and urban systems, we differentiate ‘metropolisation processes’ as resulting from both concentration (centripetal) and regionalisation (centrifugal) processes. Both processes have been discussed for some time. In 1933, Colby already differentiated centripetal and centrifugal forces that influence changing functional locations within city regions. Although some of the discussed reasons for centripetal and centrifugal still hold, the scale and also the structural change of the economy towards a knowledge economy have changed some reasons and spatial consequences.

Metropolisation as a result of concentration processes – Our understanding of metropolisation as resulting from concentration processes has developed against a background of globalisation processes (Krätke 2007; Pumain & Rozenblat 2019). Pumain and Rozenblat (2019, p. 1646) summarised the understanding as follows: ‘Metropolisation is a term used in urban geography for coining the concentration of attributes associated with the highest levels of urban functions in large cities’. The reasons

for these concentration processes can be found in agglomeration economies and the structural changes towards knowledge-based and cognitive-cultural economies (Krätke 2007; Scott 2008). The positive agglomeration externalities that foster concentration processes and metropolisation include benefits due to a large (local) market (Keeble & Nachum 2002); the provision of a prestigious address (Colby 1933); a large labour supply and, thus, the increased opportunity to quickly balance the supply and demand for labour, especially for specialists; the agglomeration of knowledge and human capital that can lead to processes of knowledge spillover between companies (Breschi & Lissoni 2001); the facilitation of face-to-face contact (Storper & Venables 2004; Growe 2019); as well as easily accessible, high-level infrastructure (e.g. transportation infrastructure) (Colby 1933; Beaverstock *et al.* 2010) and trade fairs (Maskell 2014).

This understanding of metropolisation refers not only to a concentration of functions in a few metropolises, but it also assumes changed relations between the cities. Metropolisation is assumed 'to increase inequalities among cities in national and transnational urban systems and reinforces their hierarchical structure over time' (Pumain & Rozenblat 2019, p. 1646). In referring to metropolises as parts of urban systems and their relationships to other cities, metropolisation research also refers to the changes in global urban systems (Derudder 2008; Derudder & Taylor 2016) and Global or World Cities that result from concentration processes caused by economic globalisation (Derudder & Taylor 2020). The common roots of metropolisation research and Global/World Cities research can be traced back to the world city approach, under which a city is to be seen as a base for global capital and as a centre of power (Hall 1966; Friedmann 1986).

However, while Global/World City research has developed a strong focus on the network characteristics of cities—or the process of city-ness, as coined by Taylor *et al.* (2010)—the metropolisation research is strongly concerned with the relationships between metropolises and their surroundings—or the process of town-ness, as coined by Taylor *et al.* (2010). While

city-ness describes equivalent, horizontal connections between cities, and explicitly extends beyond the immediate surroundings of a city, town-ness has been conceptualised in terms of central place theory. Here, the connection between cities and their surroundings is understood to be a hierarchical relationship in which the city (or metropolis) assumes a supply function vis-à-vis its surroundings (Taylor *et al.* 2010). Taylor *et al.* (2010) argued that both processes (city-ness and town-ness) have always existed in parallel in cities, but the importance of the two processes in the development of individual cities may differ (Humer & Granqvist 2020). Some cities are more characterised by city-ness processes and less by town-ness processes, whereas others are more characterised by town-ness processes and less by city-ness processes.

While the urban network focus on analysing city-ness processes has been covered by a broad and well-established body of literature (Derudder & Taylor 2016, 2020), the analysis of town-ness processes, and the relationship between metropolises and their surrounding areas is not simple and goes far beyond the identification of catchment areas (Blotevogel 2004; Meijers *et al.* 2016). Metropolises have repeatedly been discussed as cities of the highest hierarchical level in the central place system and have been linked to analyses of their catchment areas, beyond their respective nation-states (Christaller 1950; Blotevogel 2004). More recent approaches, however, have mainly been concerned with changes in the relationship between metropolises and their surrounding areas (Schmitt *et al.* 2015; Volgmann *et al.* 2022; Volgmann & Münter 2022) and with changes in the polycentric, regional urban systems around one or more large metropolises (Bontje & Burdack 2005; Meijers *et al.* 2016; van Meeteren *et al.* 2016).

Following Cardoso and Meijers, highlighting 'polycentricity as a defining feature of metropolisation, as well as intra-regional convergence indicating a process of integration' between the metropolitan agglomeration and the region (Cardoso & Meijers 2021, p. 6), metropolisation is not only a result of concentration processes, but also of regionalisation processes.

Metropolisation as a result of regionalisation processes – While metropolisation as result of concentration processes is based on the assumption of centripetal forces, the explanation for metropolisation as a result of regionalisation processes is based on the assumption of centrifugal processes. The latter perspective follows the assumption that agglomeration benefits are no longer limited to the large core cities, but work in favour of the whole city region. It has been assumed that centrifugal forces distribute urban functions over a large area (Meijers *et al.* 2014; Cardoso & Meijers 2021). Reasons for the enrichment of urban functions in metropolitan regions include agglomeration disadvantages – particularly high rents and land prices in core locations, as well as poor accessibility due to city-centre traffic congestion (Colby 1933; Volgmann *et al.* 2022).

Against the background of polycentricity and intra-regional convergence as mechanisms of metropolisation (Meijers 2005), changes in the regional surroundings, as drivers of metropolisation, come into focus. This perspective can be differentiated into two threads:

1. a focus on the intra-regional polycentric urban system that grows together as a dense metropolis (van Meeteren *et al.* 2016; Cardoso & Meijers 2017, 2021); and
2. the understanding of urbanisation as a regional phenomenon (Soja 2013; Phelps *et al.* 2014; Oueslati *et al.* 2015; Shaw *et al.* 2020), where the division between ‘city’ and ‘countryside’ becomes increasingly blurred, resulting in metropolisation as peri-urban processes and the development of in-between cities (Soja 2013; Addie 2016; Vidovich & Scolari 2022).

With regard to the first perspective, Meijers *et al.* (2014, p. 35) emphasise that, ‘Metropolisation is understood here as the process through which a loose collection of proximally located cities starts to become more functionally, culturally and institutionally integrated’. With this understanding, the cities in the regions surrounding a large city or cities play an important role as anchor points for further development. Through the functional, cultural and institutional integration of these cities, the surrounding area gains in functions and forms the basis for metropolisation

beyond the core city into the surrounding area. While cities might be obvious anchor points for polycentric regional development around metropolises (Lüthi *et al.* 2010; Meijers *et al.* 2016; Volgmann & Münter 2018; Wagner & Growe 2020), other ‘new centres’ (Kane *et al.* 2018; Krehl 2018) – such as so-called ‘edge cities’ (Garreau 1992; Bontje & Burdack 2005) or airport locations (Growe 2012; Wenner *et al.* 2020) – can be drivers of regionalisation. Agglomeration economies are no longer confined to core cities, and different places can ‘borrow size’ in order to access greater benefits, as the necessary resources operating at the urban region scale become available to them (Alonso 1973; Burger & Meijers 2016; Phelps *et al.* 2001).

Using the example of high-order service employment in Ile-de-France (France), Shearmur and Alvergne (2002) systematised three potential forms of dispersion – scatteration, dispersion to satellite towns and dispersion to other suburban communes. While dispersion to satellite towns and to other suburban communes can be positioned in the context of polycentric development, the description of scattered dispersion is different. Scattered urbanisation describes a highly diffuse development (Shearmur & Alvergne 2002) that is closely related to urban sprawl (Oueslati *et al.* 2015), peri-urbanisation and regional urbanisation (Soja 2013).

Münter & Volgmann (2021, p. 691) referred to this functional upgrading of the polycentric metropolitan surrounding as ‘a universal phenomenon in post-industrial countries’. While scattered metropolitan dispersion into a region is more associated with development in the US (Soja 2014) and, partly, in large Asian regions (Hui *et al.* 2020; Feng *et al.* 2020), polycentric metropolitan development, which links the region to existing or new centres and metropolises, is associated with development in Europe (Meijers *et al.* 2016).

However, it must be emphasised that polycentric developments in metropolitan regions are not limited to anchors in existing central business districts in smaller cities located in the vicinity of metropolitan cores. The notion of contemporary metropolisation (van Meeteren *et al.* 2016; Cardoso & Meijers 2021) through regionalisation assumes that an integration

and consolidation of fragmented urban spaces happens at the regional level (Cardoso & Meijers 2017), and that centrifugal forces distribute urban functions over a large area (Meijers *et al.* 2014; Cardoso & Meijers 2021). This means that existing urban centres are included in these regionalisation processes (Grove 2012; Wagner & Grove 2020), but that, at the same time, urban fragments are newly created, grow through metropolisation processes and are integrated into networks of urban systems (Meijers *et al.* 2014; Cardoso & Meijers 2021).

Empirical studies on European city regions in the Netherlands (Bontje & Burdack 2005; Lambregts 2009), Belgium (van Meeteren *et al.* 2016), Sweden (Schmitt *et al.* 2015), France (Shearmur & Alvergne 2002; Bontje & Burdack 2005), Italy (Vidovich & Scolari 2022) and Germany (Grove 2012; Volgmann *et al.* 2022) have shown that contemporary metropolisation goes beyond an understanding of polycentricity oriented towards core cities. However, contemporary metropolisation also differs from the sprawl-like in-between-city landscape of regional urbanisation (Sieverts 1999) by assuming (urban) cores and new functional locations as anchor points for development.

Against this backdrop, we understand regionalisation as the result of centrifugal forces distributing metropolitan functions across the surrounding region around one or more metropolitan core cities. It is assumed that the surrounding region extends beyond the directly neighbouring municipalities that have suburban locations so as to include the wider commuter catchment area of the metropolitan core cities.

Metropolitan functions – Metropolises are defined by more than population size. Although metropolises are large cities, they are understood to be the bases of specific functions that enable these cities to be anchors in networks of control and power (Hall 1966; Friedmann 1986). Hall (1966, p. 9) described these characteristics as ‘metropolitan functions’ and mentioned the features of national and international politics, trade, economy, communication, banking, finance, knowledge-based technology and insurance companies, as well as higher education, mass media, the

production of luxury and mass-quality goods, culture, arts and entertainment, all of which strengthen concentration processes in large agglomerations.

Capello and Camagni (2000, p. 1483) wrote that high-order or metropolitan functions are ‘characterised by higher thresholds for the level of appearance in the city (in terms of urban population)’. The idea of metropolitan functions ties in with the idea of the different centralities of these functions. Metropolitan functions, such as different levels of facilities and the services offered by these facilities, have a particularly large reach and, conversely, also require a particularly large catchment area. Thus, their functions correspond to the character of a supra-local function; for example, as an additional hierarchical level above the upper central level of the central places (Meijers 2007; Shearmur & Doloreux 2015). The theory of central places (Christaller 1933) assumes that the existence of such metropolitan or urban functions is directly related to the size of cities and their surrounding areas (Meijers *et al.* 2016). Although it has been assumed that metropolitan functions can be observed predominantly in larger cities, they are not classic supply functions in the sense of the central place theory, but rather large-scale organisational and developmental services, as well as exerting symbolic effects on a national (and partly international) level.

In German-language urban research, a typology of four metropolitan functions has been established. The starting point for the typology of metropolitan functions was a systematisation of the different modes of internationalisation of the so-called ‘specific features of international cities’ (Bonneville 1994, p. 276). The differentiation of these modes subsequently became the basis for four metropolitan functions (Blotvogel & Danielzyk 2009, p. 1). (i) The high-level decision-making and control functions exercised by public and private players (governments, corporate headquarters); (ii) innovation and competition functions (the generation and knowledge transfer of product and process innovations); (iii) gateway functions (transport and communication functions) and (iv) symbolic functions (the cultural and cultural-economic

dimension). This system has led to an understanding of metropolitan functions that goes beyond a purely business perspective (Growe & Volkmann 2016; Growe 2018).

While metropolitan functions were originally developed to examine the degree of metropolitanism and functional specialisation (Shu *et al.* 2020) of large cities, these functions can also be used to analyse changes in city surroundings (Meijers *et al.* 2016; Cardoso & Meijers 2017). If metropolisation is fostered through processes of regionalisation, and if a region's different centres can fulfil different roles and allow mutual synergies between the centres to emerge (Meijers 2005), then the existence and growth of metropolitan functions in the regional surroundings of a metropolis can indicate contemporary metropolisation and metropolitan integration.

The extent and intensity of these processes are further investigated below.

1. How pronounced is the regionalisation of metropolitan functions? In which sub-areas of the surrounding region can the regionalisation of metropolitan functions be observed?
2. Does the intensity of regionalisation differ for different metropolitan sub-functions? Do changes in the locations of metropolitan functions differ for the various metropolitan sub-functions?
3. Which places are anchor points of metropolitan regionalisation? Can we observe scattered metropolitan dispersion, which starts from the centre, or polycentric metropolitan development, which links to existing or new centres in the surroundings?

RESEARCH DESIGN

Study region – The spatial reference was the German urban system. We used a specific functional delineation of the urban regions (*Großstadregionen*) of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR 2019). Core cities are defined as those having at least 100,000 inhabitants and that have a commuter surplus—that is, the number of inbound commuters exceeds that of outbound travellers.

The regions surrounding the core cities—analysed in the following—are defined as follows. The complementary area to core cities

comprises directly adjacent municipalities that are particularly closely intertwined with the cores. They are characterised by a high daily population density of >500 (inhabitants + inbound commuters – outbound commuters) and by a surplus of commuters and/or a high share of more than 50 per cent of commuters to the cores. The wider surrounding region is divided into two zones based on the degree of commuter linkages—the inner commuter belt, in which at least 50 per cent of commuters commute to a core/complementary area, and the outer commuter belt, where 25 per cent to 50 per cent of commuters commute to a core/complementary area. The affiliation of a municipality in the surrounding region to an urban region is based on the delineation of the urban–rural regions (Stadt–Land–Regionen), which, in turn, refers to criteria regarding commuter relations and accessibility (BBSR 2015).

Due to the varying size of municipalities in the federal states, the level of the ‘Verbandsgemeinde’ (the supra-municipal district level) is most suitable for spatial analysis because the spatial units are more homogeneous in terms of population distribution. In the following analysis, 2376 Verbandsgemeinden, as the surrounding region, are differentiated based on three sub-areas:

- complementary area to the core city (396 Verbandsgemeinden);
- inner commuter belt (921 Verbandsgemeinden); and
- outer commuter belt (1059 Verbandsgemeinden).

Measuring metropolitan functions – Despite the complex and extensive data requirements for operationalising metropolitan functions, some empirical measurements are already available. The BBSR study on metropolitan areas in Europe provides a European-wide dataset (BBSR 2011). However, this study only includes data for one point in time and, thus, does not allow for an analysis of the shifts in urban systems. The dataset has been used in various international studies (e.g. Burger & Meijers 2016; Sohn & Licheron 2018). Further studies have examined the process of the hierarchical diffusion of innovations in urban systems with urban functions at higher levels of the urban hierarchy (Korcelli-Olejniczak 2008;

Pumain & Rozenblat 2019). However, as these studies only include data for certain dates, they also do not allow for any analysis of shifts in urban systems.

Another dataset, which does allow for comparisons over time, covers the German urban system and uses numerous indicators to operationalise the four metropolitan functions. The data were collected for the purpose of comparing changes between 1995 and 1997 as well as 2014 and 2017 for all German nomenclature of territorial units for 3rd-level statistics (NUTS-3) regions (Volgmann 2014; Growe & Volgmann 2016).

The aim of this work was to analyse the development of metropolitan regionalisation processes over time, with regard to individual metropolitan functions for the areas surrounding the urban regions, and to identify the underlying explanatory factors. For intra-regional analyses, however, we needed to look at the details of the development processes operating in urban regions, meaning that it was desirable to break down the dataset into municipal-level (local-administrative) units. This enhancement of the dataset allowed deeper knowledge to be gained of the contemporary metropolitanisation and metropolitan integration, especially with regard to the question of where in the metropolitan region which metropolitan functions increased over time.

Constructing metropolitan indices – The conceptual framework of the metropolitan functions was used to develop a wide-ranging set of 44 indicators for the time periods 2008–2010 and 2014–2017.² These two periods of data collection reflect the spatial development phases of centripetal tendencies in favour of the metropolitan areas in the 2000s (i.e. the larger cities became stronger) and a centrifugal enrichment in the surrounding areas in the 2010s. The collection of functional attribute data reflected the four metropolitan functions (see section on *metropolitan functions*), which, in turn, were subdivided into eight sub-functions (see Table 1).³ All data were collected at the municipality level. Following the studies described above and the world city discussion, an attempt was made to derive indicators that

would have had an influence on international processes—the locations of stock exchanges and the total assets of the 50 largest banks have an influence on international finance processes, for example. Another example is the location of universities or non-university research institutions because they are always integrated into international research networks. Nevertheless, there were national limitations, especially in the symbolic function of the indicators of the largest book or national newspaper publishers.

Data collection was conducted for the two time periods. This meant that, for the first time, it was possible to analyse shifts in the German urban system in terms of metropolitan functions for municipalities. The procedures used to build the metropolitan index and the indices for the sub-functions are explained below.

Step 1: To simultaneously detect and compare a number of metropolitan facets, the raw data for the local authorities for each indicator were z-standardised and proportionally weighted by the value of the factor loading from a previously conducted principal component analysis using all 44 indicators. This weighting was necessary because the indicators have varying degrees of significance in the overall index.

Step 2: Then, the whole metropolitan index for the years 2008–2010 and 2014–2017 was constructed from the various indicators using additive linking.

Step 3: The eight sub-functions were also weighted by the number of indicators per sub-function, so that all eight sub-functions were comparable and had the same weight. They were then linked additively. The metropolitan indices and the sub-indices could have both positive and negative values. In further calculations (e.g. aggregation to urban regions), only the local authorities that had positive values (above a mean average of 0) were included. These were the factors that determined the metropolitanity of the 2438 Verbandsgemeinden in the 62 German urban regions.

Step 4: The development index was estimated using the difference in the indices for 2008/10 and 2014/17 (= index point changes). Indices that were greater than 0 showed an increase in metropolitan growth,

Table 1. The 44 localised functional attribute indicators used to construct the overall metropolitan index and the eight metropolitan sub-functions.

Control function	Innovation function	Gateway function	Symbolic function
<i>Business and finance</i>	<i>Private-sector research/development</i>	<i>Market volume</i>	<i>Media and cultural economy</i>
Headcount of the 500 largest companies	Locations of the 100 most innovative companies in Germany	Transhipment volumes in inland ports	Locations of private and public broadcasting companies
Turnover of the 500 largest companies	Number of engineers employed	Turnover of the top 100 logistic companies (in € million)	Film studios
Total assets of the 50 largest banks	Employees working in business-oriented services	Air freight volumes at airports	The 100 largest book publishers
Gross income of the 30 largest insurance companies	Employees with an academic degree	Visitors at trade fairs/exhibitions	National newspaper publishers
Stock exchange locations			Employees working in cultural occupations
Turnover of the top 30 retail food companies			
<i>Policy</i>	<i>Science and research</i>	<i>Transportation</i>	<i>Arts, culture and architecture</i>
Locations of federal ministries	Locations of DFG special research areas	Flight activity at international airports	Locations of buildings by famous architects
EU/UN institutions	Research locations belonging to the Helmholtz Community	Passenger volumes at international airports	Locations of Germany's 25 highest buildings
Embassies and consulates	Locations of Max Planck, Fraunhofer, Leibniz, Academies and Leopoldina	ICE/TGV stations	Location of major urban development competitions
Associations	University locations		Opera audiences
Development organisations	Media units in science-oriented general and university libraries		Theatre audiences
Foundations	Employees working in research		Concert audiences
			Capacities of the 20 largest football stadia
			Number of overnight stays

For details on the data collection, see Grove and Volkmann (2016).

while indices less than 0 showed negative growth.

Step 5: To determine whether the metropolitan functions were becoming regionalised—that is, whether high-level urban functions were showing a positive development in the areas surrounding the core cities—the index point changes of the metropolitan indices were calculated for the total surrounding area and for the three sub-areas of the surrounding area (complementary area+inner commuter belt + outer commuter belt) of the 62 core cities from 2008/10 to 2014/17.

ANALYSIS AND EMPIRICAL RESULTS

Regionalisation of metropolitan functions – The empirical results of the overall metropolitan index indicated regionalisation processes by using two concentration measures—the Hirschman–Herfindahl Index (HHI)⁴ and the Gini index.⁵ Both measures indicated a decrease in the concentration of metropolitan functions in the 2376 surrounding municipalities between the initial period 2008/2010 (HHI = 0.011 and GINI = 0.478) and 2014/2017 (HHI = 0.008 and GINI = 0.470). This implies that metropolitan functions regionalise with time. A confirmation of this process can be obtained by focusing on the surrounding regions of the 62 German city regions. Out of 62 surrounding regions, centrifugal forces were observable in 52 surrounding areas (see Figure 1). The highest functional regionalisation (absolute index point changes between 2008/2010 and 2014/2017) scores were observed in Frankfurt a.M. (43.4), Stuttgart (29.7), Cologne (18.9), Bielefeld (18.6), Dortmund (15.8) and Reutlingen (12.7). By contrast, there were 10 urban regions – Halle (Saale) (–9.5), Erfurt (–5.9), Ulm (–4.4), Mönchengladbach (–3.0), Freiburg (–1.6), Berlin (–1.2), Bochum (–0.7), Hildesheim (–0.6), Bremerhaven (–0.6) and Wiesbaden (–0.6)—with declining metropolitan growth in the surrounding area.

Table 2 displays the different metropolitan growth rates for the aggregated surrounding regions and for the aggregated three sub-areas of the surrounding region—the complementary

area, and the inner and outer commuter belts (sub-areas are defined in the section *study region*). It can be seen that the total surrounding region of the 62 surrounding regions grew by 298 index points over time. Compared to the growth of the core city (382 index points), growth in the surrounding region was admittedly lower, but this is not surprising because metropolitan functions were originally developed to indicate metropolitan cores. The distribution of metropolitan growth is very different in the three sub-areas of the surrounding region. The complementary area—the area directly adjacent to the core cities—saw the highest growth, at 155 index points, while the inner commuter belt grew by 74 index points and the outer commuter belt by 68 index points.

The relative development of the metropolitan functions supports the identification of regionalisation processes even more. The relative growth rate of the surrounding area (at 33.8%) outranked the relative growth of the core cities (at 7.6%). There were also differences between the sub-areas of the surrounding region. The inner and outer commuter belts (38.2% and 40.4%) were the most dynamic in terms of relative growth, whereas the growth rate of the complementary area was 30.1 per cent. These shifts led to an increase in the share of metropolitan functions (see Table 2) in the surrounding region (from 14.9% to 17.9%). Although the core cities still held the highest shares, there was a centrifugal development in the shift of shares in favour of all three types of the surrounding area.

These results answer research question one: regionalisation processes can be interpreted as coming from centrifugal forces that distribute various urban functions in city regions. It seems that the different degrees of metropolitanisation of the core cities, and their sub-areas in the surrounding regions, increasingly converged, leading to metropolitanisation processes in the region. In addition, the hierarchy gradient between the cores and the surrounding regions significantly decreased for all three sub-areas of the surrounding region. In this sense, there was not only regionalisation in the immediate surrounding area, but also in the wider surrounding area.

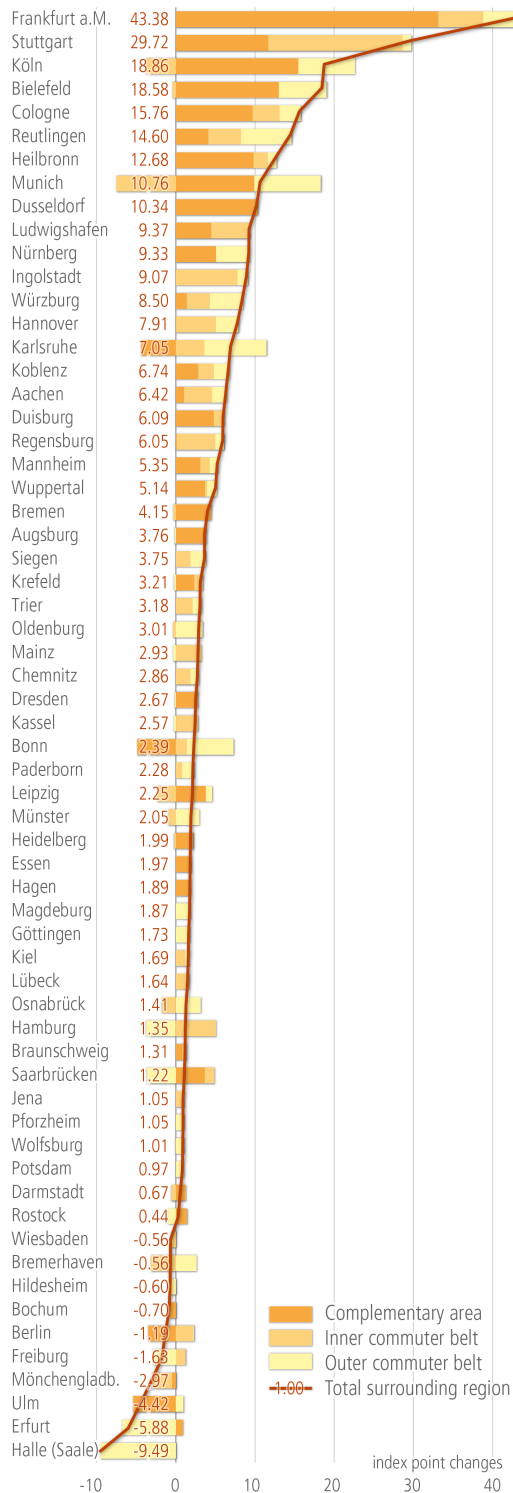


Figure 1. Absolute changes in the metropolitan index for the whole surrounding region and the three sub-areas of the 62 German urban regions (2008/2010–2014/2017).

Table 2. Regionalisation of the metropolitan index in the sub-areas of the surrounding area (2008/2010–2014/2017).

	Metropolitan index 2008/2010	Metropolitan index 2014/2017	Total index point development 2008/2010–2014/2017	Relative index point development 2008/2010–2014/2017	Share 2008/2010	Share 2014/2017
Core cities	5030.6	5412.82	382.22	7.60%	85.10%	82.12%
Surrounding region	880.86	1.178.85	298.00	33.83%	14.90%	17.88%
Complementary area	517.04	672.42	155.37	30.05%	8.75%	10.20%
Inner commuter belt	194.7	268.98	74.28	38.15%	3.29%	4.08%
Outer commuter belt	169	237.45	68.35	40.41%	2.86%	3.60%
Sum	5911.45	6591.67	680.22		100%	100%

Regionalisation of the metropolitan sub-functions – Statements about the sub-functional regionalisation processes can be made with reference to data on the absolute development that occurred in the eight sub-functions between 2008/2010 and 2014/2017 for the whole surrounding region and three sub-areas, as presented in Table 3. The sub-function *research and development in the private sector* is the most regionalised sub-function (a 27.1 absolute index point development), followed at some distance by the sub-functions *transportation* (9.5) and *arts, culture and architecture* (8.9). The sub-functions *business and finance* (4.6) and *market volume* (5.2) were regionalised to a moderate level. *Science and research* (0.3), *policy* (2.6) and *media and cultural economy* (3.5) were barely regionalised.

The spatial scope of regionalisation or the spatial scope of enrichment of urban qualities could be determined for differentiation of the three sub-areas of the surrounding region (Table 3). The most regionalised sub-function—*research and development in the private sector*—is not located solely in the direct proximity of the core cities (complementary area = 12.3), but can also be detected in the inner (12.3) and outer (9.0) commuter belts. In addition, major pushes towards the complementary area can be seen in *transportation* (6.9), *arts, culture and architecture* (4.3), *business and finance* (4.1) and *market volume* (4.0), with these functions starting out from a high level and being able to leverage certain location advantages, such as their proximity to the core city. The dynamic developments in *transportation* during this period, as witnessed by the expansion and development of airports as knowledge-economy hubs, are reflected in the values because their locations are often in the surrounding area, but close to the core city. Turning to the inner commuter belt, notable absolute developments were found in the sub-function *media and cultural economy* (2.3). The other sub-functions developed much less here than in the complementary area, ranging between 0.9 and 1.8 index points. With regard to the outer commuter belt, the sub-function *arts, culture and architecture* (2.8) had developed particularly positively. *Business and finance* (−0.2) and

Table 3. Regionalisation of metropolitan sub-functions (2008/2010–2014/2017).

Metropolitan sub-function	Total index point development in the metropolitan sub-function 2008/2010–2014/2017				Relative index point development in the metropolitan sub-function 2008/2010–2014/2017			
	Surrounding region	Complementary area	Inner commuter belt	Outer commuter belt	Surrounding region	Complementary area	Inner commuter belt	Outer commuter belt
Business and finance	4.55	4.11	0.76	-0.31	20.89	23.03	31.02	-20.26
Policy	2.55	1.12	0.03	1.40	31.25	29.63	2.00	48.61
Research/development in the private sector	27.12	12.25	5.90	8.97	105.85	107.64	68.05	161.04
Science and research	0.29	0.00	1.80	-1.51	0.83	0.00	22.25	-15.38
Market volume	5.22	3.98	1.17	0.07	51.23	56.78	81.25	4.02
Transportation	9.48	6.86	1.36	1.26	27.76	51.85	9.40	19.53
Media and cultural economy	3.49	-0.12	2.26	1.36	16.11	-0.59	194.83	348.72
Arts, culture and architecture	8.83	4.26	1.74	2.83	59.14	55.83	46.65	79.27

science and research (-1.5), on the other hand, recorded decreases.

These results indicate that, for many sub-functions, the most intensive absolute regionalisation processes reached into the complementary area. These effects can be interpreted not only as spillover effects, but also as the newly upgraded effects of high-level functions in the surrounding region.

The spatial patterns of regionalisation for the metropolitan sub-functions in the 62 German city regions are illustrated in Figure 2, in which the positive (>0) and absolute index point developments in the eight sub-functions for the 62 surrounding regions between 2008/2010 and 2014/2017 are shown. As can be seen, Germany's urban regions are becoming regionalised in very different ways and by different sub-functions. The findings indicate that the eight sub-functions are not equally regionalised and that there are also different manifestations in the regions depending on size or spatial structure. In particular, the more populous and polycentric urban regions in western and southern Germany are in a position to exploit their functional urban-regional strengths, such as their good transport infrastructures and existing functions in the surrounding area, and to further develop regional urbanisation.

Business functions are devolving particularly strongly into the surrounding region, as are transportation-linked gateway functions (airports and high-speed train (ICE) stations). Frankfurt a.M., Munich and Bremen were found to be very dynamic in this sense. Furthermore, major enrichment effects can be demonstrated in the sub-function private-sector research and development. In particular, the areas surrounding Frankfurt a.M., Karlsruhe, Bielefeld, Munich and Würzburg in southern Germany are benefiting greatly from highly qualified employees in the engineering and high-end service sectors—the sectors also featuring the most innovative companies. The third sub-function spreading quickly to the surrounding areas is the symbolic function of arts, culture and architecture, backed by its high level of cultural and architectural offerings and hotel accommodation. By contrast, there are selective regionalisation tendencies

in the cultural economy, such as in Munich, Reutlingen and Hamburg.

The lowest surrounding dynamics were found in the sub-functions *policy, science and research* and *media and cultural economy*. This can be attributed to the fact that these functions have a high city-centric attraction, with urban advantages playing a much greater role than with other functions. In particular, political players and lobbyists seek proximity to political power centres in national or state capitals.

These results can answer the second research question about the regionalisation processes of the metropolitan sub-functions in different surrounding areas. There are clear differences in the development of the eight metropolitan sub-functions. Certain functions—for instance, those belonging to the knowledge economy—became more regionalised than others, suggesting that certain urban advantages of established economic sectors no longer counted alone, and that certain inner-city disadvantages predominated. Push factors for this spatial-structural functional upgrading of the surrounding areas certainly include cost pressure (core cities are more expensive than their surroundings) and land availability (more available in the surrounding area).

The immediate surroundings can be viewed as an expansion space for the very urban cores and as a continuation or further development of metropolisation. This means not only that, as established in numerous studies on economic and demographic suburbanisation processes, there are spillover effects into the surrounding areas, but also that high-ranking functions are increasingly enriching the immediate surroundings, leading to metropolitan upgrading processes. Hence, the question arises whether high-value urban functions develop in the surrounding areas when they dock to existing anchor points (e.g. population centres, employment centres, infrastructure) or whether they disperse into the region. This is the subject of the next section.

Anchor points of metropolitan regionalisation –

The places that form anchor points for metropolitan regionalisation are discussed in the following. We investigated whether

size advantages, with regard to population, employment or metropolitan functions, promote metropolitan growth (i.e. polycentric metropolitan development, which links to existing or new centres in the surrounding areas) or whether there was dispersed spread of metropolitan functions into the surrounding areas (i.e. scattered metropolitan dispersion). Table 4 provides the correlations between the populations in 2008, employees in 2008, metropolitan index in 2008/2010 and metropolitan growth in 2008/2010 to 2014/2017 for the 62 surrounding regions. A strong correlation can be detected between the variables. The growth in metropolitan functions was found to be related to the size of the population (correlation 0.72) and employment (correlation 0.75) in the surrounding area. The higher the employment rate and population in the starting year of 2008, the stronger the relationships between the variables. The correlation between metropolitan growth and metropolitan functions in 2008/2010 was less pronounced (correlation 0.47). As a result, metropolitan functions also developed in certain surrounding areas in which there were still no to few metropolitan functions in the starting period of 2008/2010.

In particular, the complementary area—mainly comprising larger municipalities and medium-sized municipalities with large populations and high employment in the immediate proximity of the core cities—demonstrated enrichment effects (borrowing size). The correlation analyses confirmed the assumption that the higher the population (correlation 0.73), employment (correlation 0.76) and the more numerous the existing metropolitan functions (correlation 0.59) in the starting period, the stronger the growth of metropolitan functions. Employment strongly correlates with metropolitan functions. Whether people follow jobs or jobs follow people is one of the most heated debates in urban economics (Neal 2012). This paper does not provide a conclusive answer to this question either. However, it becomes clear that even beyond the metropolitan core cities, there is a close connection between employment and metropolitan functions. This is because many metropolitan functions reflect high-value economic characteristics, which, in turn,

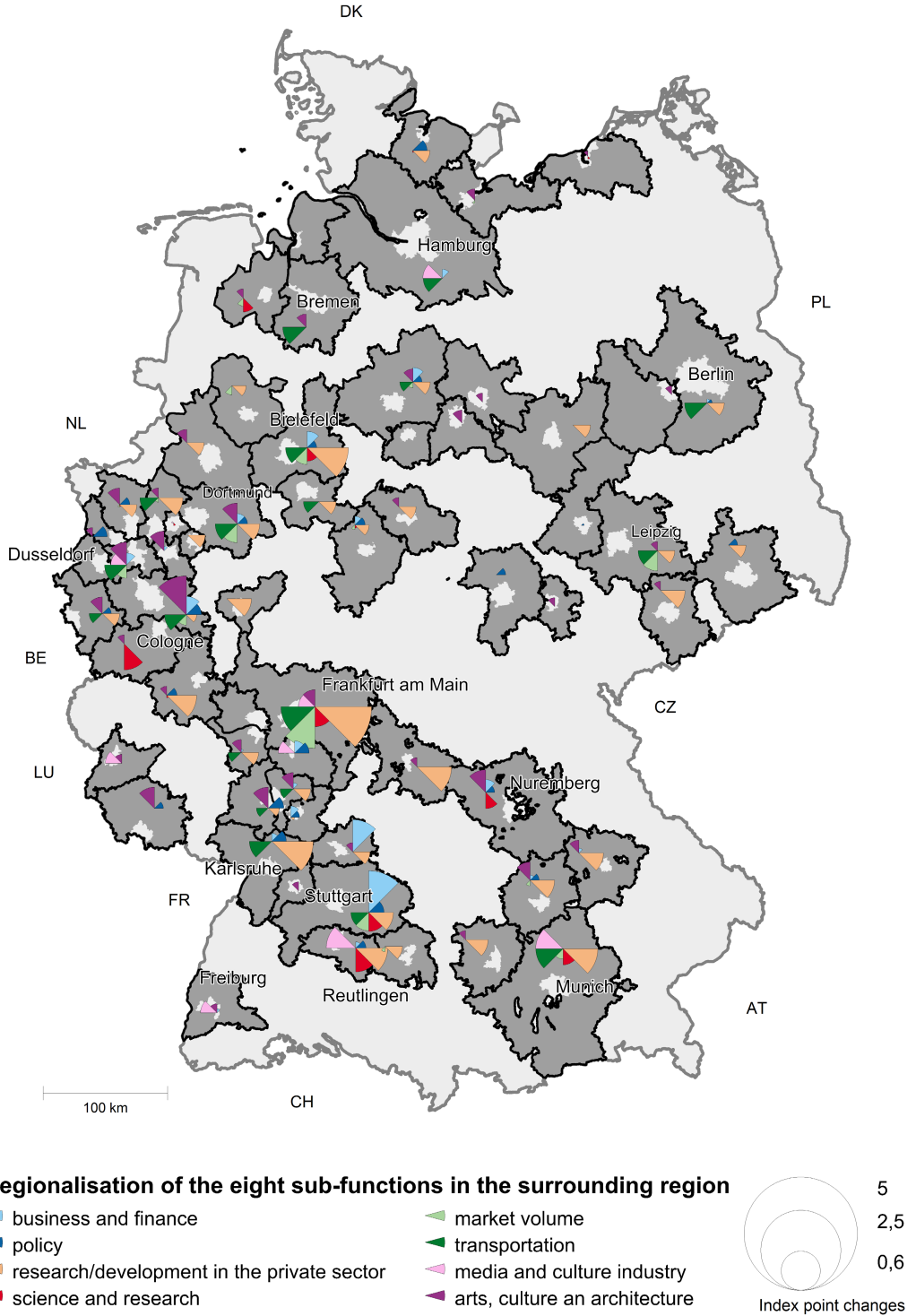


Figure 2. Regionalisation of the eight sub-functions in the surrounding 62 German regions (2008/2010–2014/2017).

Table 4. Correlations between the variable size 2008 and metropolitan growth (index point change) 2008/2010–2014/2017.

	Metropolitan growth ...			
	in the total surrounding region 2008/2010–2014/2017	in the complementary area 2008/2010–2014/2017	in the inner commuter belt 2008/2010–2014/2017	in the outer commuter belt 2008/2010–2014/2017
Population in 2008	0.724**	0.729**	0.362**	0.174
Employees in 2008	0.750**	0.758**	0.299*	0.156
Metropolitan index in 2008/2010	0.466**	0.586**	-0.242	-0.416**

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

strengthen each other. In the inner and outer commuter belts, population (correlation 0.36 and 0.17, respectively) and employment (correlation 0.30 and 0.16, respectively) seem to play rather minor roles in metropolitan growth. The negative correlations between existing metropolitan functions and metropolitan growth in the two wider surrounding areas indicate that new metropolitan functions are not solely dependent on existing metropolitan functions.

To determine in which population and employment centres metropolitan functions were developing particularly dynamically, a distinction was made based on the sub-functions and seven municipality size classes (Table 5). The anchor points for metropolitan regionalisation were not the large cities with more than 100,000 inhabitants, but the large to medium-sized cities with 50,000 to 100,000 inhabitants and smaller medium-sized cities with 30,000 to 50,000 inhabitants. These municipalities showed very positive development in several functions. The economic functions *research and development in private sector* (3.5 absolute index point changes), *market volume* (1.4) and *transportation* (4.0) showed above-average dynamics in the larger medium-sized cities. Similar sub-functional developments could also be observed for the smaller medium-sized cities. However, small towns with between 10,000 and 20,000 inhabitants also seem to be anchor points for urban functions, with *research and development in the private sector* (6.3), *market volume* (3.2) and *transportation* (2.0) being identified. The situation was similar for employees by size class, with one exception—the large employment centres with more than 40,000 employees had above-average growth in the sub-functions of *research and development in the private sector* (1.5), *science and research* (1.2) and *transportation* (3.2). The assumption here is that these locations are anchor points for regional metropolitanisation. The smaller employment centres, with fewer than 2000 employees, tend to play a subordinate role here.

This means that metropolitan functions are not primarily located in large cities in the surrounding areas, their locations being characterised by other influencing factors. Medium-sized cities and small towns in the

Table 5. Changing sub-functions in the municipalities of the surrounding regions, differentiated by municipality size categories (2008/2010–2014/2017).

	Metropolitan growth: Overall index*	Business and finance	Policy	Research/ development in the private sector	Science and research	Market volume	Transportation	Media and cul- tural economy	Arts, cul- ture and architecture
<i>Population: Type of municipality by size class</i>									
>100,000	17.60	-0.73	-0.13	-0.46	0.31	0.33	1.63	-0.38	2.28
>50,000	55.65**	-0.20	1.87	3.46	2.21	1.35	4.03	-0.43	0.00
>30,000	54.30	1.46	1.24	2.61	0.02	0.18	1.13	0.87	2.21
>20,000	74.70	2.29	-0.50	10.63	-0.49	0.50	0.26	0.40	2.45
>10,000	71.06	1.74	1.28	6.33	-1.68	3.20	1.96	1.63	0.80
>5000	19.29	0.03	-0.46	4.38	0.12	-0.32	0.46	0.44	0.27
>0	5.39	-0.04	-0.75	0.17	-0.20	-0.01	0.00	0.98	0.82
<i>Employees: Type of municipality by size class</i>									
>40,000	30.25	-0.50	-0.13	1.50	1.20	0.73	3.21	0.00	0.96
>20,000	34.25	1.32	0.63	1.96	1.90	0.51	1.07	-0.76	0.09
>10,000	59.35	0.52	1.31	5.08	-0.70	2.27	2.54	-2.03	2.77
>5000	68.25	3.28	0.58	6.93	-2.87	1.75	1.34	1.75	1.55
>2000	91.62	0.00	1.65	7.88	1.29	-0.04	0.86	3.55	2.58
>1000	8.64	-0.05	-0.75	3.59	-0.64	-0.06	0.20	0.00	0.42
>0	5.65	0.00	-0.75	0.17	0.11	0.05	0.27	0.98	0.46

*The sum of the eight sub-indices for the municipality by size class does not correspond to the value of metropolitan growth (overall index) between 2018/2010 and 2014/2017. This is because a weighting was applied to the indices of the sub-functions (see section on the construction of metropolitan indices).

**The values highlighted in bold are greater than the mean.

surrounding areas can develop urban qualities, such as living space, place of residence and place of work, with transport functions. On one hand, anchor points were found in existing large centres. On the other hand, there was a tendency to favour smaller cities that may establish a network around themselves with other cities in the urban region. In particular, it tends to be the denser polycentric city networks in southern and western Germany (see section *regionalisation of the metropolitan sub-functions*) that benefit from proximity to large and smaller centres. It seems to be important that smaller centres/subcentres are located close to the core cities.

DISCUSSION

In this paper, evidence is provided on how pronounced the regionalisation of metropolitan (sub-)functions is, and where the anchor points of metropolitan regionalisation are. Data on German urban regions show that centrifugal forces have led to regionalisation processes of metropolitan functions in the areas surrounding core cities. The most pronounced enrichment processes can be detected in the immediate surroundings (i.e. the complementary area) of an urban region's core cities, although enrichment can also be found in more-distant surrounding areas. Based on the data for eight metropolitan sub-functions in German urban regions, we identified regionalisation processes primarily in the economic innovation function and the land-intensive gateway function (e.g. airports and trade fairs).

The regionalisation of metropolitan functions was observed mainly in large and prosperous urban regions, with the need to search for new locations being triggered by the growth pressure arising in the core cities. However, polycentric urban regions with several cities in the areas surrounding the large core cities also became more regionalised. This occurred primarily at the anchor points of the large- and medium-sized employment centres, as well as in the smaller medium-sized towns. In this way, a virtuous cycle is created. The analysis showed that the economic dynamics in the overall polycentric structure

of south-western Germany, as well as the existing polycentric urban regions acting as anchor points, are particularly influenced by the regionalisation of metropolitan functions. Municipalities that benefit most from regionalisation processes are those that have both urban amenity advantages and hinterland advantages, such as lower prices and land availability. Thus, the results suggest that smaller cities that gain significantly in metropolitan functions are located in the most vibrant metropolises in Germany, pointing to advantages of borrowing size from the large cities that are economically successful.

The regionalisation process of metropolitan functions is driven by two factors—cost pressure (e.g. high rents and land prices, with the core cities being more expensive than the hinterland) and land availability (more land available in the hinterland). Based on the data from Germany, it can be concluded that metropolitan patterns that develop in polycentric urban regions are oriented towards existing centres. Metropolitan functions do not disperse into the inter-urban landscape, where peri-urban structures lead to a further blurring between the centres and the landscape. We conclude that agglomeration benefits are not limited to the large core cities, but also work in favour of large and medium-sized cities in the surrounding areas. Subcentres have decisive advantages compared to scattered metropolisation—spatial locations close to a (smaller) CBD, a labour market and good access to the rail and road network. However, benefiting from regionalisation processes depends on how well the subcentres exploit their advantages over the core city's advantages.

The characterisation of metropolisation as a 'process through which a loose collection of proximally located cities starts to become more functionally, culturally and institutionally integrated' (Meijers *et al.* 2014, p. 35) can be verified for numerous urban regions in Germany. This is particularly important in the case of metropolitan functions because these are not only aimed at size effects, but also reflect qualitative urban characteristics.

The results on metropolisation and regionalisation processes in this paper substantiate assumptions from approaches to 'borrowed size'

(Meijers *et al.* 2016; Meijers & Burger 2017) and extend the discussion by focusing on the development of medium-sized cities and larger small towns in metropolitan areas. The results of this paper can also be linked to other studies dealing with enrichment processes in the surrounding areas through populations and the (knowledge) economy (Burger *et al.* 2015; Volkmann & Rusche 2019; Wagner & Growe 2020). Against this background, the findings emphasise the function of secondary cities in the labour market, as well as their provision of space for economic activities, which is scarce in the metropolitan cores. Functional enrichment is by no means accompanied by a loss of functions from core cities. The enrichment and spillover effects of functions into medium-sized cities and larger small towns can be observed primarily in the prosperity of the overall regions (Volkmann *et al.* 2022). Medium-sized 'cities as second-tier cities' or 'second-ranked cities' (Cardoso & Meijers 2017) are therefore a central spatial category for further analysis that require indications of the interconnectedness of urban regions in terms of spatial patterns and the direction of the metropolisation process.

To explain these processes, overlapping bundles of causes need to be analysed. On one hand, the distance to the core city plays a role in the intensity of the enrichment process, while on the other hand, the existence of existing cores is important. However, it is still unclear what share distance to the core city and size of existing cores play within the cause complex. In this context, small-scale analyses of individual polycentric urban regions would be helpful in revealing further correlations and reasons for growth.

Digitalisation and increasing teleworking, in particular, will further change the location preferences for workplaces in the importance of individual metropolitan functions. It can be assumed that these changes will also lead to further deconcentration and regionalisation processes in the future.

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Endnotes

- ¹ In this paper, the term metropolitan region is not used in the sense of statistical-administrative delineation, as it is used in the USA, for example. Instead, the term is used with the meaning of a region with 'metropolitan grandeur'.
- ² The indicators are not collected annually and were therefore collected for the periods 2008–2010 and 2014–2017.
- ³ The sub-functions are split into eight sub-functions instead of four functions because they show different locational systems. For instance, the control function refers to both: (i) economic entities, such as global headquarters; and (ii) national and international policies. National and international institutions are usually localised in certain cities on the basis of political decisions that consider planning and structural policy objectives. The locations of private-sector firms are generally based on economic decisions.
- ⁴ Formally, this is noted as $HHI = \sum_{i=1}^n a_i^2$, where a_i is the share of the metropolitan index for region i . The minimum HHI is $1/n$ of the number of municipalities ($n = 2376$), whereas the maximum is 1, corresponding to a purely concentrating structure.
- ⁵ The Gini index is a measure of statistical dispersion: $G = \frac{\sum_{i=1}^n \sum_{j=1}^n |x_i - x_j|}{2 \sum_{i=1}^n \sum_{j=1}^n x_j} = \frac{\sum_{i=1}^n \sum_{j=1}^n |x_i - x_j|}{2n \sum_{i=1}^n x_j} = \frac{\sum_{i=1}^n \sum_{j=1}^n |x_i - x_j|}{2n^2 \bar{x}}$. A Gini coefficient of 0 expresses equality, whereas 1 is the maximal inequality among values.

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