

Spatial-functional patterns in the European urban system: metropolitan functions in small and medium-sized towns

Thomas Terfrüchte, Department of Spatial Planning, TU Dortmund University

Anna Growe, Department of Architecture - Urban Planning - Landscape Planning, University of Kassel

Abstract

The paper deals with spatial-functional patterns in the European urban system. Special attention is paid to metropolitan functions in small and medium-sized towns. Based on the assumption that metropolitan functions can also be found outside large cities, the location of metropolitan functions in three town size classes (small towns, small medium-sized towns and large towns) is examined. The results confirm the assumption that settlement size and the location of metropolitan functions are positively related: the larger the town or city, the stronger the metropolitan functions. The range of metropolitan functions is also more extensive in medium-sized towns than in small towns. In addition to the size of the town or city, its location also influences the expression of metropolitan functions. In small and medium-sized towns in spatial proximity to large urban centres, some functions can benefit from the spatial proximity to a large market and thus accommodate functions that would be expected in larger cities instead of in small and medium-sized towns. These borrowing-size effects can be observed for the two metropolitan subfunctions science and transport.

Keywords

Small and medium-sized towns, European urban system, Metropolitan functions, Agglomeration shadow, Borrowing size

Introduction

Since the 1990s, urban research has mainly focused on large cities and metropolises (Growe & Terfrüchte, 2023; Harrison & Hoyler, 2015). Small and medium-sized towns (SMSTs) have only recently become the focus of research, although they are significant places of settlement in Europe (Grabski-Kieron & Boutet, 2022; Wagner & Growe, 2021). In 2011, the EU Commission documented that 38 percent of the EU population live in small and medium-sized towns with 5,000 to 100,000 inhabitants (European Commission, 2011). In contrast, only 30 percent of the EU population live in large cities with more than 100,000 inhabitants (Hamdouch et al., 2017).

Corresponding author: Thomas Terfrüchte, Department of Spatial Planning, TU Dortmund University, thomas.terfruechte@tu-dortmund.de, ORCID: [0000-0001-8378-8099](https://orcid.org/0000-0001-8378-8099).

Authors:

Thomas Terfrüchte, Department of Spatial Planning, TU Dortmund University, thomas.terfruechte@tu-dortmund.de, ORCID: [0000-0001-8378-8099](https://orcid.org/0000-0001-8378-8099);

Anna Growe, Department of Architecture - Urban Planning - Landscape Planning, University of Kassel, anna.growe@uni-kassel.de, ORCID: [0000-0002-2751-7435](https://orcid.org/0000-0002-2751-7435).

Studies show that small and medium-sized towns in the polycentric urban system in Europe (Hall & Pain, 2006; Korcelli-Olejniczak, 2022; Servillo et al., 2017) are less characterised by services and still feature more industry and manufacturing, but at the same time they also have a comparatively good labour market situation and, in addition, have an important function as places to live (Hamdouch et al., 2017).

Nevertheless, Mayer and Lazzeroni (2022) point out that new developments are also being triggered in small and medium-sized towns, which are reinforced by a focus on innovation, creativity, attractive livelihoods and heritage (Bole, 2022; Hamdouch et al., 2017; Mayer, 2022; Meili & Mayer, 2017; Rabbiosi & Ioannides, 2022). In addition, some small and medium-sized towns also have close functional ties with large cities in polycentric European metropolitan areas (Grove & Volgmann, 2022; Hall & Pain, 2006; Meijers, 2008b; Schmitt et al., 2015). These relations create different functional framework conditions than those of small and medium-sized towns in the European urban system characterised by a solitary location (Grove & Terfrüchte, 2023). Moreover, small and medium-sized towns have a wide range of population sizes. Based on previous studies on the role of cities and towns in urban systems (Grove, 2012b; Korcelli-Olejniczak, 2022; Lüthi et al., 2013), it can be expected that the size of the small and medium-sized towns influences the possible functional patterns of these settlements in the urban system. Differentiations in functional patterns are possible both in terms of the expression of various functional specialisations in certain settlement sizes and in the overall functional importance of certain settlement sizes. The combination of functional differentiation possibilities, as well as the differentiation of size and location, is also emphasised by Bański (2022).

This paper therefore explores the following questions: What forms of functional patterns can be identified for small and medium-sized towns in the European urban system? And what are the differences in functional patterns between small and medium-sized towns within and outside metropolitan areas in the European urban system?

The article is structured as follows: at the beginning, two sections review literature on functionality in urban systems and on the importance of the location of small and medium-sized towns within and outside metropolitan areas. Based on this, the research questions and the data basis used for the empirical analyses are developed, the spatial units are considered, and the methods are explained. Subsequently, the results of the empirical study are presented and finally discussed.

Location patterns of metropolitan functions in urban systems

Since the 1970s, cities and towns have been discussed as part of urban systems, with consideration turning first to national and then to global urban systems (Bourne & Simmons, 1978; Dunn, 1983). Since the beginning of urban systems research, analyses have focused on the interactions between cities, as they cannot be considered as isolated spatial units (Servillo

et al., 2017). Only through exchange with other cities can they develop dynamic economic exchange processes (Taylor et al., 2010).

An important question on the role of cities in urban systems is whether and to what extent cities have the same or at least very similar functions or whether the urban system is characterised by a spatial division of labour. Furthermore, cities have been seen to differ from each other in terms of the functions located within them (Grove & Volkmann, 2016; Krätke, 2007; Volkmann, 2014). For large cities and metropolitan areas in particular, the regularity of spatial location patterns for especially “metropolitan” functions has been analysed (BBSR, 2011). On the one hand, outstanding economic activities, especially from the knowledge-intensive services (Grove, 2012b; Lüthi et al., 2013; Taylor et al., 2014) may be considered while, on the other hand, attention can be directed towards comprehensive economic, innovation-oriented, transfer-oriented and social functions under the umbrella term of metropolitan functions (Grove & Volkmann, 2016; Schulze & Terfrüchte, 2010; Volkmann, 2014).

The idea and substantive elaboration of metropolitan functions in science predominantly serves the purpose of analysing the role of particularly large cities (metropolises) and understanding the functional division of labour between large cities in global and national urban systems (BBSR, 2011; Grove, 2018; Volkmann, 2013, 2014). Against this background, the conceptualisation of metropolitan functions is oriented towards particularly metropolitan features and characteristics (Blotevogel & Danielzyk, 2009; Blotevogel & Schulze, 2009).

Even if analysing small and medium-sized towns through the lens of metropolitan functions seems unusual at first glance, this perspective is a useful complement to an analysis of other functions, such as considering supply functions through the central-place system (Grove & Terfrüchte, 2023). Metropolitan functions aim to capture (among other things) special innovativeness, special accessibility or special market size. Obviously, small and medium-sized towns do not have the same characteristics of metropolitanity as large cities and metropolises. Nevertheless, it has already been demonstrated in the literature that some small and medium-sized towns in Germany, especially in the hinterland of large cities, also exhibit metropolitan functions (Grove & Volkmann, 2022). Therefore, it cannot be generally assumed that no metropolitan functions are located in small and medium-sized towns. When considering metropolitan functions in small and medium-sized towns, these towns should by no means be conceptualised as locations that are “competing” with large cities and metropolises. However, the presence of metropolitan functions in a small or medium-sized town indicates a particular strength of this town. Small and medium-sized towns with metropolitan functions have functions that go beyond what would usually be expected for towns of this size. Thus, small and medium-sized towns can be compared and typified in their (lower) degree of metropolitanity. Furthermore, the degree of metropolitanity, especially in comparison to the degree of the supply function (e.g. central places in Christaller’s sense, see

Terfrüchte & Flex, 2018), gives an indication of the differentiated roles that SMSTs can play in urban systems.

The regularity of different location patterns for metropolitan functions can lead to a division of labour in the urban system and is mainly explained by two approaches. On the one hand, this development is explained by historical path dependencies – e.g. for the German urban system based on the division of labour (Blotevogel, 2004; Growe, 2012b; Volgmann, 2014) – and, on the other hand, by different comparative advantages, e.g. in the availability of infrastructure (Burger et al., 2015; Growe & Volgmann, 2022; Meijers, 2008b).

However, the questions about different location patterns and thus about a division of labour in the urban system are linked to spatial references. Several studies highlight the scale dependency of functional polycentricity (Meijers, 2008a; Vasanen, 2013). This leads to a differing assessment of whether spatial structures are polycentric or monocentric depending on whether one considers global, national or regional urban systems (Vasanen, 2013). In addition, the question of spatial division of labour changes with the scale level considered (e.g. neighbourhood, city and region).

The relationships of cities to other spatial units can be differentiated into relationships between cities themselves and relationships between cities and their surrounding areas. The relationship of cities to other cities is called “city-ness” (“city-ness as complex urban external relations”, Taylor et al., 2010: 2812). The relationship of cities to their surrounding areas is characterised by the term “town-ness” (“town-ness as simple urban external relations”, Taylor et al., 2010: 2811). Both relationships can involve a division of labour and exist simultaneously in cities:

- The analysis of spatial location patterns for metropolitan functions as a result of historical path dependencies predominantly refers to the comparison of different large cities and metropolitan areas in a national or global urban system (Growe & Volgmann, 2016; Volgmann, 2014). Here, the functional location patterns in different settlements of the same size are compared.
- The analysis of spatial location patterns for metropolitan functions, focusing on various comparative advantages, is mainly discussed in the context of polycentric regions (i.e. in relation to a regional urban system). Here, for example, the focus is on the cheaper availability of building land in the surrounding areas of large cities vs. the easier access to high-quality infrastructure within the large cities themselves (Growe & Volgmann, 2022; Humer et al., 2022; Schiller et al., 2015; Volgmann & Münter, 2022).

This analysis creates cross-references between questions of the division of labour within urban systems (between cities) and within polycentric regions (between cities and their surrounding areas or between large cities and medium-sized and small towns in the surrounding areas of large cities).

Small and medium-sized towns within and outside metropolitan areas

So far, small and medium-sized towns have mainly been considered from the perspective of large agglomerations. The focus is on the interactions between small and medium-sized towns and one or more large cities in polycentric agglomerations. The best-known discussions are those on “borrowed size” and “agglomeration shadow” in polycentric agglomerations (e.g. Cardoso & Meijers, 2017; Meijers & Burger, 2017).

The basic idea of “borrowing size” is the complementarity between the local advantages of small and medium-sized towns (such as lower rents and less traffic congestion) and the advantages of large cities (such as a broad sales market, a labour pool and diverse consumer/cultural facilities) (Phelps, 1998). Due to their proximity to large urban centres, small and medium-sized towns in agglomeration areas can thus draw on far more agglomeration advantages than small and medium-sized towns of similar size in isolated locations. The proximity to the large urban centres means that, for example, leisure, shopping or educational opportunities in the large cities can also be used by the inhabitants of the smaller towns (Meijers & Burger, 2017: 271). Companies in smaller towns in agglomeration areas can make use of the infrastructure of the large centres, e.g. airports, conference centres and trade fairs.

However, not all small and medium-sized towns benefit equally from the proximity to metropolitan cores (Cardoso & Meijers, 2021). Smaller and medium-sized towns near large urban centres may also suffer from an agglomeration shadow and be overshadowed by the large city (Burger et al., 2015; Cardoso & Meijers, 2021; Meijers & Burger, 2022). Where smaller towns are located in close proximity to other towns or larger cities (e.g. in agglomerations), they compete with them as locations for functions, which may result in fewer functions being located in such towns than in similarly sized towns in a remote location. This situation is referred to as an “agglomeration shadow” (Burger et al., 2015). This notion assumes that while smaller and medium-sized towns suffer from fewer agglomeration disadvantages than larger cities, for some functions accessibility to the market or to a particular labour pool is so important that the advantages of such access outweigh the agglomeration disadvantages suffered by the larger cities (Meijers & Burger, 2022). Such functions therefore prefer locations in the largest cities to maintain close spatial proximity.

Based on the above, the following questions arise:

1. Do we observe metropolitan functions in small and medium-sized towns? If so, what functional patterns of metropolitan functions can be identified at the level of small and medium-sized towns in the European urban system?
2. Do European small and medium-sized towns of different size classes exhibit different functional patterns?
3. Are there different functional patterns between small and medium-sized towns within and outside metropolitan areas in the European urban system?

Data, methods and spatial focus

To answer the research questions, different European datasets are linked and aggregated to the Local Administrative Unit (LAU) level. This is necessary because European spatial monitoring used several levels at the local scale until 2017 (LAU level 1 and LAU level 2) (Website Eurostat, 2023a).

Data

The analyses are based on the following data sources:

- Metropolitan functions and allocation to metropolitan areas as point data from the BBSR study (2011) (LAU level 2); the reference year is mostly 2008 or 2009, partly earlier, but there has been no update since then. The spatial allocation of metropolitan (sub)functions in the study is shown in Figure 1. However, since no population data is stored in the dataset of this study, a link with other datasets is necessary for a targeted analysis of small and medium-sized towns.
- Population data in tabular form from Eurostat's dataset "Historical Population Data from 1961 to 2011" (mostly LAU level 2, partly LAU level 1) (Website Eurostat, 2023b).
- Spatial references as polygons (shape files) to the uniform LAU level 2011 (partly 2012) from Eurostat (Website Eurostat, 2023c).

The various data sources were either clearly assigned to each other via identifiers in the data tables or, where absent, intersected with the polygons via spatial connections of the point data within the geographic information system (GIS). For some countries, a valid join via identifiers was only possible with the help of older (e.g. Germany) or more recent (e.g. Denmark, Croatia, Portugal and Switzerland) spatial references, and in several hundred individual cases a comparison had to be made by the GIS "near-function" in combination with town names.

For the United Kingdom and Ireland, the available Local Administrative Units are not comparable with the rest of Europe, as the 2011 datasets contains local subdivisions (mostly electoral districts), and the more recent datasets are based on local authority districts usually consisting of several towns. The UK and Ireland are therefore excluded from the analysis.

The result is a consolidated dataset with the reference year 2011 for the 32 European states (with a total of 93,925 towns) for which both population information and metropolitan functions are available. Despite the availability of metropolitan functions, some eastern and south-eastern European states (Albania, Belarus, Bosnia and Herzegovina, Moldova, Russia, Serbia and Ukraine) as well as the smallest spatial units like Andorra, Monaco and San Marino are missing because Eurostat does not maintain population data for these units in the Historical Population Dataset.

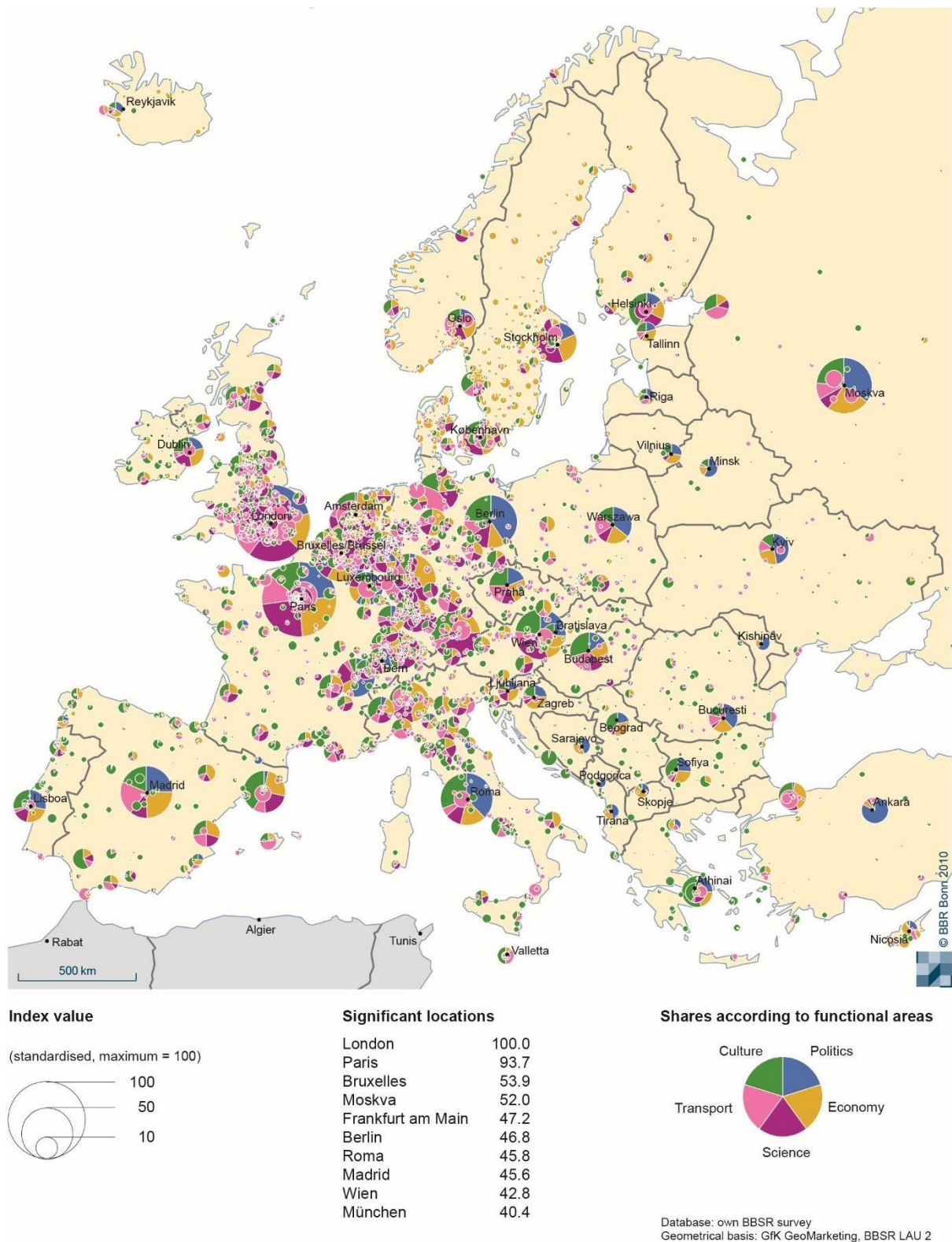


Figure 1 - Spatial distribution of metropolitan functions in Europe, Source: BBSR (2011, p. 84)

Methods

The BBSR dataset on metropolitan functions includes the respective normalised indices for total metropolitan functions and for functions subdivided into politics, economy, science, transport and culture (BBSR, 2011: 41). It also contains the allocation of towns to metropolitan areas (BBSR, 2011: 95). In some cases, the data had to be aggregated to the uniform LAU level.

For this purpose, the index values were added up in each case, which is statistically possible due to the availability of normalised data. Subsequently, the indices were z-standardised. In this way, when evaluating the town size class or the spatial location (within or outside metropolitan areas), it is possible to use the mean values to assess whether these are above average in a Europe-wide comparison (greater than 0) or not. The population data from Eurostat were also aggregated by addition if they were available at LAU level 2. With regards to population size, we have deliberately not undertaken a conversion (e.g. per 1,000 inhabitants), as we are interested in the absolute performance of the SMSTs for this paper. However, due to the different delimitation or definition of LAUs, this hampers cross-country comparisons to some extent, as some countries have much larger LAUs than others (France, for example, has hundreds of LAUs with less than 100 inhabitants, Belgium has only two LAUs with less than 1,000 inhabitants, and the smallest LAU in Denmark has just under 14,000 inhabitants). We make allowance for these differences in the interpretation of the results by relating certain atypical patterns of functioning to the specifics of each national urban system.

For the analysis, the LAUs were either clearly not assigned to any metropolitan area or clearly assigned to one. If the assignment was unclear due to inconsistent administrative delineations, the following steps were taken. If parts of the spatial aggregate were assigned to a metropolitan area in the BBSR dataset, the entire aggregate was assigned to it. If the spatial aggregate belonged to several metropolitan areas, it was assigned to the metropolitan area in its own state (if the metropolitan areas were located in different states). If the spatial aggregate belonged to several metropolitan areas in the same state, it was completely assigned to the metropolitan area with the higher total functionality (in cases of functional differences) or with the larger population (in cases without functionality or in cases with the same functionality).

Spatial focus

The spatial focus of this paper is on small and medium-sized towns in Europe, which are defined as spatial units with at least 5,000 and at most 100,000 inhabitants (a total of 15,877 towns in the dataset). These spatial units are further subdivided into three classes:

- small towns with 5,000 to 20,000 inhabitants;
- medium-sized towns with 20,000 to 50,000 inhabitants; and
- large towns with 50,000 to 100,000 inhabitants.

Table 1 shows that about half of the towns are located within metropolitan areas, as are half of the cities with more than 100,000 inhabitants. In contrast, the smallest towns with less than 5,000 inhabitants are mostly located outside the metropolitan areas.

Population	within		outside		total	
	metropolitan area		metropolitan area		(within & outside)	
less than 5,000	21,420	27.7%	55,989	72.3%	77,409	100.0%
5,000 - 20,000	5,440	45.3%	6,560	54.7%	12,000	100.0%
20,000 - 50,000	1,561	52.1%	1,435	47.9%	2,996	100.0%
50,000 - 100,000	423	48.0%	458	52.0%	881	100.0%
more than 100,000	305	47.7%	334	52.3%	639	100.0%
total (all classes)	29,149	31.0%	64,776	69.0%	93,925	100.0%

Table 1 – Number of towns and cities by size class and location

Results

Based on the data described, functional patterns for small and medium-sized towns in the European urban system can be identified and differentiated. The results are presented according to the three questions developed in the theory section.

Metropolitan functions at the level of towns in the European urban system

The results show that metropolitan functions can also be found outside the major cities (i.e., cities above 100,000 inhabitants) (Figure 2). In the analysis, 15,877 European towns with populations between 5,000 and 100,000 are considered. 1,749 of them have an above-average score (greater than 0 due to z-scored values) on the total metropolitan function index. Cities larger than 100,000 inhabitants and towns smaller than 5,000 inhabitants are not shown in Figure 2.

In about one-fifth of the towns between 5,000 and 100,000 inhabitants (3,309) substantial metropolitan functions can be found in at least one of the five subfunctions. Substantial means that the functionality is at least above average in a Europe-wide comparison (i.e., index value above 0). For comparison: of the 639 cities, 451 (70 percent) have substantial metropolitan functions and of the cities with over 500,000 inhabitants, only a few in Turkey do not have above-average metropolitan functions in a Europe-wide comparison.

Figure 2 demonstrates that metropolitan functions in the European urban system are also located outside of large cities and metropolises. However, no functional patterns can be identified with this analysis. This requires an analysis that differentiates between subfunctions, size classes and location types.

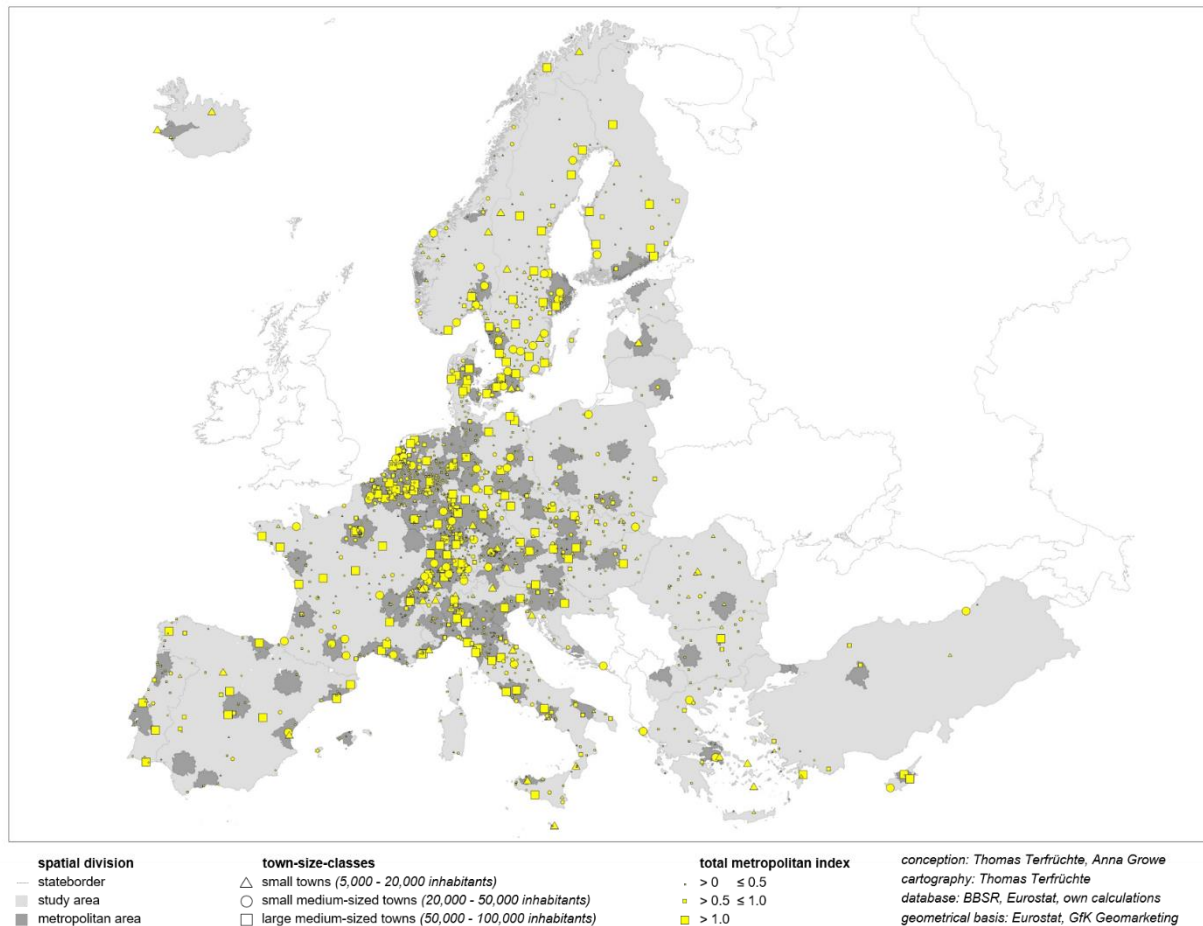


Figure 2 – Spatial distribution of metropolitan functions (total metropolitan function) in Europe, differentiated in town size classes and locations within and outside of metropolitan areas, Source: authors' illustration

Functional patterns in small and medium-sized towns of different population size in Europe

If the towns considered are differentiated according to population size, a clear correlation between town size and metropolitan indices emerges. Substantial metropolitan functions characterise 61.7 percent of the large towns (50,000 to 100,000 inhabitants), 37.6 percent of the small medium-sized towns (20,000 to 50,000 inhabitants) and only 13.7 percent of the small towns (5,000 to 20,000 inhabitants) (Table 2).

In some cases, there are also clear differences with regard to the subfunctions. While the subfunction science dominates in the small towns (this is often because small and medium-sized enterprises (SMEs) are based there and have registered patents there, which are part of the subfunction), only the subfunction politics is largely insignificant in the SMSTs. For the large towns, the subfunction culture is just as important as the subfunction science. And for all subfunctions, the proportion of towns with substantial functionality increases with the size of the town, especially in the case of the subfunction culture.

Subfunction	5,000 - 20,000		20,000 - 50,000		50,000 - 100,000		total	
	inhabitants		inhabitants		inhabitants		(all classes)	
politics	3	0.0%	2	0.1%	7	0.8%	12	0.1%
economy	137	1.1%	144	4.8%	150	17.0%	431	2.7%
science	1,234	10.3%	812	27.1%	366	41.5%	2,412	15.2%
transport	186	1.6%	161	5.4%	162	18.4%	509	3.2%
culture	292	2.4%	359	12.0%	376	42.7%	1,027	6.5%
min. 1 of 5	1,643	13.7%	1,127	37.6%	539	61.2%	3,309	20.8%

Table 2 – Number and share of towns with metropolitan subfunctions by size class and functionality

The total metropolitan index also correlates fundamentally with the size of the population in small and medium-sized towns in Europe. The correlation coefficient between the number of inhabitants and the total metropolitan function across all towns and cities in the European urban system (including the smallest towns of less than 5,000 inhabitants and the largest cities of more than 100,000 inhabitants) is 0.7. The coefficient of determination of 0.49 means that the number of inhabitants explains 49 percent of the variance of the total metropolitan function. While a positive correlation can be found across all cities and towns in the European urban system, this is no longer clear when looking at SMSTs (5,000 to 100,000 inhabitants). Here, the correlation coefficient is only 0.17 and the coefficient of determination only 0.03. In contrast, the correlation coefficient between population size and total metropolitan function for cities (over 100,000 inhabitants) is 0.75. For cities, population size thus explains 56 percent of the variance of the total metropolitan function. Thus, across all town and city sizes, the larger the town, the more metropolitan functions are located in the respective town. If only the group of SMSTs is considered, this correlation cannot be established to the same extent, in contrast to the group of large cities. The significantly lower correlation indicates a heterogeneously structured group of towns in this population size. A further differentiation into small towns (explanatory power 0.18 percent), small medium-sized towns (explanatory power 0.85 percent) and large towns (explanatory power 1.10 percent) does not reveal any significant differences either. For a better understanding of the role of small and medium-sized towns as locations for metropolitan functions, the metropolitan subfunctions and the location of the towns are therefore examined in a differentiated manner in the following.

In Table 3, the subfunction politics is not shown because the subpopulation (12 cases) is not significant. The mean value per size class shows clear jumps for all subfunctions and the maximum index values for the group of small and medium-sized towns always result from the maximum index value of the large towns. It is also remarkable that the maximum values of the

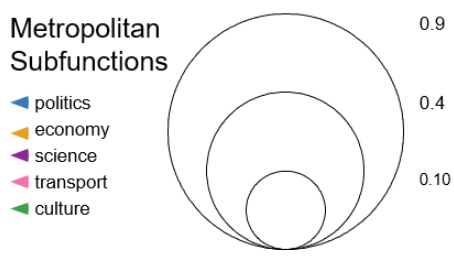
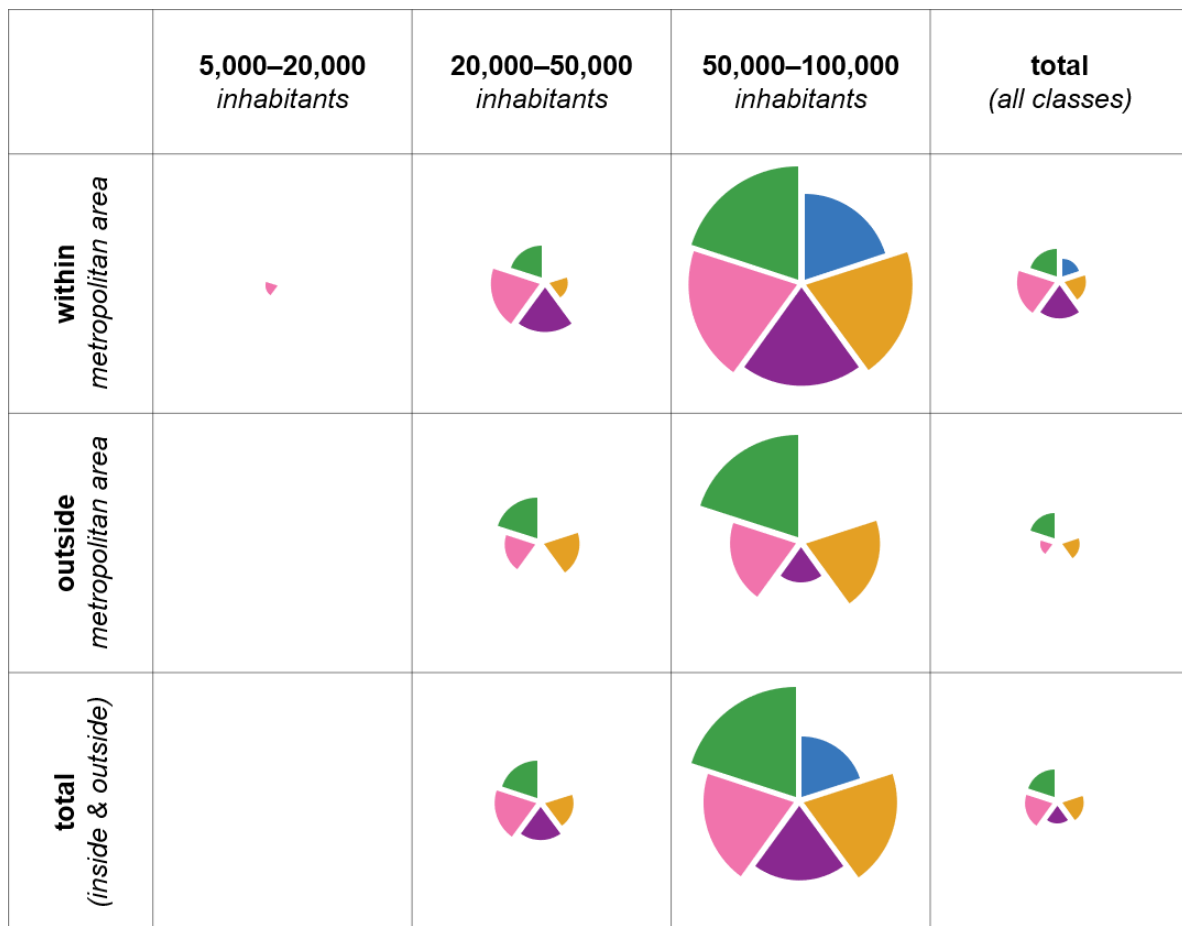
small and medium-sized towns only reach between about half (subfunction science) to one-third (subfunction economy) of the maximum values overall.

Metropolitan functions are thus also located outside the metropolitan cores, but are far less pronounced there, which is shown here by comparison with the cities over 500,000 inhabitants. Due to the z-scored index values for all 93,925 cities and towns surveyed, the mean value and standard deviation for the small and medium-sized towns are also directly comparable with all cases (where, as is well known, the mean value is always 0 and the standard deviation (stdev) is always 1). The relative homogeneity of the SMSTs (standard deviations between 0.70 and 1.03 compared to 1.00 for all size classes) is essentially due to the towns with less than 50,000 inhabitants, as we have standard deviations between 2.54 and 2.88 for this group. Large towns are thus usually much more heterogeneous in terms of functionality than small medium-sized towns and small towns. The results thus once again confirm the aforementioned heterogeneity between the sub-classes of SMSTs, especially large towns. However, small towns have such a low standard deviation and thus less heterogeneity that no further spatial differences are to be expected for this town size group.

Population	economy			science			transport			culture		
	mean	max	stdev	mean	max	stdev	mean	max	stdev	mean	max	stdev
5,000 - 20,000	-0.02	23.75	0.31	-0.01	19.31	0.26	-0.01	37.48	0.60	-0.02	22.09	0.42
20,000 - 50,000	0.05	7.36	0.48	0.07	63.33	1.24	0.11	43.15	1.29	0.09	12.45	0.73
50,000 - 100,000	0.56	53.52	2.54	0.36	74.16	2.88	0.54	61.82	2.87	0.79	41.94	2.41
total SMSTs	0.03	53.52	0.70	0.02	74.16	0.90	0.05	61.82	1.03	0.05	41.94	0.77
500,000 and more	20.26	148.23	25.70	15.63	149.29	25.47	13.42	143.27	22.98	20.78	92.94	23.78
total (all classes)	0.00	148.23	1.00	0.00	149.29	1.00	0.00	143.27	1.00	0.00	92.94	1.00

Table 3 – Mean, maximum and standard deviation of metropolitan subfunctions by town and city size class

Figure 3 shows the functional differentiation depending on the town size class and location within or outside a metropolitan area. The arithmetic mean values for each subfunction are shown (for mean index values above 0). The larger the section, the more pronounced the respective subfunction.



conception: Thomas Terfrüchte, Anna Growe
 design: Thomas Terfrüchte
 database: BBSR, Eurostat, own calculations

Figure 3 – Average index size of metropolitan subfunctions in towns with different size classes and locations within and outside metropolitan areas. Source: authors' illustration

While all five metropolitan subfunctions have a clearly pronounced index value for larger towns (with culture being the most pronounced and politics the least pronounced), an average of only four subfunctions are pronounced for the size class of smaller medium-sized towns. Here, the policy subfunction is absent and the transport subfunction is the most pronounced. It is striking that, on average, no substantial metropolitan functions are to be found in small towns. From the 12,000 small towns (Table 1), only 1,643 (Table 2) have any metropolitan functions at all.

The bottom row in Figure 3 thus shows: on average, only larger towns have a complete profile of metropolitan functions; smaller medium-sized towns still have a comprehensive profile of metropolitan functions (with four of five subfunctions, without the subfunction of politics); and, on average, small towns do not have a metropolitan function profile.

Functional patterns in small and medium-sized towns of different location types in Europe

Based on the results described so far, the last step of the analysis involves differentiating between the locations of the small and medium-sized towns within and outside metropolitan areas. The delimitation of metropolitan areas can be seen in Figure 2. The results of differentiating metropolitan functional patterns by location within and outside metropolitan areas are shown in the top two columns of Figure 3. As in the previous analysis on metropolitan functional patterns in all European small and medium-sized towns, no comprehensive functional patterns for small towns can be identified through this differentiation.

It is striking that in the small medium-sized towns the subfunction science is only substantially pronounced within metropolitan areas, while the subfunctions economy and culture are more pronounced outside the metropolitan areas. In contrast, in the large towns all subfunctions are more pronounced within the metropolitan areas, whereby the difference is very small for the culture subfunction and very large for the science subfunction. For the subfunction politics, the small number of cases is not sufficiently significant.

Thus, this step of the analysis confirms that larger towns have a more comprehensive profile of metropolitan functions than smaller medium-sized towns. In both size classes, the towns within metropolitan areas have a more comprehensive functional profile than the towns outside metropolitan areas.

Figure 4 shows the spatial distribution of the metropolitan subfunctions economy (map A), science (map B), transport (map C) and culture (map D), differentiated by town size class (squares show large towns with 50,000 and 100,000 inhabitants, circles show small medium-sized towns with 20,000 to 50,000 inhabitants and triangles show small towns with 5,000 to 20,000 inhabitants) and location within or outside metropolitan areas (metropolitan areas are coloured dark grey). The larger the symbols, the more pronounced the respective subfunction.

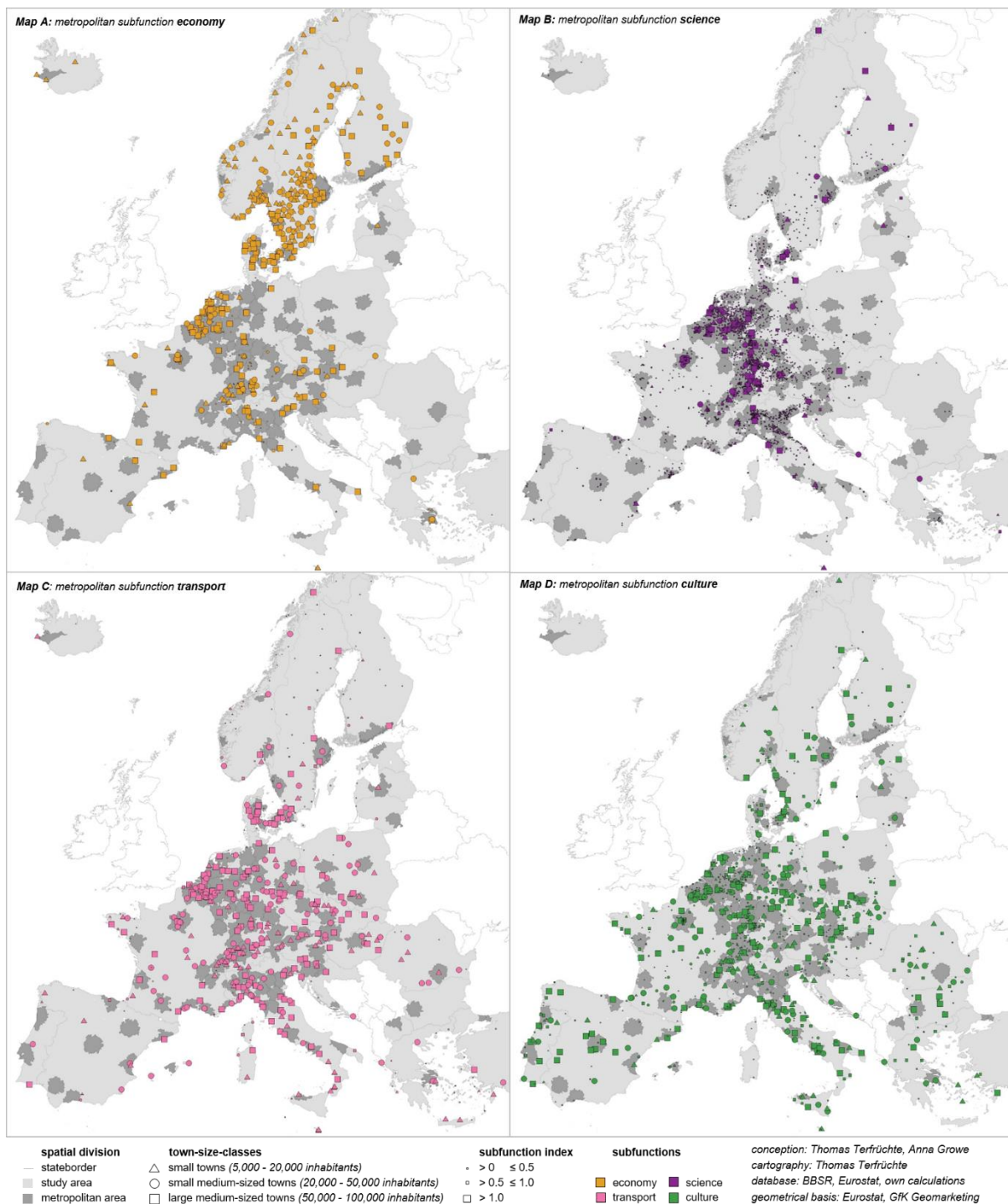


Figure 4 – Spatial distribution of metropolitan subfunctions in Europe, differentiated in town size classes and locations within and outside of metropolitan areas. Source: authors' illustration. Note: parts of Turkey are cut off here for display reasons

In addition to confirming the previous findings (e.g. high importance of the subfunction culture also outside the metropolitan areas), some differences also become apparent with regard to the situation in Europe:

- The significance of the subfunction economy for small and medium-sized towns outside metropolitan areas that has been established so far is mainly due to the distribution in Scandinavia (where there are also comparatively few large cities). In

the rest of Europe, predominantly small and medium-sized towns within metropolitan areas are economically strong. Otherwise, in some southern and eastern European countries the subfunction economy is located almost exclusively in the large cities (cities with more than 100,000 inhabitants are not shown here).

- Medium-sized towns in the “blue banana” in western and central Europe are particularly important for the subfunction science. Small and medium-sized towns in Scandinavia, but also in parts of France, for example, are again important, albeit to a much lesser extent.
- With regard to the transport subfunction, mainly port towns outside metropolitan areas exhibit comparatively outstanding functionality.
- Respecting the subfunction culture, there is a rather equal distribution of significant small and medium-sized towns in Europe; this also corresponds with the previous findings.

The comparative presentation of the subfunctions in connection with their location in Europe shows that the heterogeneity of the small and medium-sized towns attested to at the beginning can also be explained by the different urban systems and variations in the definition of LAUs within Europe. In the Scandinavian countries, there are significantly fewer large cities than in Germany, France or Italy, for example, due to the smaller total population. Nonetheless, in the latter countries as well as in the Scandinavian countries, a similar number of metropolitan functions are located in the large cities (on average positive index values of 7 to 8 per large city). However, in Germany (80 percent) or Italy (71 percent), the majority of metropolitan functions are located in large cities. Small and medium-sized towns are less significant (Germany 19 percent of metropolitan functions; Italy 27 percent). In contrast, in Denmark (56 percent), Sweden (51 percent) and Norway (50 percent), for example, only about half of the nationwide metropolitan functions are located in large cities and the other half are mostly located in small and medium-sized towns (Sweden 49 percent, Norway 47 percent and Denmark 44 percent). The absolute importance of large cities in the countries mentioned here is thus comparable on average. The relative importance in the Scandinavian countries, however, is much lower in favour of small and medium-sized towns.

Discussion and conclusion

Metropolitan regions play an important role in European spatial development (Salet et al., 2003; Salet et al., 2015). In many countries – such as Germany (Diller & Eichhorn, 2022; Growe, 2018), France (Lefèvre, 2003; Savini, 2012), Italy (Gualini, 2003) and Sweden (Hårsman & Olsson, 2003) – they are seen as key drivers of economic development and (continue to be) regions with migration gains at the expense of more rural regions (Eurostat, 2022).

However, metropolitan functions are also located outside the metropolitan areas and beyond the core cities in small and medium-sized towns. Their role in the urban system is characterised by a very different development of metropolitan subfunctions. For large towns, this study reveals many starting points for the further development or promotion of metropolitan functions, both within and outside metropolitan areas. A differentiated picture emerges for small medium-sized towns. Within metropolitan areas, the subfunctions of science and transport are the main strengths of small medium-sized towns, which offer starting points for a “strengthen the strengths” approach. Outside metropolitan areas, the subfunctions of economy and culture are the main points of departure for small medium-sized towns.

Reflection in the context of theory

In line with the theoretical debates presented above, two central findings can be summarised. First, a positive correlation between settlement size and the metropolitan functions located within them can be seen in all steps of the analysis: the larger the place, the stronger the expression of metropolitan indices (total index as well as sub-indices) in the cities and towns. This shows the validity of the conceptualisation of metropolitan functions in the BBSR study from 2011 and, furthermore, the validity of the indicators used there to measure metropolitanity. The functions were conceptualised to capture particularly high-ranking functions of cities and indicators were chosen that are primarily located in large cities and metropolises (BBSR, 2011; Blotevogel & Schulze, 2009; Volgmann, 2013). This is confirmed by the analyses in this paper.

Second, an analysis of the location of the valid metropolitan indices in the European urban system shows that high-ranking urban functions are also located in small and medium-sized towns, both within and outside metropolitan areas. With regard to the localisation of metropolitan functions in small and medium-sized towns, it can be observed that medium-sized towns in particular play a role as locations of high-ranking functions. On average, small towns are only the locations of limited metropolitan functions in the European urban system.

Borrowing size effects within metropolitan areas

When comparing the location of metropolitan functions in small and medium-sized towns within and outside metropolitan areas, reference can be made to the debate on borrowing size and the agglomeration shadow (Meijers & Burger, 2017, 2022).

Borrowing size effects are particularly evident for large towns. Here, potential borrowing size effects can be observed for all five subfunctions. Within metropolitan areas, large towns with populations between 50,000 and 100,000 inhabitants are thus to be regarded as substantial functional locations in the European urban system.

This is somewhat more differentiated for small medium-sized towns. The subfunctions transport and science are also characterised by potential borrowing size effects. These subfunctions are more pronounced in small medium-sized towns within metropolitan areas than in small medium-sized towns outside metropolitan areas. Particularly impressive is the subfunction science, which is located in this size class exclusively within metropolitan areas. For transport and science functions, small medium-sized towns benefit from a close spatial proximity to large centres in metropolitan areas. However, agglomeration shadow effects can be seen for the subfunction culture and especially the subfunction economy in the size class of small medium-sized towns. These two subfunctions are more pronounced in small medium-sized towns outside metropolitan areas than within them. In metropolitan areas, these medium-sized towns suffer from the spatial proximity of larger centres and thus the good accessibility of various high-ranking cultural institutions in such metropolitan centres. Small medium-sized towns can thus occupy an important position in the European urban system for the functions of culture and economy, especially outside metropolitan areas, and serve as anchor points for spread effects (Volgmann & Rusche, 2020). At the same time, there are clear differences between countries and their urban systems, as the greater importance of small and medium-sized towns in Scandinavia shows.

Methodological reflections

After the discussion of the substantive results, we want to point out some key methodological limitations. The starting point for the empirical findings presented here was spatially differentiated data on metropolitan functions. In the European urban system, however, small and medium-sized towns also assume supply functions with regard to services of general interest (they are also classic central places, see Terfrüchte & Flex, 2018; Terfrüchte, 2022) and they are labour market centres. Some of the usual high-level supply functions (Terfrüchte, 2022, p. 118) are also metropolitan functions (especially culture and science/research). Whether and how the location of small and medium-sized towns also potentially influences their function as central places or employment centres (see the discussions on agglomeration shadow and borrowing size) cannot be answered here. Furthermore, the different administrative structures of the European countries pose problems for comparative research across Europe, since even the Local Administrative Units – as shown by the examples of the UK and Ireland – do not represent a suitable spatial reference for urban system research. And also, some of the countries included here and even certain federal states (for instance in Germany as a result of different territorial reforms) have by definition much larger LAU units than others.

Further need for research

Based on the results of this paper, further research needs can be identified in three areas in particular: first, more in-depth research on borrowing size and agglomeration shadow effects; second, investigation of the role of other town and city size classes in the European urban system; and third, work on the relative importance of SMSTs.

First: potential borrowing size effects and agglomeration shadow effects were identified for small and medium-sized towns in the European urban system. With regard to this discussion thread, it would be desirable to further analyse such effects in small and medium-sized towns by recording the actual networking of small and medium-sized towns with the metropolitan centres. More information on the interconnectedness of small and medium-sized towns with the metropolitan cores could provide information on actual borrowing size and agglomeration shadow effects. In the literature, linkages between cities are mentioned as a prerequisite for the emergence of borrowing size and agglomeration shadow effects. The dataset used in this paper only allows indications of potential borrowing size and agglomeration shadow effects.

Networking and accessibility between settlements both of the same size class and also of different size classes can be examined using regional polycentricity patterns in connection with the specific functionality of interest. Especially against the background of the heterogeneity of large towns, a further differentiation of this town size class is necessary since the number of inhabitants alone cannot be used as an explanation for the observed functional patterns. For example, two medium-sized towns of the same size can take on completely different roles as functional locations if one city is the sole centre in a region and the other city is located in the direct vicinity of one or more large cities (Grove & Terfrüchte, 2023). The findings presented here on the relatively high importance of small and medium-sized towns in Scandinavia already suggest such spatial-functional differences.

Second: the spatial focus of this article is on small and medium-sized towns in Europe. Between these town size classes and the metropolitan cores (mostly over 500,000 inhabitants), other city size classes are relevant to urban systems research. Particularly with regard to metropolitan functions, the discourse in Germany on regiopolises shows that larger towns or smaller large cities can have functionally complex profiles which correspond, on the one hand, to metropolitan functions in the sense of high-ranking, sometimes global functions and, on the other hand, to supply functions in the sense of the central-place system, e.g. through hospitals and administrations (Aring & Reuther, 2008; Grove & Terfrüchte, 2023; Terfrüchte et al., 2021). This city size class of regiopolises has so far received little attention in European contexts. The size class of small towns should therefore also be taken up in comparative urban system analysis in order to better understand the functional profiles of the various town and city size classes in their specific features.

Finally, with regard to population size, we have deliberately not presented the data as a ratio (e.g. per 1,000 inhabitants), as we are interested in the absolute performance of the SMSTs for this paper. This is mainly because very small LAUs would perform much better relative to population, even if they had the same absolute functionality as LAUs with a larger population. An alternative to this would be the operationalisation of a genuine hinterland significance (co-supplying function), as Christaller assumes for central places (Terfrüchte & Flex, 2018); indeed, for metropolitan and central place functions, there are first valid empirical findings for the German urban system (BBSR, 2023).

Implications for spatial planning and development

Based on the realisation that some specific metropolitan functions are located even in small towns, there are starting points for policy and planning, especially with regard to cultural funding and cultural tourism in small towns. This has also been discussed in some recent studies (Rabbiosi & Ioannides, 2022) where culture is identified as a starting point for small towns.

For spatial planning and development, a region-specific view is more relevant than a perspective based on a specific settlement size. Due to the spatial proximity of settlements of different sizes and functionality, polycentric urban areas with an intra-regional division of labour can develop (Grove, 2012a; Münter & Volgmann, 2021). This also provides starting points for settlement and transport development (Liu et al., 2016), because depending on the spatial and settlement structure in the regions, improvement would need to target networking between the regions or the functional cores of the regions, or alternatively networking between the core cities with their surrounding areas. The organisation of European funding policy can also be targeted at strengthening polycentric regions in order to strengthen networking at these different scale levels: the networking of metropolises and large cities in the European and national urban systems and the networking of metropolises and small and medium-sized towns in the polycentric regions in order to generate spread effects.

Acknowledgements

The authors would like to thank the organisers of the seminar “Small Towns and Metropolitan Cores: Functional Relations, Spatial Imaginaries and Cooperation Arrangements” by the ARL – Academy for Territorial Development in the Leibniz Association for enabling fruitful discussions and comments on the first idea for this paper. The authors received no financial support for the research, authorship and/or publication of this article.

Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

References

- Aring, J., & Reuther, I. (2008). Die Regiopole: Vom Arbeitsbegriff zur konzeptionellen Idee. In J. Aring & I. Reuther (Eds.), *Regiopolen: Die kleinen Großstädte in Zeiten der Globalisierung* (pp. 8–30). Jovis.
- Bański, J. (2022). The Functions and Local Linkages of Small Towns: A Review of Selected Classifications and Approaches to Research. In J. Bański (Ed.), *The Routledge Handbook of Small Towns* (pp. 7–19). Routledge.
- BBSR – Bundesinstitut für Bau-, Stadt- und Raumforschung (2023). Regiopolen und Regiopolregionen in Deutschland. Empirische Befunde und raumordnungspolitische Empfehlungen. BBSR.
<https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/sonderveroeffentlichungen/2023/regiopolen-regiopolregionen-deutschland.html>
- BBSR – Bundesinstitut für Bau-, Stadt- und Raumforschung (2011). Metropolitan areas in Europe. BBSR.
<https://www.bbsr.bund.de/BBSR/EN/publications/OnlinePublications/2011/ON012011.html>
- Blotevogel, H. H. (2004). Städtesystem und Metropolregionen. In G. Heinritz (Ed.), *Nationalatlas Bundesrepublik Deutschland. Nationalatlas Bundesrepublik Deutschland: Dörfer und Städte* (pp. 40–43). Spektrum Akademischer Verlag.
- Blotevogel, H. H., & Danielzyk, R. (2009). Leistungen und Funktionen von Metropolregionen. In J. Knieling (Ed.), *Metropolregionen und Raumentwicklung / Akademie für Raumforschung und Landesplanung: Teil 3. Metropolregionen: Innovation, Wettbewerb, Handlungsfähigkeit* (pp. 22–29). Verlag der ARL.
- Blotevogel, H. H., & Schulze, K. (2009). Zum Problem der Quantifizierung der Metropolfunktionen deutscher Metropolregionen. In J. Knieling (Ed.), *Metropolregionen: Innovation, Wettbewerb, Handlungsfähigkeit* (pp. 30–58). Verlag der ARL.
- Bole, D. (2022). (Re)discovering the small and medium-sized industrial town and its development potential. In H. Mayer & M. Lazzeroni (Eds.), *A Research Agenda for Small and Medium-Sized Towns* (pp. 89–106). Edward Elgar.
- Bourne, L. S., & Simmons, J. W. (1978). *Systems of Cities: Readings on Structure, Growth and Policy*. Oxford University Press.
- Burger, M. J., Meijers, E. J., Hoogerbrugge, M. M., & Tresserra, J. M. (2015). Borrowed size, agglomeration shadows and cultural amenities in North-West Europe. *European Planning Studies*, 23 (6), 1090–1109. <https://doi.org/10.1080/09654313.2014.905002>
- Cardoso, R. V., & Meijers, E. J. (2017). Secondary yet metropolitan? The challenges of metropolitan integration for second-tier cities. *Planning Theory and Practice*, 18 (4), 616–635. <https://doi.org/10.1080/14649357.2017.1371789>
- Cardoso, R., & Meijers, E. (2021). Metropolization processes and intra-regional contrasts: the uneven fortunes of English secondary cities. In M. Pendras & C. Williams (Eds.), *Secondary Cities: Exploring Uneven Development in Dynamic Urban Regions of the Global North* (pp. 103–132). Bristol University Press.
- Diller, C., & Eichhorn, S. (2022). 25 Jahre Metropolregionen in Deutschland im Spagat zwischen Raumordnung und Raumentwicklung: Ein Klassifizierungsvorschlag. *Standort: Zeitschrift für angewandte Geographie*, 46 (1), 16–23.
<https://doi.org/10.1007/s00548-021-00760-4>
- Dunn, E. S. (1983). *The development of the US urban system. Industrial shifts, implications: Vol. 2*. Johns Hopkins University Press.
- European Commission. (2011). *Cities of tomorrow: Challenges, visions, ways forward*. Publications Office of the European Union. <https://doi.org/10.2776/41803>
- Eurostat. (2022). *Eurostat regional yearbook: 2022 edition (2022 edition)*. Publications Office of the European Union.
- Grabski-Kieron, U., & Boutet, A. (2022). Small and Medium-Sized Towns – Situation, Development and Prospects in Different Types of Areas. In E. Gustedt, U. Grabski-Kieron, C. Demazière, & D. Paris (Eds.), *Forschungsberichte der ARL: Vol. 20. Cities and metropolises in France and Germany* (pp. 80–101). ARL.

- Große, A. (2012a). Emerging polycentric city-regions in Germany: regionalisation of economic activities in metropolitan regions. *Erdkunde*, 66 (4), 295–311. <https://doi.org/10.3112/erdkunde.2012.04.02>
- Große, A. (2012b). Knoten in Netzwerken wissensintensiver Dienstleistungen: Eine empirische Analyse des polyzentralen deutschen Städtesystems. Rohn.
- Große, A. (2018). Metropolregionen. In H. H. Blotvogel, T. Döring, & S. Grotefels (Eds.), *Handwörterbuch der Stadt- und Raumentwicklung* (pp. 1507–1517). ARL.
- Große, A., & Terfrüchte, T. (2023). Bedeutende Städte jenseits der Metropolen? Regiopolen und ihre Rolle im deutschen Städtesystem. *Raumforschung und Raumordnung*, 81 (2), 154–169. <https://doi.org/10.14512/rur.756>
- Große, A., & Volkmann, K. (2016). Exploring cosmopolitanity and connectivity in the polycentric German urban system. *Tijdschrift voor Economische en Sociale Geografie*, 107 (2), 214–231. <https://doi.org/10.1111/tesg.12142>
- Große, A., & Volkmann, K. (2022). Metropolisation through regionalisation? Spatial scope and anchor points of metropolitan functions in German urban regions. *Tijdschrift voor Economische en Sociale Geografie*, 113 (5), 502–522. <https://doi.org/10.1111/tesg.12532>
- Gualini, E. (2003). The region of Milan. In W. Salet, A. Thornley & A. Kreukels (Eds.), *Metropolitan Governance and Spatial Planning: Comparative Case Studies of European City-Regions* (pp. 264–283). Spon.
- Hall, P., & Pain, K. (Eds.). (2006). *The Polycentric Metropolis: Learning from Mega-City Regions in Europe*. Earthscan.
- Hamdouch, A., Demaziere, C., & Banovac, K. (2017). The socio-economic profiles of small and medium-sized towns: insights from European case studies. *Tijdschrift voor Economische en Sociale Geografie*, 108 (4), 456–471. <https://doi.org/10.1111/tesg.12254>
- Harrison, J., & Hoyler, M (Eds.). (2015). *Megaregions: Globalization's New Urban Form?* Edward Elgar.
- Hårsman, B., & Olsson, A. R. (2003). The Stockholm region: metropolitan governance and spatial policy. In W. Salet, A. Thornley & A. Kreukels (Eds.), *Metropolitan Governance and Spatial Planning: Comparative Case Studies of European City-Regions* (pp. 91–109). Spon.
- Humer, A., Cardoso, R., & Meijers, E. (2022). Breaking with the spatial-cycle model: the shift towards 'syncurbanization' in polycentric urban regions. *Regional Studies*, 56 (1), 21–35. <https://doi.org/10.1080/00343404.2021.1969008>
- Korcelli-Olejniczak, E. (2022). Small towns in settlement systems: a return to the foreground? In J. Bański (Ed.), *The Routledge Handbook of Small Towns* (pp. 20–31). Routledge.
- Krätke, S. (2007). Metropolisation of the European Economic Territory as a consequence of increasing specialisation of urban agglomerations in the knowledge economy. *European Planning Studies*, 15 (1), 1–27.
- Lefèvre, C. (2003). Paris – Île-de-France region. In W. Salet, A. Thornley & A. Kreukels (Eds.), *Metropolitan Governance and Spatial Planning: Comparative Case Studies of European City-Regions* (pp. 287–300). Spon.
- Liu, X., Derudder, B., & Wu, K. (2016). Measuring polycentric urban development in China: an intercity transportation network perspective. *Regional Studies*, 50 (8), 1302–1315. <https://doi.org/10.1080/00343404.2015.1004535>
- Lüthi, S., Thierstein, A., & Bentlage, M. (2013). The relational geography of the knowledge economy in Germany: on functional urban hierarchies and localised value chain systems. *Urban Studies*, 50 (2), 276–293. <https://doi.org/10.1177/0042098012452325>
- Mayer, H. (2022). Innovation and entrepreneurship in small and medium-sized towns. In H. Mayer & M. Lazzeroni (Eds.), *A Research Agenda for Small and Medium-Sized Towns* (pp. 73–87). Edward Elgar.
- Mayer, H., & Lazzeroni, M. (2022). Introduction to *A Research Agenda for Small and Medium-Sized Towns*. In H. Mayer & M. Lazzeroni (Eds.), *A Research Agenda for Small and Medium-Sized Towns* (pp. 1–7). Edward Elgar.
- Meijers, E. (2008a). Measuring polycentricity and its promises. *European Planning Studies*, 16 (9), 1313–1323. <https://doi.org/10.1080/09654310802401805>

- Meijers, E. (2008b). Summing small cities does not make a large city: polycentric urban regions and the provision of cultural, leisure and sports amenities. *Urban Studies*, 45 (11), 2323–2342. <https://doi.org/10.1177/0042098008095870>
- Meijers, E. J., & Burger, M. J. (2017). Stretching the concept of 'borrowed size'. *Urban Studies*, 54 (1), 269–291. <https://doi.org/10.1177/0042098015597642>
- Meijers, E. J., & Burger, M. J. (2022). Small and medium-sized towns: out of the dark agglomeration shadows and into the bright city lights? In H. Mayer & M. Lazzeroni (Eds.), *A Research Agenda for Small and Medium-Sized Towns* (pp. 23–38). Edward Elgar.
- Meili, R., & Mayer, H. (2017). Small and medium-sized towns in Switzerland: economic heterogeneity, socioeconomic performance and linkages. *Erdkunde*, 71 (4), 313–332. <https://doi.org/10.3112/erdkunde.2017.04.04>
- Münter, A., & Volgmann, K. (2021). Polycentric regions: proposals for a new typology and terminology. *Urban Studies*, 58 (4), 677–695. <https://doi.org/10.1177/0042098020931695>
- Phelps, N. A. (1998). On the edge of something big: edge-city economic development in Croydon, South London. *Town Planning Review*, 69 (4), 441–465. <https://doi.org/10.3828/tpr.69.4.dv1t387m20078jpp>
- Rabbiosi, C., & Ioannides, D. (2022). Cultural tourism as a tool for transformation in small and medium-sized towns. In H. Mayer & M. Lazzeroni (Eds.), *A Research Agenda for Small and Medium-Sized Towns* (pp. 107–126). Edward Elgar.
- Salet, W., Thornley, A., & Kreukels, T. (Eds.). (2003). *Metropolitan Governance and Spatial Planning: Comparative Case Studies of European City-Regions*. Spon.
- Salet, W., Vermeulen, R., Savini, F., Dembski, S., Thierstein, A., Nears, P., Vink, B., Healey, P., Stein, U., & Schultz, H. (2015). Planning for the new European metropolis: Functions, politics, and symbols/Metropolitan regions: functional relations between the core and the periphery/Business investment decisions and spatial planning policy/Metropolitan challenges, political responsibilities/Spatial imaginaries, urban dynamics and political community/Capacity-building in the city region: creating common spaces/Which challenges for today's European metropolitan spaces? *Planning Theory and Practice*, 16 (2), 251–275. <https://doi.org/10.1080/14649357.2015.1021574>
- Savini, F. (2012). Who makes the (new) metropolis? Cross-border coalition and urban development in Paris. *Environment and Planning A*, 44 (8), 1875–1895. <https://doi.org/10.1068/a44632>
- Schiller, D., Burger, M. J., & Karreman, B. (2015). The functional and sectoral division of labour between Hong Kong and the Pearl River Delta: from complementarities in production to competition in producer services? *Environment and Planning A*, 47 (1), 188–208. <https://doi.org/10.1068/a140128p>
- Schmitt, P., Volgmann, K., Münter, A., & Reardon, M. (2015). Unpacking polycentricity at the city-regional scale: insights from Dusseldorf and Stockholm. *European Journal of Spatial Development*, 59, 1–26. <https://doi.org/10.5281/zenodo.5141277>
- Schulze, K., & Terfrüchte, T. (2010). Keine Metropolregion an Rhein und Ruhr? *Geographische Rundschau*, 62 (11), 32–35.
- Servillo, L., Atkinson, R., & Hamdouch, A. (2017). Small and medium-sized towns in Europe: conceptual, methodological and policy issues. *Tijdschrift voor Economische en Sociale Geografie*, 108 (4), 365–379. <https://doi.org/10.1111/tesg.12252>
- Taylor, P. J., Derudder, B., Faulconbridge, J., Hoyler, M., & Ni, P. (2014). Advanced producer service firms as strategic networks, global cities as strategic places. *Economic Geography*, 90 (3), 267–291. <https://doi.org/10.1111/ecge.12040>
- Taylor, P. J., Hoyler, M., & Verbruggen, R. (2010). External Urban Relational Process: Introducing Central Flow Theory to Complement Central Place Theory. *Urban Studies*, 47 (13), 2803–2818. <https://doi.org/10.1177/0042098010377367>
- Terfrüchte, T. (2022). Methods of central place research. In J. M. Gurr, R. Parr, & D. Hardt (Eds.), *Metropolitan Research: Methods and Approaches* (pp. 115–134). Transcript. <https://doi.org/10.1515/9783839463109-007>
- Terfrüchte, T., & Flex, F. (2018). Central Place. In *The Compendium of Urban and Regional Development*. <https://nbn-resolving.org/urn:nbn:de:0156-559928090>

- Terfrüchte, T., Greiving, S., & Wiechmann, T. (2021). Regiopolregionen und gleichwertige Lebensverhältnisse: Regiopolindizes als Evidenzbasis der aktuellen Debatte. *Raumplanung*, 212, 47–53.
- Vasanen, A. (2013). Spatial integration and functional balance in polycentric urban systems: a multi-scalar approach. *Tijdschrift voor Economische en Sociale Geografie*, 104 (4), 410–425. <https://doi.org/10.1111/tesg.12029>
- Volgmann, K. (2013). Metropole: Bedeutung des Metropolenbegriffs und Messung von Metropolitat im deutschen Stadtesystem. Rohn.
- Volgmann, K. (2014). Entwicklung metropolitaner Funktionen im polyzentralen deutschen Stadtesystem – Raummuster der Konzentration und funktionalen Spezialisierung. *Raumforschung und Raumordnung*, 72 (1), 21–37. <https://doi.org/10.1007/s13147-013-0264-5>
- Volgmann, K., & Munter, A. (2022). Understanding metropolitan growth in German polycentric urban regions. *Regional Studies*, 56 (1), 99–112. <https://doi.org/10.1080/00343404.2020.1807491>
- Volgmann, K., & Rusche, K. (2020). The geography of borrowing size: exploring spatial distributions for German urban regions. *Tijdschrift voor Economische en Sociale Geografie*, 111 (1), 60–79. <https://doi.org/10.1111/tesg.12362>
- Wagner, M., & Growe, A. (2021). Research on Small and Medium-Sized Towns: Framing a New Field of Inquiry. *World*, 2 (1), 105–126. <https://doi.org/10.3390/world2010008>
- Website Eurostat (2023a): NUTS - Nomenclature of territorial units for statistics: Local Administrative Units (LAU). Website: <https://ec.europa.eu/eurostat/web/nuts/local-administrative-units>. Last Access 05.01.2023.
- Website Eurostat (2023c): GISCO: Geographical Information and maps. Local Administrative Units (LAU). Website: <https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/lau>. Last Access 05.01.2023.
- Website Eurostat (2023c): Population data, LAU 2 level. Website: https://ec.europa.eu/eurostat/documents/345175/6787248/LAU2_REFERENCE_DATES_POPL.xlsx. Last Access 05.01.2023.