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Medium-Sized Towns in the Knowledge Economy—Towards a Systematic Classification

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Abstract: Medium-sized towns represent important anchor points with regard to services of general interest that are also places to live and work. The increasing number of employees in the service and knowledge economy and the shift in working conditions towards more flexible and mobile working models have impacted the importance of working locations outside the metropolises. This study classifies all medium-sized German towns with a focus on the knowledge economy to analyze the role of this city type for different labor market indicators. First, 19 indicators are condensed into six principal components by means of principal component analysis. This is followed by a cluster and a discriminant analysis to determine five types of towns: (1) important working and education centers, (2) residential towns with a work function, (3) average medium-sized towns, (4) accessibility winners, and (5) tax winners. The results demonstrate that medium-sized towns should be regarded as a single and important urban category, especially concerning the knowledge economy. Our classification enables an initial evaluation that can be used for further evidence-based funding policy and spatial governance. By concluding with a methodological critique and discussing the results obtained, we argue for a more nuanced look at medium-sized towns from different disciplinary perspectives.

Keywords: classification; cluster analysis; discriminant analysis; Germany; knowledge economy; knowledge-intensive services; medium-sized towns; principal component analysis; service industry

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1. Introduction

Municipalities identified as neither metropolises (or large cities) nor rural areas have thus far remained largely unnoticed by researchers [1–3]. In this context, small towns have attracted increasing attention across the research landscape in recent years [4]. Although small towns can be distinguished from medium-sized towns as city types, scientific studies often either approach them together as a single city category or consider them on the basis of individual case studies or transnationally (ESPON-TOWN Project f. ex. [5]) (In the following article, we use the term "city" for all municipal associations with more than 100,000 inhabitants, and the term "town" for all smaller units, like small and medium-sized towns. We refer to the totality of all municipal associations as "city types".). Given the different sizes and, consequently, distinct functional and supply facilities of small and medium-sized towns, we advocate considering the two types separately [4,6]. Furthermore, according to an international-in-scope literature review, the studies that have specifically addressed these city types have used diverse parameters for city size and functional equipment, meaning individual studies offer few starting points for comparative considerations [2]. The ESPON-TOWN project "Small and Medium-sized Towns in Their Functional Territorial Context" represents a first attempt to create a uniform classification of small- and medium-sized towns across Europe [5]. However, viewed at the national level, this classification is not sufficient to derive effects on individual city systems.

Especially in monocentric urban systems, such as in France, but also in the kinds of polycentric systems exemplified by Germany, it is precisely these types of cities that play an important role. Whether as centers in the hinterlands of large cities or in more peripherally located regions, they meet, to varying degrees, the basic needs of rural areas and serve as important employment and residential locations [4,6,7]. In this context, it is notable that the economic importance of medium-sized towns has not yet been systematically investigated [8], despite individual studies recognizing that small- and medium-sized towns have a certain variety of features in the (socio-)economic field that must be studied [1,9,10] and that this economic importance cannot be explained solely with relationships and interlinkages with large cities [11] or in terms of the size of the city [12]. With the transformation from an industrial economy to a service society in the twentieth century, the importance of the knowledge economy has steadily increased. Especially in the area of knowledge-intensive services, this development is taking place with a high degree of dynamism, which at the same time also places changed demands on space and allows new spatial categories and city types to become significant. Especially, the importance and spatial distribution of highly qualified human capital and knowledge-intensive service occupations remains under-researched in medium-sized and smaller towns so far: researchers continue to focus strongly on metropolitan areas and large cities as the drivers of the knowledge economy and, thus, the hubs of innovation, globalization, and internationalization [13], only occasionally considering peripheral regions [7,14,15] and only in recent literature small- and medium-sized towns as centers of concentration of knowledge-intensive activity [16,17]. However, there have been few systematic studies concerning the functional equipment [18,19] and the economic specialization of these sites, especially studies focused on knowledge-intensive service professions [3].

To address these research gaps, our contribution investigates medium-sized towns in Germany, with a special focus on the labor market situation in the service and knowledge economy. Hereby we try to fill a research gap and to give a systematic overview of the situation of medium-sized cities in Germany by applying profound statistical methods. In doing so, we also follow up on existing studies that have been already shown for other national contexts by means of explorative analysis that small- and medium-sized towns are not only important in the context of metropolitan areas but must themselves be considered as autonomous-acting units interlinking to other organizational units [3]. We further contribute to a method-based discussion by confirming and verifying the application of the methods used (principal component analysis, cluster analysis, and discriminant analysis) to geographic units such as, in this case, a specific city type [18]. According to the definition provided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), medium-sized towns have between 20,000 and 100,000 inhabitants, most of whom perform a middle-order central function [20]. Our data set draws on direct and indirect labor market occupations with a special focus on service occupations and knowledge-intensive services (see Sections 3 and 4.1), enabling the analysis of the systematic spatial patterns of a medium-sized town typology. The analysis focuses on the following questions: What role do medium-sized towns play in the knowledge economy? To what extent can different types of medium-sized towns be identified with regard to their economic orientation? What other direct or indirect labor market-related dimensions shape medium-sized towns in different geographical locations in Germany?

This article is structured as follows: Section 2 details both the spatial location of knowledge-intensive activities in Germany and the state of the art of research on medium-sized towns. Building on this, Section 3 derives the indicators selected for the study from the literature, and Section 4 indicates the data basis and the study's research design. Section 5 describes the methods in detail and presents the results. The study concludes with a critical reflection on the methodology used and discusses the results, especially in terms of governance and policy recommendations.

2. Research Review: Spatial Dimensions of Knowledge-Intensive Business Services and the Role of Medium-Sized Towns in Germany

Within knowledge economy activities, knowledge is both a commodity supplying the production process and the output of that process. That is, knowledge workers use their specific and highly qualified know-how to not only further process explicit and tacit knowledge but also to acquire and create new knowledge by recombining already existing ideas. This is accompanied with a high volume of learning processes and also a certain need for direct exchange both between customers and service providers and within the teams themselves [21]. This assumption leads to large cities and metropolitan agglomerations being considered important working sites for knowledge-intensive activities because they feature not only the necessary human capital [22] but also other agglomeration advantages, including infrastructures that facilitate interaction [23,24] and urban diversity [25].

Other studies have demonstrated that different knowledge bases make different demands of interaction processes and, thus, spaces (for a detailed overview, see also Wagner/Growe 2022 [17]). The more knowledge can be codified in the work process, the more knowledge-intensive activities can be located in small- and medium-sized towns with, for example, good connections to large centers [17,26], among other positive factors, including lower land prices and rents [27].

This is also supported by advancing digitalization and the associated simplification of exchange possibilities across large distances, with the concept of temporary spatial proximity (e.g., coworking spaces) growing in importance by offering temporary workplaces in relation to knowledge-intensive activities [28], especially in medium-sized town arrangements [29]. Thus, in this context, the geography of work is increasingly changing [30,31].

The importance of medium-sized towns, which are often considered together with small towns, has so far been frequently neglected by the social sciences. Especially in German-speaking countries, medium-sized towns are regarded as important anchor centers for services of general interest [17,32,33] and aspects of infrastructure and quality of life [34] as potential residential locations outside large cities [35,36] including the context of housing refugees [37] and acting as cooperation partners in regional city networks [38]. For example, a research training group considering small medium-sized German towns of between 20,000 and 50,000 inhabitants uses concrete individual case studies to examine transformation processes that are particularly reflected in the area of institutions, governance and dialogue, and participation processes [39]. This foregrounds qualitative individual case studies, which precludes the determination of spatial patterns or classifications. Different thematic perspectives also appear: works are mostly limited to a certain type of space [40], remain generally descriptive in their considerations [41], or address non-economic topics, such as population dynamics and inner-city development [42]. This may be due to the poorly differentiated data situation, which has been criticized insofar as it is suitable for small-town research [4].

However, the international literature records initial attempts at general [43,44] and knowledge economy-specific typologies of this city type [3,10,25,45]. Individual studies have also addressed the development of medium-sized towns into labor market centers or residential locations [46]. However, case studies are often also selected for analysis in this area [47], or the knowledge economy is compared across all city types within a city system [48]. This situation prompts Mayer (2021) [49] to identify research gaps in the field of economic activities for the city type of small towns, namely the "economic classification of small towns in peripheral locations compared to central locations" and the "detailed analysis of individual sectors" ([48], p. 151; translated by the authors), observations that can be transferred to medium-sized towns.

3. Identification of Direct and Indirect Labor Market Indicators

To classify individual city types in terms of their economic specialization with a particular focus on the knowledge economy, there remains no fixed set of indicators in the literature. Depending on the theoretical approach, a different emphasis is placed on the characteristics of individual aspects: neoclassical approaches focus on "original" production factors to delimit individual spatial units; in demand-oriented studies, both intra- and interregional demand orientations are considered at the regional level; polarization theory approaches are more concerned with predefined growing and shrinking indicators; finally, analyses based on New Economic Geography calculate economic inequality categories, such as factor prices and transport costs [50]. Thus, this study's context can be understood in relation to, on the one hand, different approaches that define knowledge-economy activities per se on the basis of indicators (e.g., [51]) and, on the other hand, initial attempts to categorize individual city types quantitively and statistically (e.g., [25]). Our approach of classifying medium-sized German towns with a special focus on knowledge-intensive activities endeavors to combine these two dimensions.

In research, there is still no generally valid definition of knowledge-economy activities and thus no fixed set of indicators for statistical evaluation and measurement. Therefore, we undertake the explorative attempt of selecting indicator-specific categories by referring to characteristics and skills needed that are attributed to the knowledge economy. Van Winden/van den Berg/Pol (2007: 528) [25] define four pillars of knowledge economy activities in terms of Dahlmann/Anderson (2000) [52]: "(1) an economic and institutional regime that provides incentives for the efficient use of existing knowledge, the creation of knowledge and entrepreneurship; (2) an educated and skilled population that can create and use knowledge; (3) a dynamic information infrastructure that can facilitate the effective communication, dissemination[,] and processing of information; (4) a system of research centers, universities, think-tanks, consultants, firms, and other organizations that can tap into the growing stock of global knowledge, assimilate and adapt it to local needs and create new local knowledge". Based on these initial considerations, we derive analysis categories and associated indicator sets based on the literature but—-at the same time—-with special consideration of the medium-sized towns to be examined and the data available at the municipal association level (see Table 1). In addition to employment figures for the knowledge-intensive sector, this results in four other main categories that are used for analysis and whose indicators are considered measurements of prosperous urban regions:

Table 1. The indicators included in the analysis and their characteristics.

Category	Indicator	Characteristic	Year
Demography and labor structure	Population growth	Increase of the number of inhabitants over the last 5 years in %	2019
	Working-age population	Number of inhabitants aged 15 to under 65 years	2019
	Employment rate	Employees subject to social insurance at place of residence per 100 working-age inhabitants in %	2019
	Employment density at place of work	Employees at place of work per 1000 inhabitants	2019
Accessibility and labor mobility	Accessibility of high-order centers	Average car journey time to the nearest high-order center in minutes	2020
	Accessibility of motorways	Average car journey time to the nearest federal motorway junction in minutes	2020
	Commuter balance	Commuter balance per 100 employees subject to social insurance at place of work	2019
	Commuters traveling > 50 km	Share of employees subject to social insurance with a commute of 50 km or more at place of residence in %	2019
Educa-tion	Students at universities	Students at universities and colleges per 1000'inhabitants	2019
	Pupils in vocational schools	Pupils in vocational schools per 1000 inhabitants	2019
Tax	Trade tax	Trade tax in € per inhabitant	2019
	Income tax	Income tax in € per inhabitant	2019
	Tax power	Municipal power tax in € per inhabitant	2019

Table 1. *Cont.*

Category	Indicator	Characteristic	Year
Service economy and knowledge economy	Knowledge economy	Employees in knowledge-intensive occupations	2021
	Share knowledge economy/social insurance	Share of employees in knowledge-intensive occupations to employees subject to social insurance contributions in %	2021
	Change in knowledge economy	Change in the number of employees in knowledge-intensive services between 2012 and 2021 in %	2012–2021
	Services	Employees in service occupations	2021
	Share services/social insurance	Share of employees in service occupations to employees subject to social insurance contributions in %	2021
	Change in services	Change in the number of employees in service occupations between 2012 and 2021 in %	2012–2021

Demography and labor structure. Both population development and labor market structure have been cited as important factors for economic classification in relevant studies [53–55]. However, departing from most studies, we intentionally do not refer to the differentiation of the knowledge economy from other industries [25,54], instead depending upon indicators such as employment rate and employment density at workplaces. This is justified by the fact that the aim is not to analyze specializations of different sectors of medium-sized towns but to examine the interactions between indirect and direct labor market indicators with a focus on service occupations and knowledge-intensive services. The indicator of population development at the municipal association level also includes the demographic dynamics of the cities and their potential to be considered a growing and thus attractive place for knowledge-intensive activities.

Accessibility and labor mobility. As a second important category, studies mention the accessibility of different knowledge economy locations [53]: "Crucial for a city's ability to acquire, create, disseminate and use (codified and tacit) knowledge effectively for greater economic and social development. The knowledge is a networked economy" ([25], p. 531). In this context, reference is often made to information and communication technology indicators [56,57], with geographical distances [53] or commuter mobility thus far rarely included. Particularly against the background of categorizing cities as places of work and places of residence, the expansion of the set of indicators to include commuter balance and commuter routes appears logical. Different classifications of the BBSR (see f.ex. [42]), which for example territorially delimit areas of influence and thus the radiance of large cities in Germany, also refer to commuter distances.

Education. Some studies combine the factors of education and skilled workers and include them in analyses as human capital [53,54]; meanwhile, other approaches are limited to the number of educational infrastructure facilities, such as universities and schools [25], or, in international comparative studies, to indicators such as the literacy rate [57]. It seems logical to include vocational schools in analyses based on consideration of the medium-sized city type, because medium-sized towns are not only residential locations but also educational centers in more peripheral areas. Furthermore, in addition to technology centers, firms, and think tanks, van Winden/van den Berg/Pol (2007) [25] mention universities and educational institutions in general as important hubs and points of attraction for knowledge-intensive activities. We take this point into account by referring to 'education' in terms of student numbers and pupil numbers at vocational schools.

Tax. Many studies have defined indicators such as gross domestic product or industrial investment as a measure of the prosperity of regions or cities [55]. Because these indicators are not available at the level of municipal associations, we measure the prosperity of medium-sized towns in terms of both private-sector and business-related tax revenues [55]. In this context, high tax revenues indicate a numerically high settlement of prospering firms and thus also a local-regional potential of knowledge-intensive activities.

Service economy and knowledge economy. To focus on both service occupations and knowledge-intensive activities, we distinguish between these two economic sectors according to the definition of Glückler et al. (2008) [58] (see Section 4.1) and include in the analysis both static actual figures, namely, the share of employees subject to social insurance contributions as an indication of the importance of the two sectors for the respective city and dynamic changes as an indication of their development potential.

For research pragmatic and data availability reasons, the indicators assigned to the respective analysis categories are largely derived from the existing data stock of the INKAR database and own data stocks (knowledge economy) (see also Section 4.1).

4. Data and Methods

This section discusses the definition, sourcing, and preparation of each dataset and addresses in detail the research design and the choice of the different multivariate statistical methods.

4.1. Data

To classify medium-sized German towns in the context of the knowledge economy, we use data that represent, on the one hand, concrete labor market factors, such as the knowledge-intensive workforce and the demographic and employment structure, and on the other hand, indirect factors, such as commuter mobility and the accessibility of places, tax revenues, and the local education situation (see Table 1). The data set, which comprises 19 indicators, can be accessed via the online portal of the Indicators and Maps of Spatial and Urban Development (Online-Portal der Indikatoren und Karten zur Raum- und Stadtentwicklung—INKAR) [59] provided as part of the Central Place Monitoring (Zentrale-Orte-Monitoring—ZOM) of the Federal Institute for Research on Building, Urban Affairs, and Spatial Development in Germany (Bundesinstitut für Bau-, Stadt- und Raumforschung; BBSR).

The indicators from the area of the service and knowledge economy include data from the Federal Employment Agency, which represents all employees subject to social insurance contributions in these sectors at the workplace for the years 2012–2021 (with a cut-off date of 31 December). Employees subject to social insurance represent approximately 70% of German employees, with “civil servants, self-employed persons, family members helping out, professional and temporary soldiers as well as those doing military and civilian service” (Employment Statistics of the Federal Employment Agency 2021 [60] translated by the authors) not included.

The delamination of services derives from a study by Glückler et al. (2008) [58], which details the new demarcation of the concept of services and develops a differentiated typology at the sectoral level. This seemingly makes sense because there remains substantial heterogeneity of the service concept in the literature, which precludes clear delamination according to a specific set of indicators [61]. Notably, this sometimes leads to poorly justified classifications [62,63]. Knowledge-intensive services have also been defined according to different criteria, such as according to the depth of standardization of processes of knowledge generation and transformation [64], by focusing on the degree of innovation, interaction, and problem-solving of knowledge-generating activities [65,66] or by distinguishing knowledge-generating activities from research-intensive industries [67,68], financial services [69], or the cultural and creative sectors [70]. In contrast, Glückler et al. (2008) [58] distinguish the service sector from the manufacturing sector by describing the economic branches E and G to O (The economic branches include E—electricity, gas, and water supply; G—wholesale and retail trade, repair of motor vehicles, motorcycles, and personal and household goods; H—hotels and restaurants; I—transport, storage, and communication; J—financial intermediation; K—real estate, renting, and business activities; L—public administration and defense, compulsory social security; M—education; N—health and social work; and O—other community, social, and personal service activities [71].) of the WZ Classification (2003) [71] as the tertiary sector in accordance with Destatis and Eurostat classifications.

Glückler et al. (2008) [58] also differentiate three different dimensions of service sectors, which can be mapped based on business orientation, knowledge intensity, and technology intensity. The dimensions of business orientation and knowledge intensity can be depicted onto two vectors in relation to each other, enabling the distinction of four different service sectors: (a) operational household services, (b) knowledge-intensive household services, (c) operational business services, and (d) knowledge-intensive business services. In addition, technology-intensive sectors are delineated but can only be located in the knowledge-intensive, business-related sector: (e) technology- and knowledge-intensive business services. Thus, all five service sectors constitute the service economy, with knowledge-intensive household and business services and technology and business services delineated as knowledge-intensive services.

To ensure the classification corresponds to the current data status, we have taken the first step of reconciling the classification with the status of the economic sectors in 2008. Our second step involved reclassifying the classification to a functional view with the help of the Classification of Occupations of 2010. We advocate using functional data to map the "real" labor force membership in the individual municipal associations at the level of actors and individuals [17,72].

For the following analyses, all data were processed and brought to the level of the municipal associations as of September 2022.

4.2. Methods and Research Design

To obtain a classification of Germany's medium-sized towns, different multivariate analysis methods are connected in series, which complement each other to produce the best possible cluster variables (see Figure 1). In terms of the study design, we are guided by various studies with a geographical focus that have chosen comparable method combinations [73–77]. With regard to regional-economic and functional analyses of individual city types, the studies by Wieland/Fuchs (2018) [50] and Gareis/Milbert (2020) [18] serve as methodological examples for the following analysis.

The first step involves pre-structuring the 19 different indicators available at the beginning of the analysis by means of a principal component analysis across all 4391 municipal associations (area status: September 2022). Using this factor analysis simplifies the interpretation of the subsequent clusters. As Figure 2 shows, some indicators that can be traced back to the same location factors or are directly causally dependent on each other (for example, the working-age population in a community association and the absolute number of service or knowledge-intensive employees; the population development and the employment density at place of work; and the service sector and the knowledge economy sector as well as tax power and trade tax) are strongly correlated. Because strongly correlated variables are included in the calculation with a higher weighting in a cluster analysis, these correlations should be statistically eliminated to the extent possible. This is achieved by grouping them into principal components ([50], p. 159). The factor analysis is performed on all spatial units, not only the medium-sized towns. This is because, with reference to Gareis/Milbert (2020: 7) [18], the indicators could also be applied in the same form to all other city types as a delimitation criterion, with "the value space extend[ing] in the result over all city and municipality sizes" (translated by the authors). Furthermore, medium-sized towns must be considered in relation to the remaining geographical regions [78]. Thus, the criticism that geographical references cannot be sufficiently considered by means of a principal component analysis can be partially abandoned.

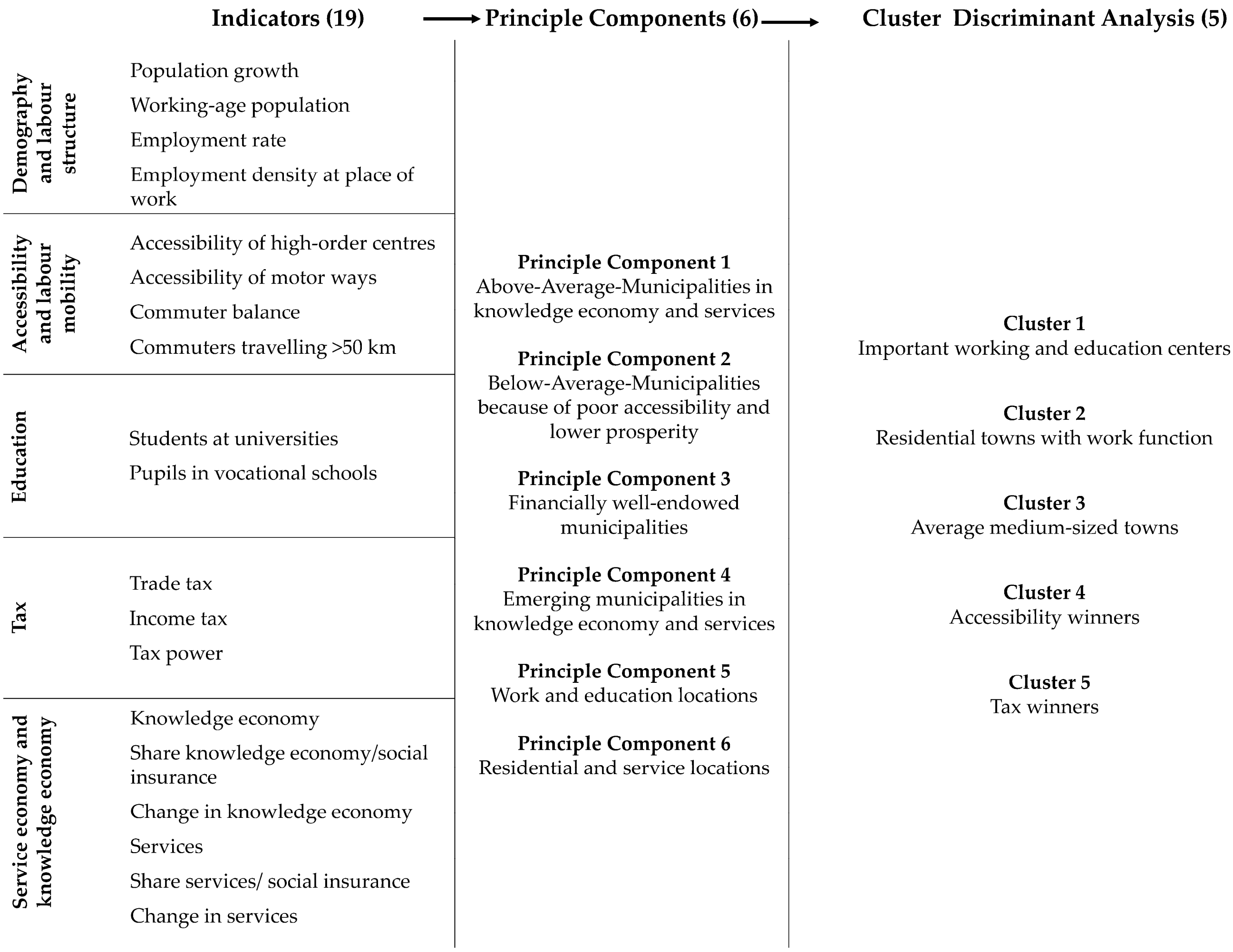

Figure 1. Study research design (own representation).

The second step is an explorative, taxonomic, hierarchical cluster analysis of all 634 medium-sized towns at the municipal association level (area status: September 2022), within which the six principal components are combined into five clusters. Because cluster analysis is an explorative multivariate-statistical procedure, different feasible solutions must be trialed. If we use the error square sum as the sole criterion, its development illustrates the meaningful formation of only two clusters, because an increase of 21% can be observed between steps 631 and 632 (see Table 2). However, the interpretation of the different solutions from two to five clusters indicates that five clusters can be interpreted logically. As such, we use a five-cluster solution for the analysis.

Table 2. Assignment overview and coefficient as error square sum.

Number of Clusters	Step	Cluster 1	Cluster 2	Coefficient	Increase
6	628	13	62	1100.489	
5	629	1	4	1228.335	12%
4	630	13	41	1379.136	12%
3	631	13	606	1603.107	16%
2	632	1	13	1945.040	21%

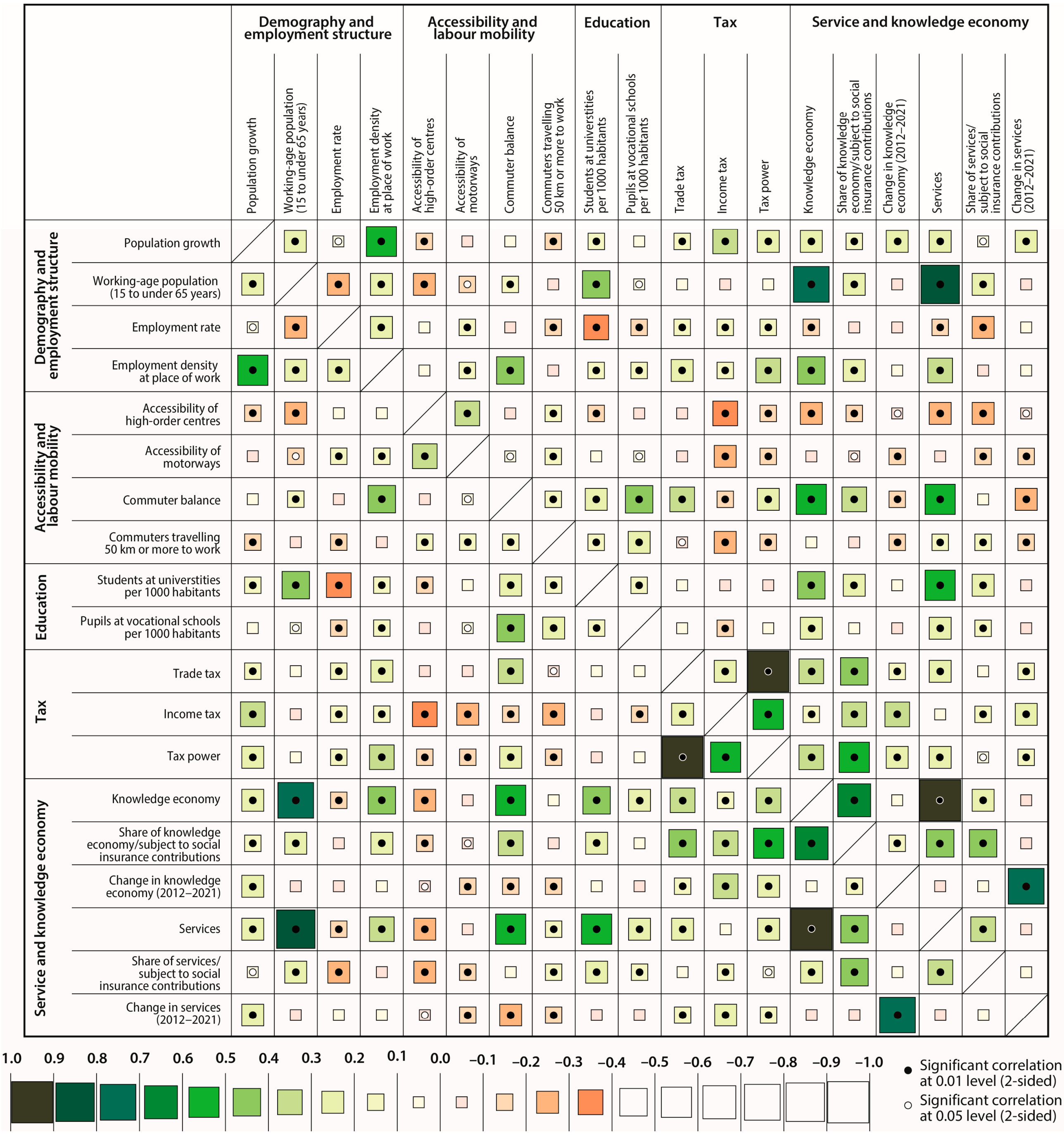

Figure 2. Correlation matrix over all 19 indicators (own representation).

Our cluster analysis uses the WARD method and the squared Euclidean distance as a distance measure. This ensures that the resulting clusters are as internally homogeneous as possible and as heterogenous as possible as a whole. The method also ensures that clusters are unevenly distributed to the extent possible, which is less important and desirable when typifying geographical units ([79], pp. 484). Another advantage of the WARD method is that, as a rule, very good clusters are outputs that are relatively robust—even after applying the discriminant analysis—and require little regrouping ([79], pp. 489).

To determine the optimal number of clusters, different statistical criteria are available, including the Elbow criterion, the Stopping Rule according to Calinski/Harabsz, and Mojena's test ([79], pp. 495). However, these must always be supplemented by a logical consideration of the content. To determine the number of clusters, we use the error sum of squares, which appears as a coefficient in the assignment overview in combination with the graphical representation in the dendrogram and an argumentation that makes sense in terms of content ([79], pp. 495).

The third step involves examining the clustering performed by means of discriminant analysis and, thus, a structure-checking procedure. Because the procedures of cluster analysis and discriminant analysis are complementary, this guarantees the best possible result for a classification, because "cluster analysis creates groups and discriminant analysis examines predefined groups" ([79], p. 217; translated by the authors; emphasis in the original). By formulating and applying discriminant functions to the existing data set, the assignment to the respective clusters already predefined in the cluster analysis is checked. Each group can be assigned a mean discriminant value (centroid), the distances between which illustrate the differences between the individual clusters (see Figure 3) ([79], pp. 221).

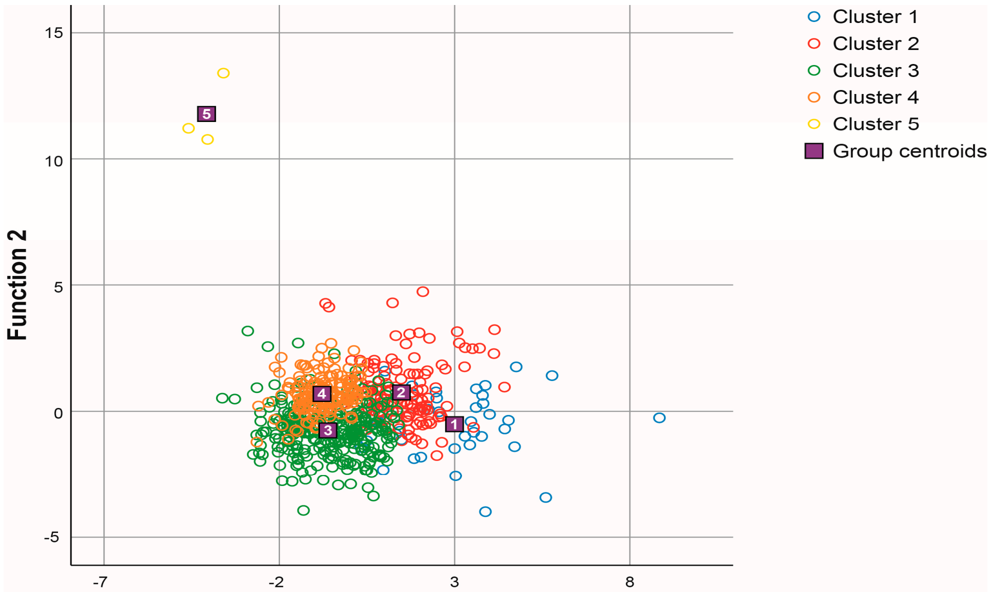

Figure 3. Group Centroids and scatter plot of the canonical discriminant function.

5. Results: Economic Focus, Tax Winners, and Residential Locations in Germany's Medium-Sized Towns

This chapter explains and interprets geographically the individual results of the factor and cluster analysis, which build on each other.

5.1. Pre-Classification: Results of the Principal Component Analysis

The principal component analysis was performed across all municipal associations (n = 4391) for the 19 indirect and direct labor market indicators identified. The Kaiser–Meyer–Olkin sample adequacy measure of 0.610 exceeds the critical value of 0.5, which means that the available data can be considered suitable for factor analysis ([79], p. 399). Six principal components were extracted using the Kaiser–Guttmann criterion, which assigns an above-average share of the variance to all components with an eigenvalue above 1, meaning that the components each contribute more to the structure than each individual variable ([79], p. 396). As Table 3 shows, the six principal components explain a total of 64.3% of the variance of the overall distribution.

To be able to interpret the output principal components, the variables uploaded to a factor are summarized by means of a collective term. This term assignment can prove difficult, because various indicators sometimes load to a component due to diverse indicators determining a principal component in terms of content. As a delamination for "high" loadings, a value of 0.5 is assumed ([79], p. 418). To further differentiate and simplify the result representation by maximizing the internal charges, the Varimax rotation method was applied (see Table 4). This orthogonal rotation method ensures that individual factors are uncorrelated after rotation ([79], p. 419).

Table 3. Principal components of economic indicators in medium-sized German towns.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.644	19.181	19.181	3.644	19.181	19.181	3.000	15.791	15.791
2	2.632	13.851	33.032	2.632	13.851	33.032	2.162	11.378	27.168
3	1.887	9.934	42.966	1.887	9.934	42.966	2.111	11.112	38.280
4	1.499	7.889	50.855	1.499	7.889	50.855	1.909	10.050	48.330
5	1.478	7.781	58.636	1.478	7.781	58.636	1.688	8.886	57.126
6	1.081	5.690	64.326	1.081	5.690	64.326	1.351	7.110	64.326
7	0.935	4.919	69.245						
8	0.862	4.535	73.780						
9	0.849	4.469	78.249						
10	0.790	4.159	82.408						
11	0.746	3.925	86.334						
12	0.721	3.792	90.126						
13	0.557	2.933	93.059						
14	0.432	2.275	95.334						
15	0.373	1.966	97.300						
16	0.255	1.345	98.644						
17	0.218	1.146	99.790						
18	0.038	0.200	99.990						
19	0.002	0.010	100.00						

Table 4. Rotated Principal Component Matrix.

Indicators	Components					
	1	2	3	4	5	6
Services	0.990	−0.056	0.045	−0.002	0.093	0.048
Knowledge economy	0.985	−0.051	0.060	0.001	0.076	0.035
Working-age population	0.980	−0.053	0.017	−0.001	0.080	0.049
Accessibility of high-order centers	−0.110	0.834	−0.015	−0.104	0.036	0.049
Accessibility of motorways	−0.011	0.740	0.038	−0.055	−0.055	−0.075
Income tax	−0.007	−0.532	0.431	0.298	−0.216	0.000
Tax power	0.019	−0.131	0.892	0.121	0.068	−0.010
Trade tax	0.038	0.150	0.867	0.036	0.077	−0.028
Share knowledge economy/social insurance	0.155	−0.386	0.494	0.074	0.383	0.109
Change in services	−0.005	−0.032	0.057	0.906	−0.013	0.025
Change in knowledge economy	0.002	−0.034	0.076	0.884	0.026	−0.030
Population development	0.002	−0.218	0.066	0.398	−0.038	0.148
Commuter balance	0.064	0.016	0.242	−0.039	0.705	−0.053
Pupils in vocational schools	0.033	−0.075	−0.055	−0.061	0.637	0.174
Employment density at place of work	−0.024	0.272	0.063	0.070	0.567	−0.131
Students at university	0.179	−0.125	−0.031	−0.003	0.444	0.213
Employment rate	−0.055	0.044	0.072	−0.098	−0.105	−0.715
Commuters traveling > 50 km	−0.038	0.420	−0.051	−0.033	0.064	0.607
Share services/social insurance	0.104	−0.337	0.199	0.063	0.143	0.570

High loadings that have a positive effect on the respective principal component are marked in green; high loadings that have a negative effect are marked in red (principal component 2—inverse indicator, see Section 5.1 (*Second Principal Component*) for an explanation).

On the *First Principal Component*, the factors of employees in service occupations, employees in the knowledge economy, and the working-age population load particularly high. Thus, these represent medium-sized towns with above-average levels of service and knowledge economy occupations (Principal Component 1—**Above-average municipalities in knowledge economy and services**).

On the *Second Principal Component*, accessibility to high-order places and motorway connections show high loads, whereas income tax as an indicator of economic prosperity is rather less pronounced. In the case of the accessibility indicators, the values must be read inversely because particularly low initial values, which are included in the initial analysis, indicate positive accessibility (0 min to the high-order place means that a medium-sized town is a high-order place, 2 min to the motorway means good accessibility) and high initial values indicate poor accessibility (e.g., 50 min to the high-order place indicates that an individual must drive 50 min to access a high-order place). Thus, those medium-sized towns that score high on this component can be described as below-average municipalities due to poor accessibility and limited prosperity (Principal Component 2—**Below-average municipalities due to poor accessibility and lower prosperity**).

On the *Third Principal Component*, the trade tax and the tax power per inhabitant are particularly high. Thus, these municipalities are financially well equipped due to above-average tax revenues (Principal Component 3—**Financially well-endowed municipalities**).

The *Fourth Principal Component* demonstrates high values for the rates of change in the service and knowledge-intensive professions between 2012 and 2021. Thus, this gathers medium-sized towns that can be considered emerging municipalities in terms of knowledge economy and service occupations (Principal Component 4—**Emerging municipalities in knowledge economy and services**).

On the *Fifth Principal Component*, the indicators commuter balance, employment density at the place of work, and pupils in vocational schools show high values. A positive commuter balance emphasizes the interpretation of the employment density value and the municipalities as general places of work not specifically related to the knowledge economy. Furthermore, these municipalities are also characterized by a focus on education, with the number of students at universities only just below the threshold value of 0.444 and the high values for pupils in vocational schools (Principal Component 5—**Work and education locations**).

On the *Sixth Principal Component*, both the share of employees in service occupations to all employees subject to social insurance and the share of commuters traveling more than 50 km to work are particularly high. Meanwhile, there is a negative value for the employment rate. This enables the conclusion that these medium-sized towns can be described as places of residence that are strongly characterized by service professions of any kind in the remaining labor market (Principal Component 6—**Residential and service locations**).

5.2. Discriminant Analysis

After performing the cluster analysis, discriminant analysis is conducted to "check the suitability of the variables for the clustering" ([79], p. 245). The classification results of the discriminant analysis show that 85.2% of the towns already assigned by the cluster analysis are classified identically after the discriminant analysis. This reiterates the robustness of the WARD method used in the cluster analysis and indicates the high validity of the analyses performed ([18], p. 551).

The arithmetic mean values of the individual principal components included in the analysis are used to interpret the classifications of medium-sized towns (see Table 5). Again, the average and median values for principal component 2 (below-average municipalities due to poor accessibility and lower prosperity) must be read inversely (see Section 4.2). There is a certain scatter across the four discriminant functions calculated for the analysis (see Figure 3). When comparing the arithmetic means and the median values, there are only minor deviations, which indicates that the few outliers have only a marginal effect on interpreting the cluster.

Table 5. Principal components assigned to the clusters according to discriminant analysis.

Mean Values								
Clusters	**Number**	**RC1**	**RC2**	**RC3**	**RC4**	**RC5**	**RC6**	**Population**
		Above-average municipalities in knowledge economy and services	Below-average municipalities because of poor accessibility and lower prosperity	Financially well-endowed municipalities	Emerging municipalities in knowledge economy and services	Work and education locations	Residential and service locations	
1	47	0.239	−1.078	−0.162	−0.218	2.391	1.569	54,852
2	131	0.029	0.172	−0.078	−0.336	0.935	1.124	36,658
3	266	0.102	−0.438	0.236	−0.254	0.883	−0.361	38,694
4	187	0.016	−0.862	0.226	−0.041	−0.074	0.319	33,066
5	3	0.067	0.086	8.842	−0.274	0.009	0.530	32,583
total	634	0.071	−0.482	0.180	−0.206	0.720	0.294	37,782
Median Values								
Clusters	**Number**	**RC1**	**RC2**	**RC3**	**RC4**	**RC5**	**RC6**	**Population**
		Above-average municipalities in knowledge economy and services	Below-average municipalities because of poor accessibility and lower prosperity	Financially well-endowed municipalities	Emerging municipalities in knowledge economy and services	Work and education locations	Residential and service locations	
1	47	0.247	−1.132	−0.211	−0.231	2.252	1.394	49,913
2	131	0.004	0.106	−0.139	−0.361	0.959	1.020	31,633
3	266	0.057	−0.513	0.166	−0.277	0.817	−0.358	32,125
4	187	−0.008	−0.878	0.116	−0.069	−0.071	0.316	28,249
5	3	−0.018	0.107	0.326	−0.177	0.130	0.362	35,193
total	634	0.033	−0.604	0.054	−0.227	0.601	0.275	31,576

Above-average values or above-median values are marked in grey.

For principal components 1 and 3–8, figures marked in grey represent values that deviate upwards from the mean or median of all medium-sized towns (total). For principal component 2, figures marked in grey represent values that deviate downwards from the mean or median of all medium-sized towns (total) (inverse indicator; see Section 4.2 for an explanation).

Important working and education centers with residential function. Cluster 1 is particularly characterized by above-average values in the areas of the employment and education function (2.4) and, in a subordinate sense, the residential and service function (1.6). This cluster numbers 47, a relatively small proportion of Germany's total of 634 medium-sized towns. It is also notable that cluster 1 features the highest average number of inhabitants (54,852). This also explains the good accessibility of the towns, articulated by their connection to motorways or their designation as a regional center. However, because this principal component remains above average in cluster 4, accessibility only plays a subordinate role in the assignment of the collective term for the cluster designation [18]. Additionally, these towns function to a certain extent as concentration points for knowledge-intensive services, at least in the hinterlands of large cities, something that is reflected by the above-average value of principal component 1 (e.g., Tübingen, Marburg, Kaiserslautern, Gießen). The function as an educational center for vocational schools is also linked to the size of the population, the provision of high-order functions, and the concentration of different functional faculties, especially in more peripheral areas. Among the educational locations classified in our analysis, several medium-sized towns have already been analyzed as "educational strongholds" by previous studies [80].

The corresponding map (see Figure 4) enables identification of regional and, to a certain extent, politically conditioned peculiarities for this type of medium-sized town. Especially in rural-peripheral Bavaria, there is a relative accumulation of medium-sized towns assigned to cluster 1. These include, for example, the municipal associations of Hof, Ansbach, Weiden in der Oberpfalz, and Immenstadt im Allgäu. In the case of these medium-sized towns, the principal component 2—-and, thus, the accessibility of high-order places—-positively impacts the clustering. Because the designation of central places is the responsibility of the individual federal states, specific federal criteria are also formulated. As such, the federal state of Bavaria features a particularly high number of not only medium-sized but also small towns as high-order places. Of the 18 medium-sized towns in Bavaria assigned to cluster 1 by the analysis, 17 are themselves designated as high-order places.

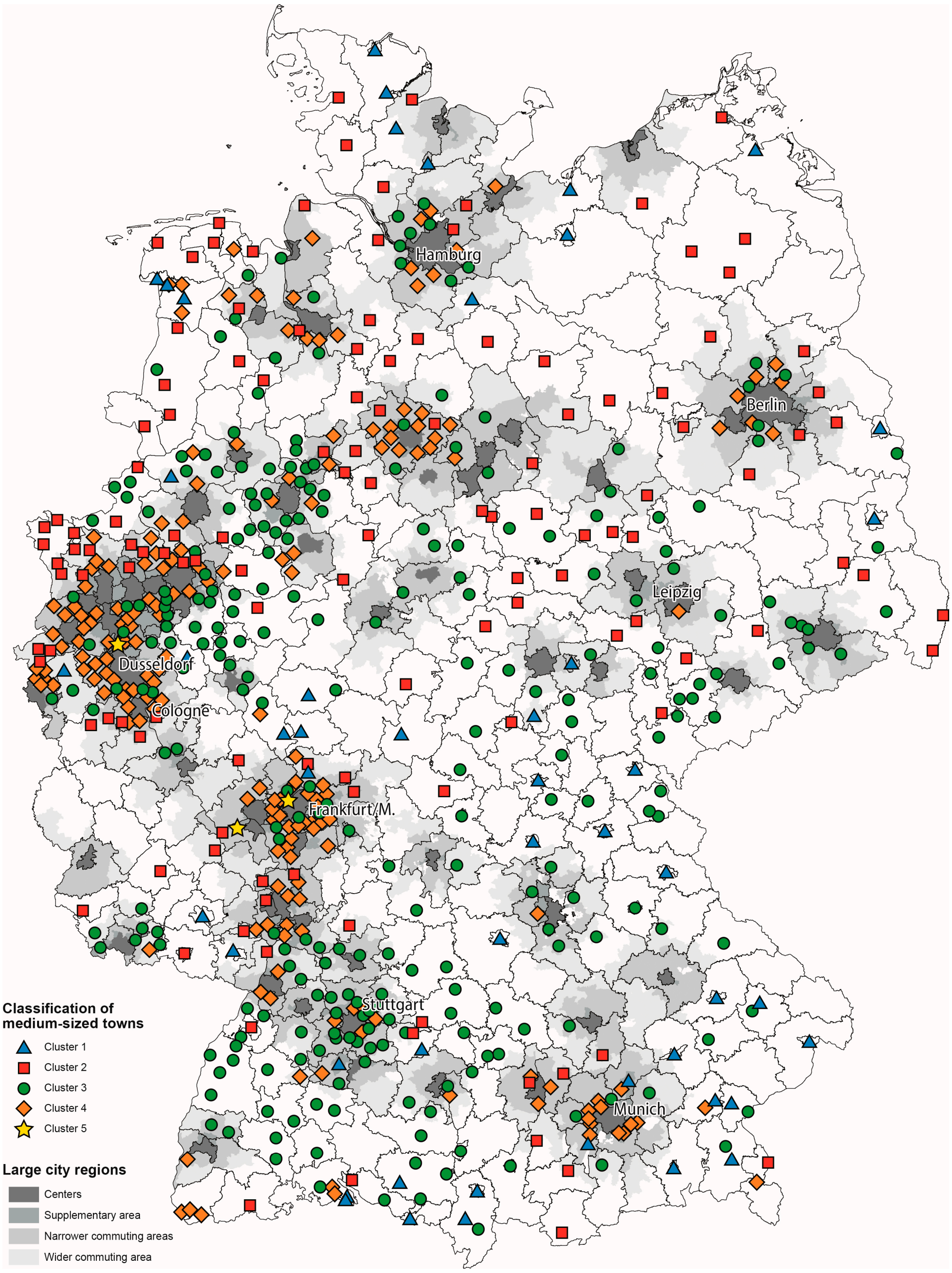

Figure 4. Map of the classifications of Germany's medium-sized towns.

Especially in the more rural areas, the medium-sized towns assigned to cluster 1 can also be interpreted as centers with a high residential quality and labor market function for the surrounding communities. According to the concept of regiopoles [81], which includes towns with fewer than 100,000 inhabitants in new methodological approaches [82], there are initial suggestions for including these city types as important centers for the hinterland in political governance processes and designating them as a spatial category in spatial planning [83] or also in other European countries.

Residential towns with work function. Cluster 2 is characterized by an above-average value in the area of residential and service function (1.1) and also certain functionality as a place of work and education center (0.9). This cluster unites 131 towns. Spatially, this type of medium-sized town appears with particular frequency in the north and east of Germany and partly in the peripheral areas of the large city regions of North Rhein-Westphalia. Meanwhile, in southern Germany, this city type is rarely found. The determining criterion of this cluster is the share of long-distance commuters that travels more than 50 km to their place of work. On average, around 15% of employees in this group of medium-sized towns commute more than 50 km to their place of work (compared to the average for all medium-sized towns of 10%). This explains, for example, the medium-sized towns of Pfaffenhofen an der Ilm, Weilheim in Oberbayern, and Landsberg am Lech, which are assigned to cluster 2 in the Greater Munich Area and which lose many commuters in the direction of Munich by acting principally as residential towns [46]. Meanwhile, in the more peripheral areas of northern Germany, the work and education function play an increasing role in cluster 2.

Average medium-sized towns. Cluster 3 represents the largest group, featuring 266 medium-sized towns. As such, it can be described as an average cluster, something that is reflected in the individual values. Medium-sized towns assigned to cluster 4 have a certain labor and education function and also a slightly above-average value for knowledge-intensive activities. Furthermore, a certain prosperity can be observed, which is generated by above-average trade tax revenues and per-inhabitant tax power of the municipalities. Geographically, these municipal associations are primarily located in the south of Germany, as well as in the more peripheral area of western and—-to a substantially lesser extent—-eastern Germany. In the country’s economically prosperous south, the structure can be explained by historically conditioned path dependencies. Meanwhile, in the west, the structural change from coal and steel industries to more service-related activities has also found its way into medium-sized towns [84].

Accessibility winners. The 87 medium-sized towns assigned to cluster 4 can be described as accessibility winners and, thus, places in central locations. This can be demonstrated cartographically: these medium-sized towns are found in the direct vicinity of the large metropolises of Berlin, Hamburg, Hanover, Bremen, Munich, Frankfurt, and Stuttgart, as well as in the highly urbanized Ruhr area (see Figure 4). Furthermore, these towns have an above-average residential and service focus and relative prosperity. In addition, a certain potential for future knowledge-intensive activities can be identified in these towns, with Principal Component 4 (emerging municipalities in knowledge economy and services) having the least negative value here. This means that these medium-sized towns are thus far the least saturated and that spillover effects or catch-up increases in highly qualified workers in the surrounding areas of the central metropolises can persist [27]. In particular, the good accessibility of the towns also represents an important advantage for increasing urbanization and labor market concentration [85]. Furthermore, according to the borrowed-size concept of Meijers/Burgers (2005) [78], these towns in the immediate vicinity of large metropolises can borrow further functions, making them important relief locations beyond the residential functions in the conurbations.

Tax winners. Three medium-sized towns can be described as tax winners, differing considerably from the rest of the medium-sized towns, especially due to their tax revenue (trade tax and tax power): Eschborn, Monheim am Rhein, and Ingelheim am Rhein. Located in the immediate vicinity of large metropolises, these medium-sized towns are home to large international companies, precipitating a special position that can be explained by the very low trade tax rates for the respective regions (Monheim am Rhein: 260; Düsseldorf and Cologne as the nearest large centers: 440 and 475; Kreis Mettmann average: 405.1; North Rhine-Westfalia: average: 448.2 | Eschborn: 330, Frankfurt am Main as the nearest major center: 460; Main-Taunus district average: 357.5; Hesse average: 379.5 | Ingelheim am Rhein: 332; Mainz as nearest major center: 440; Mainz-Bingen district average: 366; Rhineland-Palatinate average: 372.7) [86]. Thus, these three medium-sized towns are of particular importance due to their high tax revenues and worldwide renown as the home of world market leaders [87].

5.3. Summary

Our results show that the use of indirect and direct labor market-related indicators allow five different types of medium-sized towns to be differentiated in the German context: (a) important working and education centers with residential function (Cluster 1), (b) residential towns with work function (Cluster 2), (c) average medium-sized towns (Cluster 3), (d) accessibility winners (Cluster 4), and (e) tax winners (Cluster 5). Forty-seven medium-sized towns, a relatively small group, have good accessibility to motorway connections and regional centers and are important working and education centers with residential functions. Geographically, these towns are often also located in more rural areas, where they represent anchor centers for their surrounding areas and are given special weighting—-to some degree—-in regional development due to political designations as high-order places. One hundred thirty-one towns found mainly in the north of Germany can be described as residential locations with work functions. Here, there is a particularly high proportion of commuters who travel more than 50 km to work, which suggests a concentration as a residential location. With 266 towns, the largest group comprises medium-sized towns that are slightly above average in terms of (knowledge) economy and, thus, have a certain work but also education function. The towns in this cluster are frequently located in southern Germany, which represents economic prosperity due to historical path dependencies. In the central locations around Germany's large metropolises, a group of 87 medium-sized towns can be distinguished. These towns are characterized by particularly good accessibility values. Meanwhile, they also demonstrate a certain residential and service focus as relief locations for the large metropolises. The last group comprises three medium-sized towns that attract large global players due to their low business tax rates compared to the surrounding areas, enabling them to stand out as tax winners among the group of medium-sized towns.

6. Discussion

This article has aimed to consider medium-sized towns as a city category that has thus far received limited research attention and contribute to the literature on systematic-quantitative analyses of this city type. By focusing on services and knowledge-based professions, a field of activity has been chosen that, due to its flexible working arrangements and locations, offers great potential for growth, especially for medium-sized—-and, in some cases, even smaller—-towns located not only in the immediate vicinity of metropolises but also in more rural areas. Reflecting on the content analysis, the study shows that large cities are not only locations of knowledge-based work and medium-sized or small towns are not only residential locations [11]. Instead, the systematic differentiation of medium-sized towns offers an understanding of the multiple types (e.g., self-contained anchor towns in rural surroundings [8] or medium-sized towns that relieve metropolitan housing markets). It becomes clear that with the change from industry to a service society, a differentiation, specialization, and division of functions is also reflected in medium-sized towns outside of large cities, which in turn can be profitably used through skillful cooperation and interlinkages between different cities and city types. Thus, the classification of different types of medium-sized towns with special consideration of the service and knowledge economy enables an initial evaluation that can also be reacted to in terms of regional planning.

Reflecting on the method, our research design, namely the combination of factor analysis and cluster analysis, enabled us to mitigate but not eliminate certain hurdles associated with the data material at the level of analytical-statistical analysis. Regarding the discourse on intraregional linkages [17,78], subsequent analyses should also include network data that can depict cooperative and location-specific relationships. Our analysis partly covers the effect of geographical location via the indicators from the accessibility category and also via principal component analysis for all 19 indicators across all of Germany's municipal associations [18]. This refers to the fact that medium-sized towns do not exist as self-contained entities in space and, therefore, must also always be interpreted with a view to their surrounding area.

One hurdle that is ever-present in systematic-analytical studies is the selection of specific indicators. For this study, we have limited ourselves specifically to service-intensive and knowledge-intensive occupations. However, their delamination is not based on a nationally or Europe-wide generally valid definition, undermining comparability between different studies. For our analysis, we have depended upon a functional classification at the place of work, which is not based on the industry affiliation of individual companies but classifies the occupational activities of individual employees. This makes it possible to delineate individual sectors more clearly according to "real" work activities, which can provide more precise results, especially in the analysis of labor market dynamics. Furthermore, the selection of indicators requires that data available at least at the municipal association level be selected for the analysis of city types. For Germany, the INKAR-database of the BBSR provides relatively good data in this respect, although that database could be further expanded in certain areas of (infrastructural) services of general interest [88] and also with regard to mesoscale economic data [49].

7. Conclusions

In summary, on the one hand, theory- and method-based findings can be derived from the present work. An explorative approach chosen via the selected research design proved to be suitable for the classification of individual city types, especially with regard to geographical locations. On the other hand, content-based classifications that can be used for evidence-based funding policy and spatial governance "that go beyond the 'one-size-fits-all' type of recommendations" ([78], p. 33) have been revealed in the analysis. The results demonstrate that medium-sized towns are relevant urban centers in the knowledge economy and should be regarded as a single and important urban category. These centers are particularly important outside large metropolitan areas, where medium-sized towns can represent the nucleus of a labor market region. Larger medium-sized towns or smaller large cities have been discussed in this context as regiopoles within regiopolitan regions [83]. With regard to the strengthening of the function of medium-sized towns as regional centers in the knowledge economy, further evolution of the regional innovation system approach seems suitable. This would both address the individual starting position of the various clusters and enable a tailored approach to the different endowments of medium-sized towns within the subsystems of the regional innovation system (subsystem of knowledge generation and subsystem of knowledge utilization) in the context of pushing sustainable spatial development (e.g., [7,89,90]). Moreover, the classification of medium-sized towns in Germany can be used in an EU-wide comparison for regions with comparable settlement densities and labor market structures and dynamics. Although nationally or regionally specific political and institutional decisions must also be considered (see, e.g., [3]), possible recommendations for spatial planning can also be derived across national borders that assign medium-sized towns more weight in the area of knowledge-intensive activities. Therefore, future studies should include cross-border cooperation between individual medium-sized towns located in border regions in systematic analyses to obtain a more comprehensive picture regarding the focus of medium-sized towns.

Furthermore, an update of the classification of small- and medium-sized towns carried out in the framework of the ESPON Town project under the changing conditions, also due to the crises, lends itself to future research. In this context, it would be worth considering comparing the European structures and functional differentiations of these city types with those of other parts of the world, such as the mega-dynamic structures in Asia. Through this comparison, it becomes possible to examine the different task profiles of medium-sized cities on an international scale and to discuss their significance in the global urban system.

Based on the results, we argue for a more nuanced look at medium-sized towns from different disciplinary perspectives. It will be important to broaden the view and to include functions attributed to large cities, such as, for example, metropolitan functions, in the analysis. On the one hand, medium-sized towns represent important anchor points of economic activities, which need to be evaluated according to specific national or regional settings and political conditions. On the other hand, medium-sized cities also serve as basic hubs of everyday life and provide important basic functions for the quality of life of the citizens through the provision of cultural and social infrastructures. Geography can contribute by providing both quantitative overview studies and qualitative case studies concerning the impact of different policies on the development of these city types to provide holistic recommendations for future developments.

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References

1. Mayer, H.; Motoyama, Y. Editorial: Entrepreneurship in small and medium-sized towns. *Entrep. Reg. Dev.* **2020**, *32*, 467–472. [CrossRef]
2. Wagner, M.; Growe, A. Research on small and medium-sized towns: Framing a new field of inquiry. *World* **2021**, *2*, 105–126. [CrossRef]
3. Meili, R.; Mayer, H. Small and medium-sized towns in Switzerland: Economic heterogeneity, socioeconomic performance and linkages. *Erdkunde* **2017**, *71*, 313–332. [CrossRef]
4. Steinführer, A.; Porsche, L.; Sondermann, M. (Eds.) *Kompendium Kleinstadtforschung*; Forschungsberichte der ARL 16; ARL: Hanover, Germany, 2021.
5. Russo, A.P.; Giné, D.S.; Albert, M.Y.P.; Brandais, F. Identifying and classifying small and medium-sized towns in Europe. *Tijdschr. Voor Econ. Soc. Geogr.* **2017**, *108*, 380–402. [CrossRef]
6. Porsche, L.; Steinführer, A.; Beetz, S.; Dehne, P.; Fina, S.; Großmann, K.; Leibert, T.; Maaß, A.; Mayer, H.; Milbert, A.; et al. *Small Town Research in Germany—Status Quo and Recommendations*; Position Paper of the ARL 114; ARL: Hanover, Germany, 2019.
7. Mayer, H. Innovation and entrepreneurship in small and medium-sized towns. In *A Research Agenda for Small and Medium-Sized Towns*; Mayer, H., Lazzeroni, M., Eds.; Edward Elgar Publishing: Cheltenham, UK; Northampton, MA, USA, 2022; pp. 73–88.
8. Mayer, H.; Lazzeroni, M. The road ahead: Advancing our research agenda for small and medium-sized towns in a world of uneven development. In *A Research Agenda for Small and Medium-Sized Towns*; Mayer, H., Lazzeroni, M., Eds.; Edward Elgar Publishing: Cheltenham, UK; Northampton, MA, USA, 2022; pp. 195–200.
9. Servillo, L.; Atkinson, R.; Hamdouch, A. Small and medium-sized towns in Europe: Conceptual, methodological and policy issues. *Tijdschr. Voor Econ. En Soc. Geogr.* **2017**, *108*, 365–379. [CrossRef]

10. Hamdouch, A.; Demaziere, C.; Banovac, K. The socio-economic profile of small and medium-sized towns: Insights from European case studies. *Tijdschr. Voor Econ. Soc. Geogr.* **2017**, *108*, 456–471. [CrossRef]
11. Camagni, R.; Capello, R.; Caragliu, A. The rise of second-rank cities. What role of agglomeration economies? *Eur. Plan. Stud.* **2015**, *23*, 1069–1089. [CrossRef]
12. Parkinson, M.; Meegan, R.; Karecha, J. City size and economic performance: Is bigger better, smaller more beautiful or middling marvelous? *Eur. Plan. Stud.* **2015**, *23*, 1054–1068. [CrossRef]
13. Elche, D.; Consoli, D.; Sánchez-Barrioluengo, M. From brawn to brains: Manufacturing-KIBS interdependency. *Reg. Stud.* **2021**, *55*, 1282–1298. [CrossRef]
14. Shearmur, R.; Doloreux, D. The geography of knowledge revisited: Geographies of KIBS use by a new rural industry. *Reg. Stud.* **2021**, *55*, 495–507. [CrossRef]
15. Glückler, J.; Sheramur, R.; Martinus, K. Liability or opportunity? Reconceptualizing the periphery and its role in innovation. *J. Econ. Geogr.* **2022**. *online first*. [CrossRef]
16. Wagner, M.; Growe, A. Regional urbanization and knowledge-intensive business activities (KIBS): An example of small and medium-sized cities in the Greater Stuttgart Region (Germany). *Urban Sci.* **2019**, *4*, 1. [CrossRef]
17. Wagner, M.; Growe, A. Patterns of knowledge bases in large city regions in Germany: Comparison of cores and their surrounding areas. *Geogr. Ann. Ser. B Hum. Geogr.* **2022**. *online first*. [CrossRef]
18. Gareis, P.; Milbert, A. Functional classification of small towns in Germany. A methodological approach. *Raumforsch. Raumordn. Spat. Res. Plan.* **2020**, *78*, 537–557. [CrossRef]
19. Giffinger, R.; Kramar, H.; Fertner, C.; Meijers, E.J. City-ranking of European medium-sized cities. In *Futures of Cities*; Ostergard, N., Ed.; IFHP: London, UK, 2007; pp. 1–12.
20. Research on Building, Urban Affairs and Spatial Development (BBSR): Laufende Stadtbeobachtung: Raumabgrenzung. Stadt- und Gemeindetypen in Deutschland. Available online: https://www.bbsr.bund.de/BBSR/DE/forschung/raumbeobachtung/Raumabgrenzungen/deutschland/gemeinden/StadtGemeindetyp/StadtGemeindetyp.html#:~{}:text=Stadt-%20und%20Gemeindetypen%20in%20Deutschland%20Der%20Stadt-%20und,2003%20im%20Rahmen%20einer%20Untersuchung%20zum%20Stadtumbau%20entwickelt (accessed on 1 December 2022).
21. Winter, L. Urban knowledge economy. In *The Wiley Blackwell Encyclopedia of Urban and Regional Studies*; Ocrum, A.M., Ed.; Wiley Online Library: New York, NY, USA, 2019.
22. Breschi, S.; Lissoni, F. Localised knowledge spillovers vs. innovative milieus: Knowledge "tacitness" reconsidered. *Pap. Reg. Sci.* **2001**, *80*, 255–273. [CrossRef]
23. Beaverstock, J.V.; Faulconbridge, J.R.; Hall, J.E. Professionalization, legitimization and the creation of executive search markets in Europe. *J. Econ. Geogr.* **2010**, *10*, 825–843. [CrossRef]
24. Maskell, P. Assessing remote knowledge—The role of trade fairs, pipelines, crowdsourcing and listening posts. *J. Econ. Gegography* **2014**, *14*, 883–902. [CrossRef]
25. Van Winden, W.; van den Berg, L.; Pol, P. European cities in the knowledge economy: Towards a typology. *Urban Stud.* **2007**, *44*, 525–549. [CrossRef]
26. Cardoso, R.; Meijers, E. Metropolization processes and intra-regional contrasts: The uneven fortunes of English secondary cities. In *Secondary Cities, Exploring Uneven Development in Dynamic Urban Regions of the Global North*; Pendras, M., Willams, C., Eds.; University Press: Bristol, UK, 2021; pp. 133–156.
27. Volgmann, K.; Growe, A.; Münter, A.; Osterhage, F. Does the hinterland benefit from the boom of the large cities? Spatial range and functional differentiation of spillover effects in German urban regions. *Raumforsch. Raumordn. Spat. Res. Plan.* **2022**, *80*, 397–413. [CrossRef]
28. Leclerq-Vandelannoitte, A.; Issac, H. The new office: How coworking changes the work concept. *J. Bus. Strategy* **2016**, *37*, 3–9. [CrossRef]
29. Jamal, A.C. Coworking spaces in mid-sized cities: A partner in downtown economic development. *Environ. Plan. A Econ. Space* **2018**, *50*, 773–788. [CrossRef]
30. Ojala, S.; Pyöriä, P. Mobile knowledge workers and traditional mobile workers: Assessing the prevalence of multi-locational work in Europe. *Acta Sociol.* **2018**, *61*, 402–418. [CrossRef] [PubMed]
31. Reuschke, D.; Ekinsmyth, C. New spatialities of work in the city. *Urban Stud.* **2021**, *58*, 2177–2187. [CrossRef]
32. Danielzyk, R.; Priebs, A. Die Sicherung der Daseinsvorsorge durch Klein- und Mittelstädte als Beitrag des zentralörtlichen System zu gleichwertigen Lebensverhältnissen. *Eur. Reg.* **2020**, *26*, 7–21.
33. Kühn, M.; Milstrey, U. Medium-sized cities as peripheral centres: Cooperation, competition and hierarchy in shrinking regions. *Raumforsch. Raumordn. Spat. Res. Plan.* **2015**, *73*, 185–202. [CrossRef]
34. Gareis, P.; Diller, C.; Winkler-Kühlken, B. Infrastructure as an aspect of quality of life and its influence on life satisfaction in small towns of the German region type central location. *Raumforsch. Raumordn. Spat. Res. Plan.* **2021**, *79*, 39–57. [CrossRef]
35. Seyfahrt, E.; Osterhage, F.; Scheiner, J. Really permanently urban? An empirical study of young adults' short- and long-term wishes for residential environment as a contribution to the debate on reurbanization. *Raumforsch. Raumordn. Spat. Res. Plan.* **2021**, *79*, 453–469. [CrossRef]

36. Erhardt, D.; Eichhorn, S.; Behnisch, M.; Jehling, M.; Münter, A.; Schünemann, C.; Siedentop, S. City region in between housing issues and tacking land take. Trends, strategies and potential solutions in core cities and their hinterland. *Raumforsch. Raumordn. Spat. Res. Plan.* **2022**, *80*, 522–541. [CrossRef]
37. Adam, F.; Föbker, S.; Imani, D.; Pfaffenbach, C.; Weiss, G.; Wiegandt, C.-C. Social contact and networks of refugees in the arrival context—Manifestations in a large city and in selected small and medium-sized towns. *Erdkunde* **2019**, *73*, 31–45. [CrossRef]
38. Schorn, M.; Priebs, A. Cooperation between small- and medium-sized towns and their surrounding areas. Implementation of the Austrian city regional policy. *Raumforsch. Raumordn. Spat. Res. Plan.* **2021**, *79*, 257–274. [CrossRef]
39. Mittelstadt als Mitmachstadt. Qualitativer Wandel durch neue Kultur des Stadtmachens. Graduiertenkolleg und Mittelstadtnetzwerk—Interessenbekundung kleiner Mittelstädte. Available online: https://www.arl-net.de/de/system/files/Graduiertenkolleg_Mittelstadt_Ausschreibung_St%C3%A4dte.pdf (accessed on 10 December 2022).
40. Ries, J. Mittelstädte als Stabilisatoren ländlich-peripherer Räume. Ph.D. Thesis, Technische Universität Kaiserlautern, Kaiserlautern, Germany, 11 December 2018.
41. Adam, B. Medium-sized cities in urban regions. *Eur. Plan. Stud.* **2006**, *14*, 547–555. [CrossRef]
42. Adam, B.; Blätgen, N. *Bevölkerungsdynamik und Innenentwicklung in Mittelstädten*; BBSR-Analyse Kompakt 10/2019; BBSR: Bonn, Germany, 2019.
43. Hildreth, P. *Understanding Medium-Sized Cities*; Town and Country Planning Association: London, UK, 2007.
44. Escudero Gómez, L.A.; Garía Gonzáles, J.A.; Martínez Navarro, J.M. Medium-sized cities in Spain and their urban areas within national network. *Urban Sci.* **2019**, *3*, 5. [CrossRef]
45. Lüthi, S.; Thierstein, A.; Betlage, M. The relational geography of the knowledge economy in Germany: On functional urban hierarchies and localised value chain systems. *Urban Stud.* **2013**, *50*, 276–293. [CrossRef]
46. Kaufmann, D.; Wittwer, S. Business centres or bedroom communities? The development of employment in small and medium-sized towns. *Reg. Stud.* **2019**, *53*, 1483–1493. [CrossRef]
47. Raspe, O.; van Oort, F. The knowledge economy and urban economic growth. *Eur. Plan. Stud.* **2007**, *14*, 1209–1234. [CrossRef]
48. Zenka, J.; Slach, O.; Ivan, I. Spatial patterns of knowledge-intensive business services in cities of various sizes, morphologies and economies. *Sustainability* **2020**, *12*, 1845. [CrossRef]
49. Mayer, H. Wirtschaftliche Entwicklung und Innovationsdynamiken in Kleinstädten. In *Kleinstadtkompendium*; Steinführer, A., Porsche, L., Sondermann, M., Eds.; Forschungsbericht der ARL 16; ARL: Hanover, Germany, 2021; pp. 140–154.
50. Wieland, T.; Fuchs, H. Regionalökonomische Disparitäten im Spiegel von Raumtypisierungen. Ein Konzept zur Identifikation strukturell benachteiligter Gebiete in Südtirol (Italien). *Standort* **2018**, *42*, 152–163. [CrossRef]
51. Bedford, D.A. Expanding the definition and measurement of knowledge economy: Integrating triple bottom line factors into knowledge economy index models and methodologies. *J. Mod. Account. Audit.* **2013**, *9*, 278–286.
52. Dahlman, C.; Anderson, T. *Korea and the Knowledge-Based Economy. Making the Transition, IBRD*; World Bank: Washington, DC, USA, 2000.
53. Agarwal, S.; Rahman, S.; Errington, A. Measuring the determinants of relative economic performance of rural areas. *J. Rural Stud.* **2009**, *25*, 309–321. [CrossRef]
54. Margarian, A. *Strukturwandel in der Wissensökonomie: Eine Analyse von Branchen-, Lage-, und Regionseffekten in Deutschland*; Thünen Report, No. 60; Johann Heinrich von Thünen-Institut: Brunswick, Germany, 2018.
55. Barjak, F.; Franz, P.; Heimpold, G.; Rosenfeld, M.T.W. *Regionalanalyse Ostdeutschland: Die Wirtschaftliche Situation der Länder, Kreise und Kreisfreien Städte im Vergleich, Wirtschaft und Wandel*; Leibniz-Institut für Wirtschaftsforschung Halle (IWH): Halle, Germany, 2000; Volume 6, pp. 31–55.
56. Oxley, L.; Walker, P.; Thorns, D.; Wang, H. *Exploring the Knowledge Economy/Society: Another Example of Measurement without Theory*; Working Paper 03/2008; Department of Economics, University of Canterbury: Christchurch, New Zealand, 2008.
57. Zillmer, S. *Abgrenzung und Operationalisierung der Wissensökonomie in Deutschland*; Working Paper, No. 40; Leibniz-Institut für Regionalentwicklung und Strukturplanung (IRS): Erkner, Germany, 2009.
58. Glückler, J.; Zademach, H.-J.; Hammer, I.; Handke, M.; Frölich, F.; Latke, P. *Dienstleistungsstandort Bayern: Endbericht der Forschungsarbeiten*; Katholische Universität Eichstätt-Ingolstadt: Eichstätt, Germany, 2008.
59. INKAR. Indikatoren und Karten zur Raum- und Stadtentwicklung. Available online: https://www.inkar.de/ (accessed on 2 November 2022).
60. Employment Statistics of the Federal Employment Agency 2021. Available online: https://statistik.arbeitsagentur.de/DE/Statischer-Content/Grundlagen/Definitionen/Generische-Publikationen/Kurzinformation-Beschaeftigungsstatistik.pdf?__blob=publicationFile&v=11 (accessed on 2 November 2022).
61. Galipoglu, E.; Wolter, M. Typologien industrienaher Dienstleistungen: Eine Literaturübersicht. In *Smart Service Engineering: Konzepte und Anwendungsszenarien für die Digitale Transformation*; Thomas, O., Nüttgens, M., Fellmann, M., Eds.; Springer Fachmedien: Wiesbaden, Germany, 2017; pp. 170–192.
62. Hertog, P.; Bouwman, H.; Gallego, J.; Green, L.; Howells, J.; Meiren, T.; Miles, I.; Moerschel, I.; Narbona, A.; Rubalcaba, L.; et al. *Research and Development Needs of Business Related Service Firm*; Dialogic: Utrecht, The Netherlands, 2006.
63. Eurostat. *Europa in Zahlen 2006–07*; Eurostat Jahrbuch: Luxemburg, 2007.
64. Kujath, H.J.; Schmidt, S. Wissensökonomie und die Entwicklung von Städtesystem. *Soz. Fachinf. Sofid Stadt- Reg.* **2007**, *2*, 9–29.

65. Simmie, J.; Strambach, S. The contribution of KIBS to innovation in cities: An evolutionary and institutional perspective. *J. Knowl. Manag.* **2006**, *10*, 26–40. [CrossRef]
66. Strambach, S. Innovation processes and the role of knowledge-intensive business services (KIBS). In *Innovation Networks. Technology, Innovation and Policy*; Koschatzky, K., Kulicke, M., Zenker, A., Eds.; Physica: Heidelberg, Germany, 2001; pp. 53–68.
67. Legler, H.; Frietsch, R. *Neuabgrenzung der Wissenswirtschaft—Forschungsintensive Industrien und Wissensintensive Dienstleistungen*; Studien zum deutschen Innovationsystem; Fraunhofer Institut System-und Innovationsforschung: Karlsruhe, Germany, 2006.
68. Lüthi, S.; Thierstein, A.; Goebel, V. Intra-firm and extra-firm linkages in the knowledge economy: The case of the emerging mega-city region of Munich. *Glob. Netw.* **2010**, *10*, 114–137. [CrossRef]
69. Lo, V. *Wissensbasierte Netzwerke im Finanzsektor. Das Beispiel des Mergers & Acquisitions-Geschäfts*; Springer: Wiesbaden, Germany, 2003.
70. Thierstein, A.; Förster, A.; Lüthi, S. Kreativwirtschaft und Metropolregionen—Konturen einer systematischen Steuerung. In *Governance der Kreativwirtschaft. Diagnosen und Handlungsoptionen*; Lange, B., Kalandides, A., Stöber, B., Wellmann, I., Eds.; Transcript Verlag: Bielefeld, Germany, 2009; pp. 61–85.
71. Destatis. *Klassifikation der Wirtschaftszweige, Ausgabe 2003 (WZ 2003)*; Destatis: Wiesbaden, Germany, 2003.
72. Manniche, J.; Moodysson, J.; Testa, S. Combinatorial knowledge bases: An integrative and dynamics approach to innovation studies. *Econ. Geogr.* **2016**, *93*, 480–499. [CrossRef]
73. Wiersma, S.; Just, T.; Heinrich, M. Segmenting German housing markets and using principal component and cluster analysis. *Int. J. Hous. Mark. Anal.* **2022**, *15*, 548–578. [CrossRef]
74. Ducre, R.; Lemarié, B.; Roset, A. Cluster analysis and spatial modeling for urban freight. Identifying homogenous urban zones based on urban form and logistics characteristics. *Transp. Res. Procedia* **2015**, *12*, 301–313. [CrossRef]
75. Penkova, T.G. Principal component analysis and cluster analysis for evaluating the natural and anthropogenic territory safety. *Procedia Comput. Sci.* **2017**, *112*, 99–108. [CrossRef]
76. Keskin, B.; Watkins, C. Defining spatial housing submarkets: Exploring the case for expert delineated boundaries. *Urban Stud.* **2017**, *54*, 1446–1462. [CrossRef]
77. Ibes, D.C. A multi-dimensional classification and equity analysis of an urban park system: A novel methodology and case study application. *Landsc. Urban Plan.* **2015**, *137*, 122–137. [CrossRef]
78. Meijers, E.; Burger, M. Small and medium-sized towns: Out of the dark agglomeration shadows and into the bright city lights? In *A Research Agenda for Small and Medium-Sized Towns*; Mayer, H., Lazzeroni, M., Eds.; Edward Elgar Publishing: Cheltenham, UK; Northampton, MA, USA, 2022; pp. 23–38.
79. Backhaus, K.; Erichson, B.; Plinke, W.; Weiber, R. *Fortgeschrittene Multivariate Analysemethoden. Eine anwendungsorientierte Einführung*, 3rd ed.; Springer Science+Business Media: Berlin/Heidelberg, Germany, 2015.
80. Lüttich, H. *Die Bildungshochburgen unter den Mittelstädten*; Standort Kompass, Contor: Hünxe, Germany, 2020.
81. Aring, J.; Reuther, I. *Regiopolen. Die kleinen Großstädte in Zeiten der Globalisierung*; Jovis Verlag: Berlin, Germany, 2008.
82. BMI/BBSR. Fachforum. Regiopolen und Regiopolregionen für Deutschland—Ein Mehrwert für Regionen und ihre Städte 2021. Available online: https://www.region-gestalten.bund.de/Region/DE/vorhaben/regiopolregionen/1.Fachforum%20Zusammenfassung.pdf?__blob=publicationFile&v=1 (accessed on 1 December 2022).
83. Growe, A.; Terfrüchte, T. Significant cities beyond the metropolises? Regiopolises and their role in the German urban system. *Raumforsch. Raumordn. Spat. Resarch Plan.* **2022**. *online first*. [CrossRef]
84. Kiese, M. Structural change 2.0: The Ruhr area on the way to a knowledge based economy. *Standort* **2019**, *43*, 69–75. [CrossRef]
85. Zöllner, S.; Lüthi, S.; Thierstein, A. A longitudinal network analysis of the German knowledge economy from 2009 to 2019: Spatial-temporal dynamics at the city-firm nexus. *J. Soc. Struct.* **2020**, *21*, 107–133. [CrossRef]
86. Gewerbesteuer Infoportal. Available online: www.gewerbesteuer.de (accessed on 5 December 2022).
87. Erickcek, G.A.; McKinney, H. "Small Cities Blues": Looking for growth factors in small and medium-sized cities. *Econ. Dev. Q.* **2006**, *20*, 232–258. [CrossRef]
88. Mager, C.; Wagner, M. Cultural infrastructures in small and medium-sized cities in Germany. A locational typology of cultural services of general interest. *Raumforsch. Raumordn. Spat. Res. Plan.* **2022**, *80*, 379–396. [CrossRef]
89. Kaufmann, D.; Meili, R. Leaves in the wind? Local policies of small and medium-sized towns in metropolitan regions. *Eur. Plan. Stud.* **2018**, *27*, 21–41. [CrossRef]
90. Wolman, H. What cities do: How much does urban policy matter? In *The Oxford Handbook of Urban Politics*; John, P., Clarke, S.E., Eds.; Oxford Handbooks; University of Oxford: Oxford, UK, 2012; pp. 415–441.