Methods of Central Place Research

Thomas Terfrüchte

1. Positioning of the Research Field

Cities and urban systems are classic fields of research in spatial sciences. There is a vast international discourse on megacities, global cities and metropolises or rather metropolitan regions (Münter/Volgmann 2014). In Germany, urban systems research is also concerned with medium-sized cities, especially with a view to securing or restoring the equivalence of living conditions. The discourse is mainly based on the central place theory, founded by Christaller in 1933 (Christaller 1968) and was adapted by the German "Raumordnung" (spatial planning) in the 1960s. A recent discourse links aspects from metropolitan research and policy with central place policies: regiopolises are described as little sisters of metropolises and as 'deluxe' versions of higher-order central places ("Oberzentren") (Terfrüchte at al. 2021).

Based on these theoretical and political-normative considerations, modern central place research has been established as part of urban system research since the 1960s. Sometimes there are parallels to metropolitan research in terms of content and methodology (cf. Volgmann 2013). The descriptive-analytical approaches can be roughly divided into three research areas:

- *Benchmarking the performance of central places*, i.e. a hierarchical classification of cities;
- The *analysis of spatial-functional linkages* between cities;
- The *description of the urban system as a network* with central places as nodes and spatial-functional linkages as edges for a spatial-functional division (the so-called *central place system*) – as distinct from the political-administrative division (Terfrüchte/Flex 2018; Terfrüchte et al. 2017).

Depending on the research question, different research methods are suitable, ranging from procedures for determining centrality without reference to the surrounding area, to interdependence analyses with or without a priori defined centres, to integrated procedures and finally also heuristic approaches (Terfrüchte 2015, 126).

Preliminary Methodological Remarks

In the context of this paper, methodological approaches are presented and discussed that are applicable for addressing the three aforementioned areas of research, i.e. that are suitable for empirically mapping central place systems. Therefore, I suggest a few preliminary remarks (cf. Terfrüchte et al. 2017):

1. Central place systems basically comprise central places and their interactional areas. In order to describe the central place system, it is therefore necessary to determine the centrality (hierarchical level and gravity) of cities on the one hand and their interactional areas on the other.
2. Centrality is multidimensional. The hierarchy levels in the central place system are therefore not class divisions of the same dimension. In German spatial planning, a distinction is usually made between lower-, middle- and high-order centrality.
3. Depending on the epistemological interest, political-normative considerations can also justify or limit the suitability of the methodology.
4. There can thus be no single and correct research methodology. Each methodology, whether for centrality measurement or for area delineation, has its specific strengths and weaknesses.
5. However, none of the methods for the description of central place systems that are designed either solely for the benchmarking (assessment) of central places or for the delimitation of interlinked areas are applicable. Only those methods are appropriate that consider both elements of the central place system in an integrated way.

In consequence, the catalogue method frequently used in the past (i.e. the classification of cities into the central place hierarchy levels based on the presence of certain facilities, cf. Terfrüchte 2015) is not suitable on its own for measuring centrality in the sense of a classification into the hierarchical central place system. In the determination of the interactional areas, the so-called *Huff model* (gravity model by Huff 1964) is used in connection with assessment of the permissibility of large-scale retail trade centres (German “Kongruenzgebot”). However, the model is unsuitable for the delimitation of interactional areas of central places, as it infers actual interactions from potential interactions (based on accessibility). In this respect, only those delineation methods can be used that work with actual interactions (e.g. commuter linkages).

Against this background, the following procedural steps are appropriate for describing central places and their interactional areas (= central place system):

- Hierarchisation of central place supply goods and needs (Section 0),
- Determination of the gravity of all potential central places (generally all cities in the study area) – separated according to hierarchical levels – on the basis of the supply function (Section 0),
- Determination of the central place development function (Section 2),
- Determination of the supply linkages between all potential central places among each other and their respective surrounding area (Section 0),

- Area delimitation: Allocation of "co-supplied" cities to "co-supplying" cities separately according to hierarchy levels (Section 0).

1. Supply Function

The supply function of central places is the classic function in the sense that they supply their own population and the surrounding population with goods and services (cf. Terfrüchte & Flex 2018, 2972). Moreover, the supply function of central places is consistently addressed in all spatial development plans in Germany (Greiving et al. 2014). Central place supply facilities are thus geared to the end consumer; they are not ubiquitously available and clustered at central places (co-localisation). In this respect, neither technical infrastructures, such as power supply or waste disposal, nor services that are not oriented towards the end consumer, such as business consultants, belong to the central supply facilities. The supply function is equally well researched and discussed in spatial planning practice and science (Terfrüchte 2015, 98–105). Thus, while the supply function in general and also the facilities (in methodological terms, the manifest characteristics of central places) in particular can be considered indisputable (tab. 1), there are various methodological approaches to inferring the centrality of a place (in methodological terms, the latent characteristic of central places) from the facilities (Niedzwetzki 1977; Deiters 1978; Flex 2015, 235–271.; Terfrüchte 2015, 138–159).

The path presented here takes up the premises listed in Section 1 and suggests *one* possible path. Terfrüchte 2015 and Flex 2015 also show a variety of other paths, depending on the underlying premises.

The first methodological step in determining the supply function is the hierarchisation of the facilities (goods and needs) relevant to the central place (Section 0). The question is whether a hierarchy can be identified in the urban system with regard to the distribution of supply, and which facilities can then be assigned to these hierarchy levels. The dichotomously scaled data set is therefore included in the analysis, i.e. it is only asked whether at least one corresponding facility is located in the city or not. The supply strength is later constructed as a central-local gravity (Section 0).

2.1 Hierarchisation

The hierarchisation of the central facilities is carried out in two steps by the scalogram analysis (or guttman scaling, see below) and the principal component analysis. The combination seems appropriate for the following reasons: Using the scalogram analysis, hierarchy levels can be derived empirically on the basis of the dichotomously scaled frequencies of supply of central facilities; recourse to statistical class divisions (percentile values) or arbitrary threshold setting is no longer necessary. As soon as the individual facilities are divided into hierarchy levels – any number of levels can be determined – the co-localisation (covariance) is checked using principal component analysis. For this purpose, the dichotomously scaled supply frequencies of each hierarchy level are used. Facilities (variables) that have no or only a low common variance with the other facilities of a hierarchy level can thus be identified and eliminated. They are not relevant to

Tab. 1: Central facilities (supply function). Source: based on Terfrüchte 2015, 98–105

Functional sector	Central facility (examples)
Education	Primary school, Highschool
Retail	Shopping Centre, Discounter
Culture	Museum, Theatre
Healthcare	Hospital, General practitioner
Sports	Sports hall, Indoor swimming pool
Transportation	Train station, Motorway connection
Public Administration	Municipality, Employment agency
Finance and Insurance	Bank, Insurance office
Social Services	Nursing service, Counselling Centre
Other Services	Post office
Judicature	Local court, Administrative court
Science and Research	University, Research institute
Hazard Prevention	Police, fire brigade
Organisations/Associations	Chamber of Commerce and Industry
Tourism	Hotel

central places, as they do not fulfil the co-location requirement. Usually, the scalogram analysis already shows which facilities have a low common variance. The data set adjusted for the non-centrally relevant facilities defines the basis for the construction of the supply indices in Section 0.

Scalogram Analysis

Figure 1 illustrates for each facility whether it is located in a city/community at least once (1=present, 0=not present); for simplified orientation, the cells with the value 1 are coloured grey. The row sum now indicates the number of different facilities per city and the column sum the number of cities in which the respective facility is present at least once. If rows and columns are sorted in descending order, a saturation curve appears at the transition from grey cells (facility is present) and white cells (facility is not present). Wherever white cells lie in the predominantly grey area, the respective cities lack a facility that is usual for the hierarchical level. Conversely, grey cells in the predominantly white area indicate that a city has a facility that is not customary for the hierarchical level (this is often the case with airports, for example, as they are not infrequently located outside the municipal territory of the central places).

The actual classification is now done by counting the errors (grey fields in the white area and white fields in the grey area). Starting from the left, it is determined for each facility in how many cities they are not located, and starting from the right, it is determined for each facility in how many cities the facilities are located. Then the errors per facility are added up (cumulative errors). The cumulative errors are determined in the same way, starting with the rarest facility.

The principal aim now is to identify those two facilities between which the optimal class boundary lies. It is optimal when the sum of the errors on the left and right of the "dividing line" is the smallest. On the left side of the line, all white cells are counted, on the right side all grey cells. As soon as the first dividing line (class division) is found, further class divisions can be made according to the same principle; the error sums are then re-determined within one of the previously formed classes. Depending on the goal of the analysis and on the (interim) findings, individual classes can also be reassembled at the end. Such a step, however, already follows normative considerations.

Fig. 1: Scalogram analysis for hierarchisation of central facilities – Source: based on Terfrüchte 2015, 183

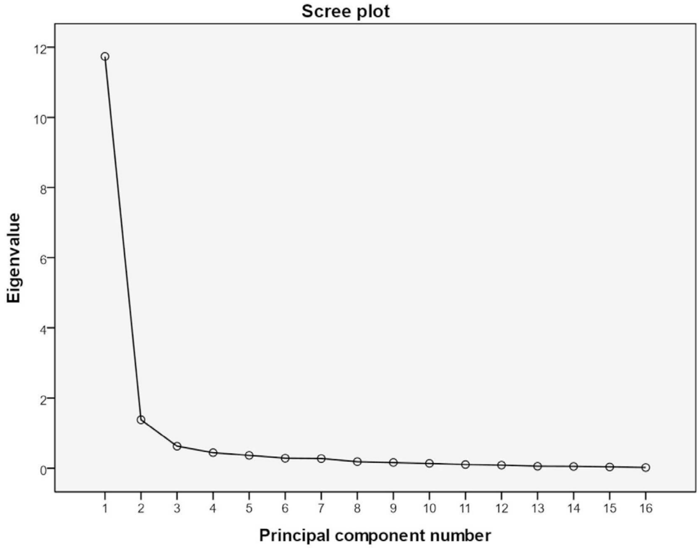
	a	b	c	d	e	f	g	…	x	y	z	∑
A	1	1	1	1	1	1	1		1	1	1	25
B	1	1	1	1	1	1	1		1	0	1	23
…												
X	1	1	0	0	0	0	0		1	0	0	3
Y	1	0	0	0	0	0	0		0	0	0	1
Z	1	0	0	0	0	0	0		0	0	0	1
∑ 1	26	24	17	16	15	11	11		5	3	2	
∑ 0	0	2	9	10	11	15	15		21	23	24	
∑ Error(left)	0	2	11	21	32	47	62		372	395	419	
∑ Error(right)	257	231	207	190	174	159	148		10	5	2	
∑ Errors	**257**	**233**	**218**	**211**	**206**	**206**	**210**		**382**	**400**	**421**	

Principal Component Analysis

With the result of the scalogram analysis, we identify those facilities that belong to a hierarchy level, at least due to the frequency of their services. The next step is to check whether the facilities fulfil the requirement of co-location. For this purpose, the spatial intercorrelation of all variables (facilities) is determined. This is done by principal component analysis.

The scree plot (fig. 2) shows whether a predominant principal component emerges. This is to be expected only for facilities whose high covariance is already apparent from the scalogram analysis. If the initial correlation of one or more variables (component/factor loading) has a value of less than 0.4, a low common variance is to be assumed and the respective facility is eliminated as not relevant to central places. This

Fig.2: Scree plot of higher-level needs. Source: based on Terfrüchte 2015, 224



procedure is repeated iteratively until the remaining facilities have a sufficient common variance with regard to spatial localisation; following the literature, this is initially assumed to be sufficient with a component/factor loading – i.e. a correlation coefficient of the original characteristic with the principal component – of at least 0.4 (Bühl 2012, 610). This threshold can also be justifiably defined differently. The remaining facilities of a hierarchy level are then used to determine the sub-indices for the supply function; one index for each level.

2.2 Gravity of Central Places

Centrality is multidimensional. The first step in dimensioning (or operationalising) centrality has already been taken with the selection of the central facilities for the scalogram analysis. The second step was the allocation of the facilities to the hierarchy levels. The next step is a dimensional reduction, i.e. the facilities of a hierarchy level are linked as manifest characteristics to a hierarchy level-specific index (interpreted as gravity of central places) as a latent characteristic. What is methodologically obvious has also become established in German-language central place and metropolitan research: the construction of centrality indices using multivariate statistics (here: principal component analysis) (Schmidt 1995, Volgmann 2013, Terfrüchte 2015, Flex 2015). This also offers the advantage that the statistical procedure already used to falsify the co-localisation hypothesis is used again, depending on the research objective with the dichotomously scaled variables (modelling the functional diversity) or the metric-scaled variables (modelling the co-supply potential).

Functional Diversity Indices

When it comes to describing the functional profile of cities, the only question is what different facilities are located in a city. In the example of universities, it is not a question of how many universities there are in a city, how many courses of study are offered there or how many students are enrolled there. It is only about the fact that the city is a higher education location.

Methodically, exactly one principal component per hierarchy level is extracted as an index. In practice, an additive weighted linkage takes place here, whereby the component/factor loadings (tab. 2) are interpreted as weights and the so-called factor values (as a result of the principal component analysis) are assigned to the cities as characteristic values. The idea behind this is that the more typical a central facility is for the respective hierarchy level, the higher its weighting.

(Co-)Supply Potential Indices – Gravity of Central Places

In contrast to the variety of facilities, the (co-)supply potential is about *how many* facilities of one type are located in a city or *how many* hospital beds are available (usage of metric-scaled variables instead of dichotomously scaled variables). One example is general education schools. Here, the number of school classes may be more relevant than the number of school locations. Sometimes no complete (service) offer is provided at certain locations (e.g. branch offices). In this case, (normative) weighting can also be applied. Ultimately, the aim is to generate a metric-scaled data set as the basis for the principal component analysis.

Based on a study of the *Mittelrhein-Westerwald* region, table 2 shows the difference between two index-varieties: functional diversity and supply frequency/potential based on the specific indicator-weights. In terms of supply frequency, facilities that have only one location in the city of Koblenz (orchestra and district court) correlate highly with other facilities that have several locations (e.g. doctors, schools, etc.). While orchestras and regional courts are rather atypical in terms of the variety of services (with a factor loading of 0.37 even just below the threshold value of 0.40), they are far more typical in terms of the frequency of services (0.73). Such differences are essential to consider for the subsequent demarcation of central places' interactional areas, as the index value (i.e. the central-location gravity) decides whether and to what extent cities can be area-forming in terms of the importance of the surrounding area (cf. Section 0).

2. Development Function

In addition to the supply function, the development function is a second essential characteristic of central places (cf. e.g. Ganser 1977). As Blotevogel (2005, 1314) puts it, the development function should be "emphasised more strongly", especially for the higher-order hierarchical levels. This is logical insofar as central places are also understood as development centres for the middle- and higher-order interactional areas (Terfrüchte 2015, 91). The more development-promoting and the fewer development-inhibiting features a city has, the more likely it is – according to the underlying thought process – to be able to set corresponding development or stabilisation stimuli for the interac-

Tab. 2: Weighting of central functions by index type. Source: based on Greiving et al. 2020, 34

Central function/facility	Diversity Index	Supply Potential Index
Job centre	0,82	0,66
Adult education centres	0,81	0,63
Primary care hospitals	0,79	0,79
Employment agency	0,79	0,72
Vocational schools	0,78	0,94
High Schools	0,77	0,94
Specialised doctors	0,76	0,94
Municipality	0,75	0,52
Local court	0,74	0,64
Orthodontists	0,67	0,92
Tax office	0,65	0,64
Theatres	0,58	0,84
Dentists	0,57	0,96
General practitioners	0,53	0,96
Specialised hospitals	0,53	0,46
Public libraries	0,46	0,60
County court	0,37	0,73
Orchestra	0,37	0,73

tional area. However, which characteristics can be regarded as conducive and which as inhibiting for (regional) development has not been sufficiently researched – in contrast to the supply function. While demographic, economic or fiscal characteristics are unanimously considered relevant, there is no agreement on the desired characteristics. The example of municipal debt, which is commonly classified as an obstacle to development, impressively shows this. Boettcher and Junkernheinrich (2010, 112) point out that "extensive investment credits tend to signal a high financial capacity", which is why primarily cash credits are "the signal of a particularly precarious financial situation" (Boettcher/Junkernheinrich 2010, 19). A differentiation of the type of credit is therefore necessary.

The same applies to demographic development: Terfrüchte (2015, 225) has found, using North Rhine-Westphalia as an example, that a low youth dependency ratio can be considered an inhibiting characteristic, but vice versa, neither a high youth dependency ratio nor a low old-age dependency ratio can be classified as development-promoting. Since the development function – in contrast to the supply function – can be said to have a considerable overall theoretical deficit (Terfrüchte 2015: 248f.), it is not surprising that there are also various methodological approaches in this area to infer the latent development capacity of cities. However, the development function is usually researched beyond the 'classical' central place research (cf. Wiechmann/Terfrüchte 2017), which can be problematic for political planning statements: when cities, on an empirical basis, are defined as central places, they should be able to remain like that in the future, and those that are not sufficiently equipped so far, should be able to 'make it' in the planning period. For this reason, a linkage of the central place concept with regional structural policy and/or municipal fiscal equalisation is sometimes made – although it is rather modest – in some German States (Greiving et al. 2014, 70–73).

Regional Development Indices

The determination of the development capacity of each city is also carried out by principal component analysis. For the development function, a preliminary hierarchisation is neither possible nor necessary. One problem with modelling the development function is the lack of information on the desired values of variables ("the more the better or the less the better?"). For individual indicators such as job density or tax revenue power, it can be assumed that particularly high values favour the ability to set development stimuli, whereas cash credits or a high unemployment rate are more likely to inhibit the development. Since, in contrast to the supply function, there are no theory-immanent prior assumptions, the index is formed in two steps:

1. First, all indicators considered to be relevant are examined in an exploratory principal component analysis (initially without rotation, see below). The component matrix (tab. 3) shows which indicators correlate with which extracted components, and how strongly. Ideally, components that can be described in terms of content as dimensions of the development function emerge at the outset. If this is not the case, the principal component analysis does not need to be considered a failure. Rather, such a finding indicates that relevant individual characteristics can be considered neither development-inhibiting nor development-promoting, at least not for the specific study area. The aim is to exclude all these indicators from the index construction (tab. 4).
2. The index construction itself is analogous to the indices of the supply function, with one difference: since two or more extracted principal components are assumed, either a so-called rotation (Bühl 2012, 589) is carried out in order to minimise the correlation between the principal components and to increase the characteristics of a principal component, or separate analyses are carried out per dimension.

Fig. 3: Scree plot for development indicators. Source: based on Terfrüchte 2015, 225

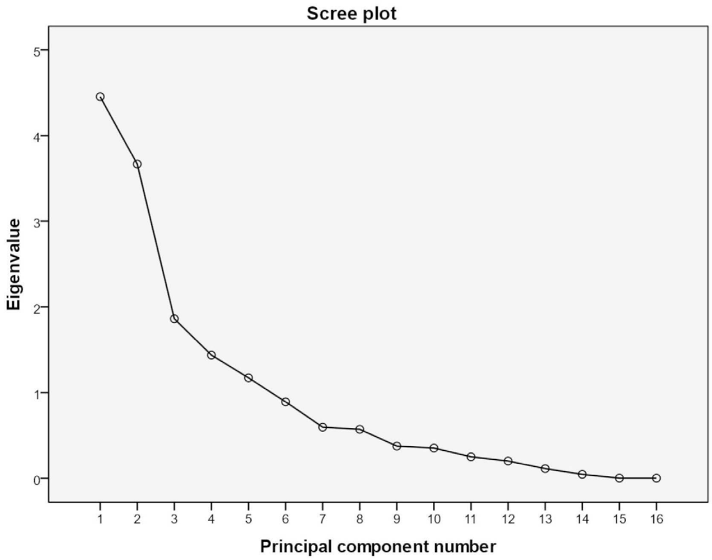


Fig. 4 summarises the functional profiles (supply function, development function and supplementary metropolitan function) for the *Mittelrhein-Westerwald* region.

4. Area-forming Function

According to the central place theory, the area-forming function serves to supply other surrounding towns (supply area) through the central places. In conjunction with the development function, the supply area can also be seen as the spatially-functional interactional area for which the central place can provide development or stabilisation stimuli. What is thus theoretically required is also regularly demanded by German jurisdiction, especially with regard to the congruence requirement ("Kongruenzgebot") and the impairment prohibition ("Beeinträchtigungsverbot") in connection with the approval of large-scale retail trade centres: central places are defined by their supra-local significance, which can only be attested if it is clearly stated how and where the supra-locality is spatially represented. Every central place therefore also needs a specific – or at least definable – supply area. Otherwise, the steering effect of the central place concepts come to nothing, because carrying capacity or accessibility criteria remain functionless as long as no "area setting is defined within which accessibility and carrying capacity are to be guaranteed" (Terfrüchte 2015, 245). The equation of central places with political municipalities, which is practised in many federal states, can nevertheless also enable so-called "self-supply areas", provided that a functional cluster also supplies

Tab. 3: Component matrix for development indicators (initially). Source: based on Terfrüchte 2015, 226

Development indicators	1	2	3	4	5
Commuter-adjusted population	0,85				
Labour market centrality	0,84				
Population density	0,69				
Employment Self-sufficiency	0,69		-0,50		
Employees in the service sector	0,57				
"Schlüsselzuweisungen"/inhabitant		-0,85			
Tax revenue/inhabitant	0,58	0,74			
Tax force/inhabitant	0,54	0,73			
Trade tax revenue/inhabitant	0,56	0,72			
Unemployment rate	0,63	-0,63			
"Kassenkredite"/inhabitant		-0,59			
Purchasing power/inhabitant			0,69		-0,44
Old-age-dependency ratio			0,65		
Youth-dependency ratio			-0,51		
Population growth				0,85	
Employees in the retail sector				0,57	

the other districts on the municipal territory. In this respect, supra-locality and supra-municipality should be separated from each other in terms of content.

As in the case of the supply function, there is widespread agreement in the literature on what needs to be researched in the delineation of linkage areas: the spatial-functional linkages between central places and non-central places, or between central places of higher hierarchical levels and central places of lower hierarchical levels (cf. e.g. Klöpper 1970; Heinritz 1977). From a methodological point of view, all interactions relating to the supply function of the central places must therefore be considered. These include, for example, visits to retail establishments, cultural facilities and events or the use of supply services. However, due to the considerable effort required for data collection, proxy indicators are usually used. In the area of medical care, for example, it was found that co-supply relationships correlate significantly with commuting relationships (Czihal et al. 2012, 9–10). In addition to commuter linkages, municipal statistics generally also show linkages in school transport, which, firstly, are directly related to the supply function (in the education sector) and secondly can also be regarded as a proxy

Tab. 4: Component matrix for development indicators (after excluding). Source: based on Terfrüchte 2015, 227.

Development indicators	Component 1 (development-promoting)	Component 2 (development-inhibiting)
Labour market centrality	0,96	
Commuter-adjusted population	0,96	
Employment Self-sufficiency	0,81	
Tax force/inhabitant	0,55	
"Schlüsselzuweisungen"/inhabitant		0,89
Unemployment rate		0,85
"Kassenkredite"/inhabitant		0,77
Youth-dependency ratio		-0,49

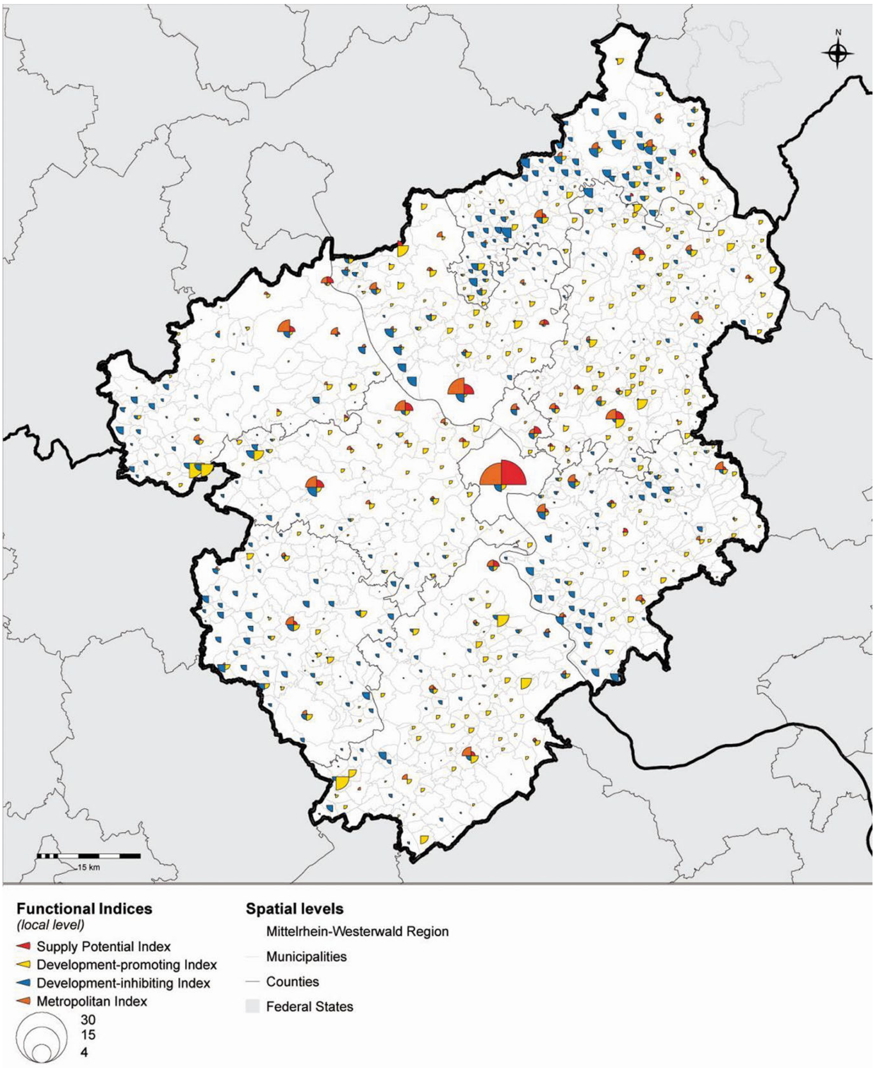
indicator for other linkages. Terfrüchte et al. 2021 were also able to show that source-destination linkages of patients to doctors can be modelled (cf. also Terfrüchte/Frank in this volume).

In contrast to the 'what?' of research, there is fundamental disagreement about the 'how'? There is no doubt about the object of research, but there *is* doubt about the way to achieve that objective. This already starts with the idea that central places can be empirically determined a priori on the basis of their supply function, without methodically considering the respective 'surrounding significance'. In terms of theory and jurisprudence, the formation of interactional areas cannot be based on threshold values (e.g., population or jobs), however normatively or empirically defined. Rather, 'area-forming' means two things: the ability to serve the population of other cities (gravity effect of central places, measured by the supply potential indices) and to actually 'unite' them on itself (measured by substantial linkages between the surrounding area and the central place).

4.1 Interconnectedness Modelling

The demarcation of the interactional areas is based on a graph-theoretical approach, whereby the gravity of each city corresponds to the supply potential index. In principle, the gravity in this model can also be determined using other methods, as Nystuen and Dacey (1961) did in their basic approach using incoming telephone calls or as is done in the labour market delineation using incoming commuter flows (Kropp/Schwengler 2011, 49). Through the underlying topological understanding of centrality, the areas/regions – understood as networks – are practically delimited on the way to identifying a network node. The assessment sounds plausible; after all, labour markets are not char-

Fig.4: Functional profiles in the Mittelrhein-Westerwald-Region. Source: based on Greiving et al. 2020, 40



acterised by one-sided and unambiguous commuter linkages from the surrounding areas to the centre, but by sub-labour markets (networks), which in turn are both embedded in a larger labour market and form sub-labour markets themselves. This indirect mapping is also referred to as the transitivity requirement. "The concept of dominant flows" (Kropp/Schwengler 2011, 49) or "strongest association" (Nystuen/Dacey 1961, 29) as a "subset of topology" (Güßefeldt 1978, 84) essentially aims at exploring redundancy within a city network, to which both direct and indirect connections contribute. It is now important that the weighting is directional: Edge AB has a value of one, whereas

Edge BA has a value of five (tab. 5). Intra-municipal linkages are indicated here with a value of zero, but they could also be quantified.

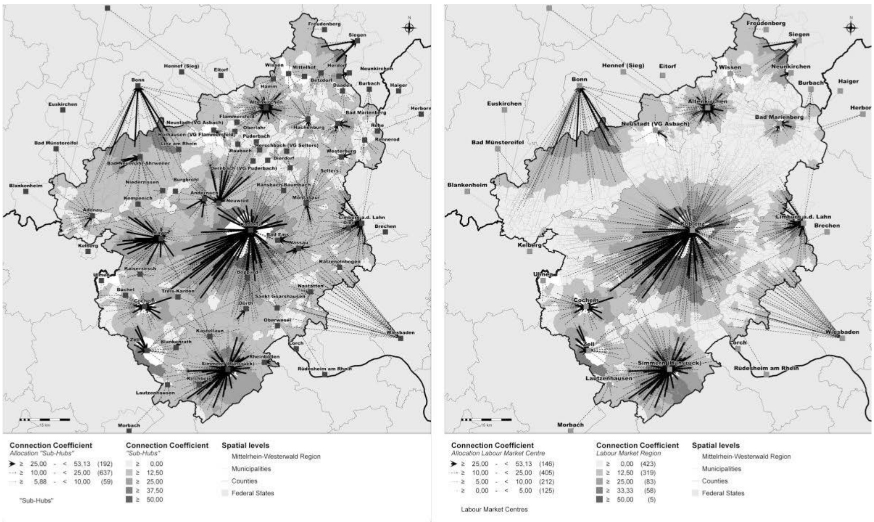
Tab. 5: Intertwining matrix for the graph theoretical approach. Source: based on Nystuen/Dacey 1961, 33

Source/ Target	A	B	C	D	Total (source)
A	0	1	2	0	**3**
B	5	0	9	2	**16**
C	7	6	0	1	**14**
D	9	1	8	0	**18**
Total (target)	**21**	**8**	**19**	**3**	**51**

For the delimitation of the interactional areas, the linkages between each city pair are modelled as a connection coefficient, i.e. it is determined how significant a certain source-target linkage is for the respective source (city). For each city, an n:n linkage matrix of all cities is then used to check where the strongest linkage exists. Nonetheless, an assignment is only made if the gravity of the target is greater than the gravity of the source. If a clear allocation is not possible because the connection coefficient to several targets (here: potential central places) is the same and the gravity of both destinations exceeds that of the source, the allocation is made to the destination that has the greater gravity. If the gravity is also identical, a normative allocation decision is necessary, possibly also as a multiple allocation. However, the latter will only rarely occur in practice, since due to the metric-scaled gravity, at least small differences in the characteristic values (i.e. the hierarchy-level-specific gravity) are usually to be expected. If the gravity were scaled ordinally (e.g. as a result of the above-mentioned catalogue method, which provides for classification into the hierarchy levels on the basis of the localised facilities), such provisional multiple assignments or normative assignment decisions would be necessary more frequently.

The assignment algorithm can be implemented as long as all cities are directly or indirectly assigned to the 'most central' place ('terminal point'). If the entire system (all cities in the study area) is considered, each city is part of exactly one interactional area. At the same time, (existing) linkages to cities outside the study area are ignored for the delineation, which can sometimes be problematic in the case of cross-border linkages (compare Osnabrück in Lower Saxony for parts of North Rhine-Westphalia in Blotevogel et al. (2009) or Bonn in North Rhine-Westphalia for the district of Ahrweiler in Rhineland-Palatinate [fig. 5]).

Fig. 5: Direct and indirect connections in the Mittelrhein-Westerwald-Region. Source: Greiving et al. 2020, 22–23



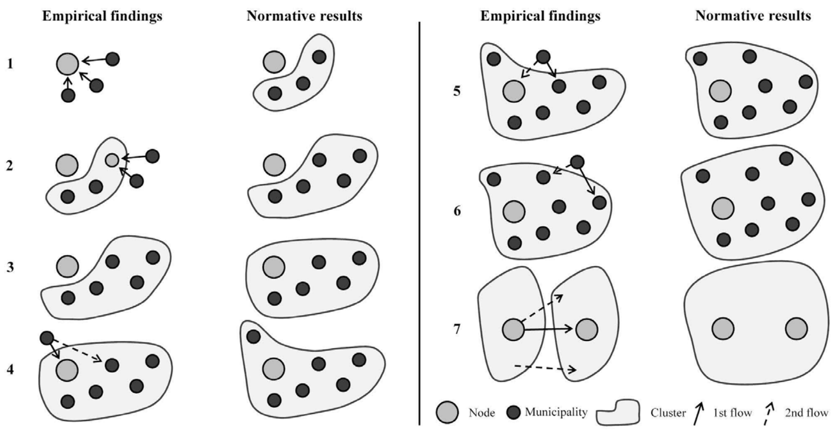
4.2 Area Delineation

Laan and Schalke (2001, 207) have modelled different topological constellations for the delineation of labour market regions in the allocation of cities to centres on the basis of interaction flows (fig. 6). This illustrates firstly the diversity of possible allocation rules and secondly the need to justify such rules against the background of the research objective and/or the use in spatial planning practice, starting with the renunciation of enclaves and exclaves up to the possibility of centre alliances with a common interlinking area.

As a result, area-forming cities are identified which are characterised by the fact that, firstly, they have a co-supply potential in the sense of a stronger supply index and, secondly, they actually realise this potential, resulting in interconnections between population in the surrounding area and the facilities located in the central place. In this way, the graph-theoretical approach also differs from pure gravity approaches such as the *Huff model*, in which potential interactional areas would be formed on the basis of the gravity in conjunction with the accessibility potentials. Stiens (1989, 33) therefore also criticises the appropriation of the gravity approach by planning, because the "fatal analogy formation" through recourse to scientific concepts is "no longer scientifically 'controllable'".

At this point, it is exciting to merge the actual interactions with reasonableness thresholds in terms of accessibility (e.g., a maximum of 60 minutes travel-time by car) and thus examine in which cases there are significant interactions despite existing accessibility deficits, or in which cases small-scale interactional areas with short distances emerge due to the density (redundancy) in the urban network (cf.fig. 5).

Fig. 6: Topological constellations in the urban system. Source: based on Laan/Schalke 2001, 207



5. Conclusion

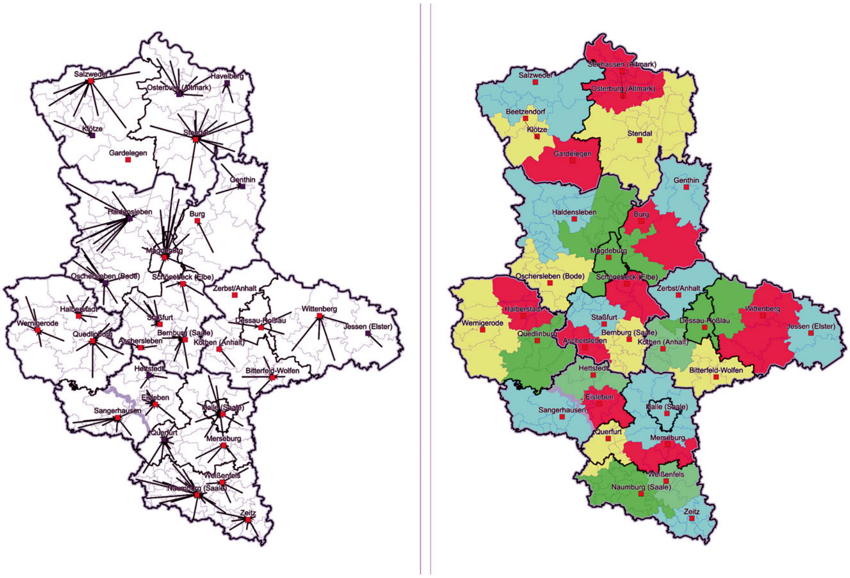
The aim of the chosen research methodology is to map the central place system empirically by analysing and describing the currently existing spatial-functional linkages and central-location functions of the cities. It is important to note that the empirical findings can and should be used to prepare political planning decisions in the sense of evidence-based planning, but should not replace them.

From Analysis to Planning Definition

The result of the analysis using the methodology presented here is a system of interactional areas and their assigned central places (separated by hierarchical levels, for the central level see fig. 7). Depending on the purpose of application, successive plausibility checks can be carried out on further – normative – premises. This is particularly necessary if the analysis is actually to prepare evidence-based political planning decisions. Such premises then also flow into the planning as rules and rule-exception relationships. The following adjustments are conceivable:

- Approximating the area boundaries to district boundaries (territorial principle),
- Allocation of enclaves and exclaves to the surrounding area (spatial contingency),
- Division of interactional/supply areas from which the assigned central place cannot be reached from all cities within the accessibility thresholds (accessibility standards),
- Combining areas that do not have sufficient carrying capacity according to normatively set population thresholds (carrying capacity standards),
- Consideration of cooperative central places as a common central place, for example to ensure a sufficient range of facilities.

Fig. 7: Central places and interactional areas at the middle-order. Source: Greiving/Terfrüchte 2020, 32–33



Taking Saxony-Anhalt as an example, figure 7 shows the existing linkages to potential middle-order centres as an empirical finding (left) and, after taking other premises into account, provides a justified proposal for middle-order centres and their supply areas.

Prospects for Further Research

This article presents methodological approaches to central place research and at the same time defines cities as spatial units for the study. Depending on the availability of data, the approaches are also suitable for identifying small-scale patterns of supply and interaction. A transfer to the neighbourhood level is discussed in the contribution by Terfrüchte and Frank in this volume. On the basis of georeferenced data, a linkage with core density approaches (cf. Flex 2015) is also possible in order to identify 'real' location clusters of central facilities. On the one hand, this makes it possible to check which facilities are actually located in the centre of the respective cities and thus characterise the actual central place. On the other hand, polycentric patterns within administrative boundaries can also be identified. For comparative metropolitan research, this offers the possibility of defining more comparable spatial units, for instance, if Berlin is not always to set the standard in a Germany-wide study.

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