

## Urban hierarchy in Slovakia: a national and regional perspective

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**Abstract:** *Since the period of post-socialist transformation and the establishment of independent Slovakia, limited attention has been paid to comprehensive assessment of its urban hierarchy. This study aims to address this research gap by proposing a hierarchical categorization of urban municipalities in Slovakia, reflecting their population size, transportation potential, availability of selected public amenities, jobs and positions in retail and commercial services. The analysis strives to capture the hierarchy both at a national and regional scale, offering insights into their roles within broader social-economic and spatial systems. The results are presented in two variants: one reflecting national-level accessibility and availability of services and jobs, and another focusing on regional contexts defined by a 40-minute commuting radius. This dual perspective emphasizes the importance of small towns in peripheral regions while demonstrating the varying positions of regional capitals based on their accessibility and amenities. The findings reveal significant disparities in urban hierarchy across Slovakia, driven by historical, infrastructural, and demographic factors. This research has practical implications for urban planning, regional development, and administrative reform. The categorization provides a framework for identifying natural centres of development and for evaluating the suitability of current administrative divisions. It also contributes to understanding the processes of urban development and regional transformation in Slovakia. The study also highlights the importance of further research. Significant differences in categorizations based on partial indicators point to the need for careful consideration of input variables, their weighting, and the refinement of threshold values. The study demonstrates differences between the national and regional significance of towns; however, it raises the question of setting spatial boundaries in the regional approach, which may vary depending on the indicators used.*

**Keywords:** *Cities, Towns, Central place theory, Centrality index, transportation potential, amenities, jobs, hierarchy*

### Introduction

Since Walter Christaller (1933) established the foundations of central place theory, the study and evaluation of hierarchical settlement structures have become a central theme in geographic research. In the following decades, this topic was further developed in German-speaking (Lösch 1940) and English-speaking (Berry 1964, Haggett 1965) scholarship. Czechoslovak geography also addressed this issue, albeit typically with narrower regional contexts. A comprehensive assessment inspired by Christaller was not undertaken until Slavík (1991), who primarily identified hierarchical structures based on the availability of public amenities. Although this study emerged after the Velvet Revolution, it effectively reflects the conditions at the end of the socialist period. In the subsequent decades, however, no similarly comprehensive studies were conducted, despite significant events such as post-socialist transformation, the establishment of independent Slovakia, integration into European structures, and global economic changes, including the development of new economic sectors. All of these factors may have influenced the urban hierarchy in Slovakia. Even several studies from neighboring (e.g., Bartosiewicz and Marcinczak 2021, Bocheński 2023) and Western countries (Griffith 2022)

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highlight the importance of understanding urban hierarchies. The present study aims to address this research gap by providing a comprehensive analysis of the urban hierarchy in Slovakia.

The primary aim of this paper is to identify the urban hierarchy in Slovakia. In addition to examining the national context, it also seeks to explore the regional context and determine the role individual towns play within their respective regions, regardless of their position in the national hierarchy. The study is based on the population size of towns, their provision of public services, as well as transport accessibility, employment levels, and, in particular, the number of jobs in retail and commercial services. These indicators serve as proxies for assessing a town's role as a service centre, serving not only to its own residents but also to its catchment area.

Given that there are slight semantic differences between Slovak and English terminology in this topic, we use the term 'cities' in the following text to refer specifically to urban municipalities with populations over 100,000 (i.e., Bratislava and Košice), while 'towns' is used more broadly to refer to all urban municipalities in Slovakia, regardless of size. This distinction is made to avoid any potential confusion arising from these terminological differences.

## **Theoretical background**

The study of the hierarchy of towns, municipalities, or central settlements has a longstanding tradition in Czechoslovak and Slovak geography. During the socialist era, numerous studies examined this topic using specific regions as case studies (e.g., Bašovský 1970, Bezák 1970, Očovský 1986, Slavík 1990, 1993) and/or focusing on particular sectors, most commonly services and retail (e.g., Očovský 1976, Wokoun 1981). The issue also extended beyond academic interest. In an effort to increase urbanization in Slovakia and optimize territorial development, Czechoslovakia introduced the Central Settlement System in 1972. This framework categorized municipalities into two types of central and two types of non-central settlements (cf. Slavík 1991). Bašovský (1991) and Slavík (1991) responded to this initiative by identifying the hierarchical structure of settlement centers across Slovakia. Bašovský (1991) primarily focused on environmental considerations, while Slavík (1991), drawing inspiration from Christaller and the Polish geographer Kamiński (1971), used the centrality index as the primary indicator of public amenity provision. This index included indicators grouped into the following categories:

- Educational facilities
- Cultural facilities
- Sports facilities
- Healthcare facilities
- Social care facilities
- Retail facilities
- Accommodation facilities
- Dining facilities
- Non-productive service facilities
- Productive service facilities
- Administrative facilities

Slavík excluded from his centrality indicators any facilities assumed to exist in every municipality studied (e.g., kindergartens, general grocery stores).

Slavík's analysis encompassed central settlements, including towns and several larger rural municipalities without status of a town, amounting to 578 municipalities in total. He classified these into seven categories (and technically an eighth category for settlements with the lowest centrality index values, which were not considered central settlements). Bratislava and Košice were placed in the first category, both achieving a centrality index of 100. Differences in population size, employment figures, and retail turnover were reflected in classification of Bratislava into subcategory I.A and Košice into subcategory I.B. Their inclusion in the highest category aligns with their roles in Slovakia's regionalization, as defined by Lukniš (1985), where both cities serve as the cores of two centralization regions separated by corridor regions, as well as the cores of two major nodal regions. The Košice nodal region covers about one-third

of Slovakia's territory, while the Bratislava nodal region spans the remaining two-thirds. Towns with a centrality index above 80 – Banská Bystrica, Žilina, Prešov, and Nitra – formed the second category. Notably, Trnava and Trenčín, which today hold the status of county seats, were placed in the third category alongside several district towns.

In the Atlas of the Landscape of the Slovak Republic (*Atlas krajiny Slovenskej republiky*), Bašovský and Švecová (2002) presented a hierarchy of towns, which is an innovation on the hierarchical structure proposed by Bašovský et al. (1986). Their hierarchy is based on nine parameters, with the resulting indicator being the sum of the Balo values of the input variables (Bašovský and Lauko 1990). Although there are several differences in categorization compared to Slavík (1991), the most notable is the classification of Košice into the second category and all other regional seats (according to the administrative division from 1996, including Prešov, Banská Bystrica, Žilina, Nitra, Trenčín, and Trnava) into the third category. However, this is merely a map output without a detailed methodology, making the results difficult to interpret. Unlike in the Czech Republic (e.g., Hampl 1996, 2005), similar comprehensive studies have not been conducted in Slovakia in subsequent periods.

Numerous studies (e.g., Sýkora and Muliček 2017, Chun and Kim 2022, Griffith 2022, Bocheński 2023, Sobala-Gwosdz et al. 2024) and practical applications of national or international development instruments suggest that understanding the urban hierarchy is a contemporary scientific challenge, even in an international context. Knowledge of this structure can contribute to improving cultural, environmental, and social aspects of urban systems, such as better cost control and more efficient provision of healthcare or public services in general, optimizing transport infrastructure development, or ensuring public transport services. An example of such a scientific study with practical implications for regionalization in Slovakia is Slavík et al. (2016), where the author created a hierarchy for identifying micro-regional centres based on 10 variables.

Understanding the urban hierarchy is also an important prerequisite for research into urban development in regional systems or subsystems of entire countries. One of the most well-known concepts applied in such studies is the model of differential urbanization. Its core idea is the differential development of regions categorized by the size of the core city (Geyer and Kontuly 1993, Geyer 1996). These categories include regions of primary cities (or groups of primary cities), medium-sized cities, and small towns. The relationships between primary, intermediate, and small towns are based on their roles within the urban system rather than population size. Primary cities focus on specialized services and advanced industries operating on international, national, or regional levels. Small towns primarily serve local needs, with economies centred around smaller businesses and basic industries. Intermediate towns combine features of both, balancing specialized functions with local services (Geyer Jr. and Geyer Sr. 2015, Magni et al. 2023). Despite this, many studies abroad (cf. Kontuly and Geyer 2003) and in Slovakia (Novotný, Pregi, and Novotná 2024), likely due to the lack of a relevant hierarchy, use population size as a proxy indicator. However, as several studies, including Slavík (1991) and Bašovský and Švecová (2002), suggest, population size does not necessarily reflect a city's position in the regional system.

Using percolation on the road network of Great Britain, Arcaute et al. (2016) revealed how infrastructure and urbanization naturally organize into hierarchical structures, emphasizing the importance of transportation and connectivity as crucial factors determining a city's hierarchical position. Similarly, Marada, Květoň and Vondráčková (2010) highlight that transport networks support and simultaneously reflect the hierarchical arrangement of towns. Higher-tier towns tend to be better connected and provide more intensive transport services. Transport intensity is closely linked to commuting for work, indicating a higher concentration of jobs in towns with a higher hierarchical status. Chun and Kim (2022) also attribute a significant role to transport connections, observing changes in the urban hierarchy in South Korea.

Several studies emphasize that population size is important, but not necessarily decisive criterion for assigning a town into a hierarchical category. Lemonakis et al. (2024) point out that although population size is only one of the factors in hierarchical classification, it cannot be overlooked, particularly in the context of changes in long-term trends, when previously growing towns have become population-shrinking ones. Using Greece as an example, they identified that this trend contributes to strengthening the hierarchical position of smaller towns at the expense of the largest ones. However, this is a rather exceptional finding. Many studies, such as Chun and Kim (2022) in South Korea, Griffith (2022) in the United States, or Bocheński (2023) in Poland, despite certain efforts to promote polycentric development, observe a persistent or even growing dominance of primary cities in the urban systems of specific countries.

Bartosiewicz and Marcinczak (2021) draw attention to the potential impact of post-socialist transformation occurring alongside post-industrial transition on changes in the urban hierarchy. Despite the expected development of polycentricity in Poland associated with the growth of employment in services at the expense of industry, they observe a strengthening of the primary city's position. Partridge et al. (2006) note that despite the significant influence of changes in the number and sectoral structure of jobs on the formation of the urban system, this issue receives relatively little attention. Therefore, our study includes estimates of the number of jobs in individual towns to identify the urban hierarchy.

We consider Slavík's (1991) study to be a highly inspiring starting point and a basis for comparison with the current state. Based on the aforementioned findings, in the proposed hierarchy we will take into account not only the population size and the centrality index reflecting selected public services and institutions, but also the transport infrastructure, the number of jobs, and specifically the number of jobs in retail and commercial services in respective town.

A town positioned higher in the hierarchy than surrounding ones is naturally equipped with infrastructure and services that smaller towns lack. This allows relatively small towns to play a significant role as regional or sub-regional centres, particularly in peripheral regions. Conversely, in metropolitan areas, even much larger towns can be overshadowed by the dominant position of major metropolises, significantly weakening their regional importance. This is also confirmed by empirical evidence from the Slovak regional system (Bezák 2014, Novotný et al. 2016, Novotný et al. 2021). Therefore, in addition to the national level, our study also focuses on the hierarchical position of towns in the regional context.

## **Methodology**

In identifying the hierarchy of towns, we used five sets of input factors. For each town, we calculated a transport potential index, an amenities index, a job accessibility index, and an index of employment in retail and commercial services. The average value of these indices was weighted by the town's population.

To evaluate the amenities of towns, we applied an amenities index derived from Kamiński (1971), aiming for at least a partial comparability with Slavík's (1991) hierarchy. The weights of individual amenity elements (tab. 1) were based on their prevalence across the towns studied. Facilities that are more common were assigned lower weights, whereas those present in fewer towns were given higher weights. This index allows for a quantitative expression of a town's degree of centrality, enabling the classification of towns into hierarchical categories (Kamiński 1971). Unlike the hierarchy by Slavík (1991), our work focuses solely on towns, with the selection of observed amenities and institutions adjusted accordingly. We excluded amenities common in any town.

Cultural amenities were assessed by the presence of a museum and a professional theatre. A professional theatre's location is a significant indicator of a higher hierarchical level, as it requires a town to have both cultural and historical significance and sufficient population to sustain its operation. Although the location of a professional theatre can be influenced by historical circumstances, O'Sullivan (2003) suggests that demand for cultural institutions such as theatres and opera houses increases with a town's hierarchical position. This is reflected in the high weight attributed to professional theatres in the centrality index. We considered all theaters managed by the Ministry of Culture, regional authorities, or municipalities, as listed in the Ministry of Culture's Theatre Network (MKSR 2024). In contrast, the presence of a museum was viewed as a supplementary indicator. Towns with significant museums are often cultural hubs for broader regions, but smaller museums, often found in small towns, generally have local or subregional significance. This was corroborated by the low weight assigned to museums in the centrality index (tab. 1). Consequently, while theatres influence the classification of towns into higher hierarchical categories, museums are more likely to impact the distribution of towns within lower categories.

Important civic amenities include courts and hospitals. Courts are facilities that residents do not use frequently, making their location an indicator of a town's higher hierarchical position (Christaller 1933, Fischer 2011, Terfrüchte 2022). In this study, we analysed the locations of courts as per the reform effective from June 1, 2023 (MSSR 2023). While the reform of court districts and their locations was a political decision, it aimed to consider court workload and optimize spatial jurisdiction for reasonable accessibility across districts. Similarly, the aforementioned authors emphasize the significance of hospitals. While hospitals are a given in large towns, their presence in smaller and mid-sized towns can be a significant differentiating factor (cf. Sobala-Gwosdz et al. 2024), as their operation requires a sufficiently large catchment area. We considered hospitals listed in the categorized hospitals database of the Ministry of Health as of January 1, 2024 (MZSR 2024) and cross-referenced healthcare facility lists from individual regional authorities. Based on this review, we included the hospital in Gelnica, which, despite its limited scope, demonstrably provides hospital care (E-VÚC/KSK 2024).

Educational accessibility was assessed by the presence of a secondary school, a tertiary education institution of any type, and a university offering a broader range of faculties in at least three distinct academic fields (e.g., medical, natural sciences, humanities, technical, legal, and educational), based on the Ministry of Education's database (MŠSR 2024) as of December 31, 2023. Universities and other tertiary education institutions, alongside professional theatres, had the highest weights (tab. 1) due to their presence exclusively in significant regional centres. We differentiated between tertiary education institutions and universities because the former often offer only a limited selection of programs (e.g., the Armed Forces Academy or the Academy of Music and Performing Arts). In Slovakia, many higher education institutions operate external study centres, often focused on part-time studies. These were excluded from consideration. This attribute was only assigned to towns hosting at least one faculty offering fully organized (full-time) studies (e.g., Jessenius Faculty of Medicine of Comenius University in Martin). However, if a city hosts a university with faculties of various specializations, it can accommodate to the interests of a wide range of students.

Following Christaller (1933), many contemporary studies also regard educational institutions as critical criteria for hierarchical classification. Terfrüchte (2022) considers the provision of tertiary education a key criterion, while Sobala-Gwosdz et al. (2024) highlight the importance of lower levels of schooling, particularly for classifying smaller towns. We excluded elementary schools, assuming they exist in every town. Among secondary schools, we included all grammar schools, vocational secondary schools, and vocational training centres in our calculations.

Another observed attribute of town amenities was the presence of the regional authority's headquarters or the historical county (*župa/stolica*) seat. This factor underscores the importance of a seat as a natural regional centre and its potential to host authorities serving residents.

Finally, we included sports facilities for Slovakia's two most prominent sports: football and ice hockey. We analysed indoor ice rinks (SZLH 2024) and football stadiums with facilities capable of hosting first- and second-league matches, which largely depend on maximum spectator capacity (SFZ 2024).

**Tab. 1.** *Attributes included in the calculation of the amenity index*

Attribute	Theatre	Museum	Court	Hospital	Current or hist. regional seat	University	Tertiary education	Secondary school	Stadium
Weight	0.91	0.19	0.67	0.52	0.87	0.94	0.87	0.14	0.60

To obtain the results when calculating the amenities index, we use two different approaches for identifying the hierarchical position of towns. Depending on the purpose of the resulting hierarchy, we either work within a nationwide context or a regional context. In the nationwide context, the number of facility types present in a town is divided by the total number of monitored facility types across the territory of Slovakia. In the regional context, the number of facility types in a town is divided by the total number of monitored facility types within a 40-minute driving distance from the town (based on network analysis of the road network from Open Street Map). The choice of car commuting is due to its dominance over other modes of transport in inter-municipal commuting for work (Gábor and PREGI 2023). The 40-minute limit was chosen as the upper threshold for commuting flows (e.g., Bratislava – Trnava, Bratislava – Dunajská Streda, Bratislava – Malacky, Košice – Prešov, Košice – Moldava nad Bodvou). Commute times exceeding 40 minutes are rare in Slovakia (SOSR 2021). Halás and Klapka (2015) demonstrate that the average commuting distance to the most significant commuting centres in Slovakia exceeds 50 km only for Bratislava, reaches 30 km for Košice, and is lower for other towns. This suggests that under optimal traffic conditions, the vast majority of commuting flows are completed within 40 minutes. Therefore, we consider this threshold generally appropriate.

This approach, particularly in the Slovak context, is primarily seen as a pilot study designed to examine the differences between nationwide and regional methods. For more precise results, it would be beneficial to consider both the varying spatial extents of individual amenities and services (e.g., school commutes are generally shorter than work commutes) and the use of gradually decreasing weights with increasing distance, rather than a strict 40-minute or other fixed thresholds. The need to explore the regional level also arises from Slovakia's pronounced spatial polarization between the developed western and northwestern parts and the underdeveloped southern and southeastern areas, which exhibit many characteristics of peripheral regions (Halás 2008, Stražovec 2024). Various delimitations of functional urban regions (Bezák 2000, 2014) or functional regions based on commuting (Halás et al. 2014, Halás and Klapka 2024) indicate that the cores of functional regions in the southern and eastern parts of Slovakia often include relatively small towns, which also suggests differences in the patterns of urban hierarchy across various parts of Slovakia.

The transport potential index incorporates six characteristics of a town, each assigned different weights (tab. 2). Connection to a highway or expressway enhances a town's position within the transport network, facilitating faster movement of people and goods, and significantly incentivizing investments in the town. Connection to a first-class road indicates the town's position within a road corridor of national or international importance. For this type of transport, we standardized the assessment of a town's connection to the higher road network

by its distance – 5 kilometres – from the road line. However, this must be a completed and operational road segment as of the end of 2023. Railway network integration was primarily assessed based on connection to the TEN-T (Trans-European Transport Network) corridor, highlighting the town's position on internationally significant routes, which are also prioritized for modernization investments. Role as a transport hub (primarily railway) was assigned a lower weight. Here, we evaluated whether a town serves as a regional railway hub, defined by the presence of railway lines extending in more than two directions. Alternatively, towns where international express trains stop (as per the timetable valid on December 31, 2023) were also considered hubs, enhancing the town's regional transport significance. The weights for highway/expressway connections and TEN-T railway corridors are double those of lower-category roads and railways. While Marada et al. (2010) assigned long-distance transport three times the weight of regional transport, we deemed this difference too large in our context, as we are also interested in centres of regional significance. We also assessed airports, given that their presence and nature reflect a town's importance and foster its development. In the globalized economy, where rapid international mobility is essential, airports play a crucial role – regular international routes are vital for employees and tourism, while private flights can serve management (Florida, Mellander and Holgersson 2015, Lenaerts, Allroggen and Malina 2021). Thus, we considered even small international airports without regular routes. However, since larger airports are particularly important for economic development (Pot and Koster 2022), we evaluated airports with regular connections separately.

**Tab. 2.** *Attributes included in the calculation of the amenity index*

Attribute	Roads		Railways		Airports	
	Highways and Expressways	First-class roads	TEN-T Corridor	Railway hub	International	With regular routes
Weight	1.0	0.5	1.0	0.5	0.5	0.5

The job accessibility index was calculated as the ratio of the number of jobs in a town to its population. Similarly, the index of employment in retail and commercial services represents the ratio of jobs in retail and commercial services to the total population of the town. Both indicators represent the significance of the town as a centre providing employment for its catchment area. The index of employment in retail and commercial services also serves as an indicator of the town's role as a service provider not only for its population but also for its surrounding area. In this way, it partially replaces the passportisation of retail and service establishments, which was the basis for Slavík's (1991) hierarchical classification. The values from the calculations of both indices were rescaled to range from 0 to 1.

Detailed data on the number of jobs and their sectoral structure are not available in Slovakia. However, based on census data on the number and economic structure of residents (SOSR 2021a) and commuting to work by sector (SOSR 2021b), it is possible to make qualified estimates. The total number of jobs in each town (J) is estimated as the number of working residents of a town (W) minus the number of out-commuters (O) plus the number of in-commuters (I). We applied this basic equation ( $J = W - O + I$ ) analogically for each economic sector separately. Due to slight differences in sector categorizations, we separately aggregated sectors related to retail, wholesale, and all services except public services (i.e., education, healthcare, public administration). Although such an estimate does not provide an absolutely reliable representation of the exact number of jobs in a town, it can be considered sufficiently accurate for comparing individual towns (cf. Novotný et al. 2023).

The calculation of the final hierarchical structure involves averaging the derived indices and multiplying them by the population of the towns according to the latest census (SOSR

2021a). The populations of the largest towns were thus multiplied by values close to 1, as they generally had excellent transport potential, amenities, good job accessibility, and a high proportion of workers in retail and commercial services.

For smaller towns, their populations were multiplied by a lower index value on average. This approach yielded a diverse differentiation, especially among medium-sized and small towns with similar population sizes. The results of the hierarchical classification are presented in two variants, as the calculation includes the centrality index based on amenities in both the national context (variant 1) and the regional context (variant 2). In all outputs, Jenks natural breaks optimization was used to categorize towns into hierarchical levels. This classification method bases the levels (classes) on the identification of natural groupings inherent in the data. Class boundaries are created to group similar values as closely as possible while maximizing differences between classes. Elements are divided into classes whose boundaries are established where relatively large differences in data values occur (ESRI 2024).

## Results and discussion

The first evaluated set of factors led to the identification of the level of amenities in towns. In seven out of eight regional seats, every type of facility under observation was found. Among the regional seat towns, only Trenčín did not reach the maximum number due to the absence of a professional theater. Only one facility was also missing in the towns of Martin, Zvolen, and Komárno. All these cities fall into the highest category according to amenities (fig. 1). On the other end of the scale are towns that do not have any of the observed facilities. These cases primarily involve the smallest towns by population, where the fulfilment of regional and especially supra-regional functions is not typically expected. However, as several studies from Slovakia (Novotný, Csachová, Kulla et al. 2016, Novotný, Kulla, Nestorová Dická et al. 2021) and abroad (Czapiewski, Bański and Górczyńska 2016, Steinführer, Vaishar and Zapletalová 2016) point out, even such towns can serve as important sub-regional centres, and in peripheral regions, even as regional centres.

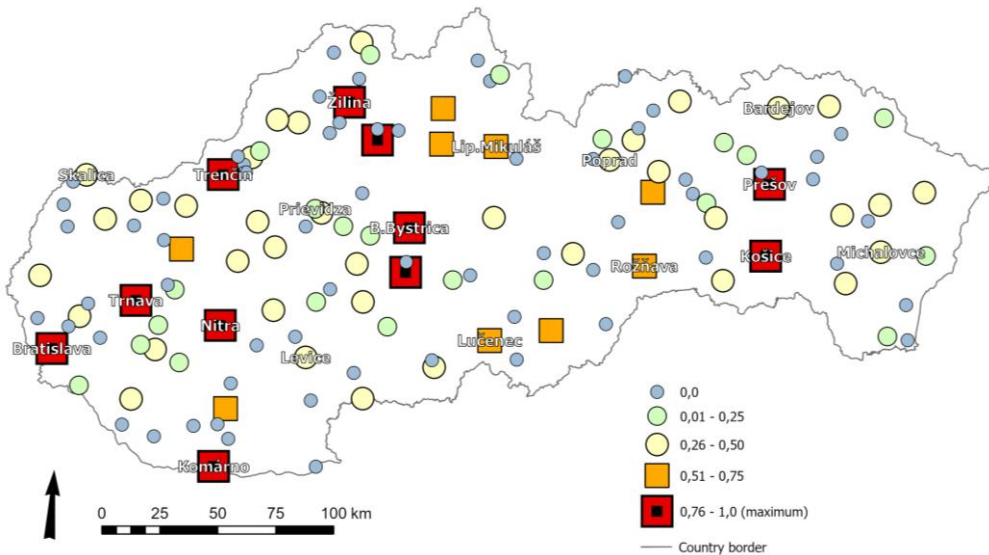
Some towns were found to host a very low number of amenities relative to their relatively high population. One such town is Poprad, which is the economic centre of the Spiš region. Yet, it does not have any universities or a professional theatre, and therefore lacks higher-level amenities compared to nearby towns like Spišská Nová Ves or Liptovský Mikuláš. However, when interpreting the results, it should be noted that our analysis only considers whether a specific facility exists in the town. Christaller (1933) himself worked with the idea that people prefer using large hospitals over local clinics, suggesting that not only the existence of a hospital but also its size is important. Several authors thus distinguish between categories of hospitals (e.g., Sobala-Gwosdz et al. 2024), or use the number of hospital beds as an indicator of size and scope (Terfrüchte 2022). An alternative approach for Slovak conditions might be to categorize hospitals according to the proposed optimization of hospital networks (e.g., MZSR 2021). Given the location of a large regional hospital in Poprad, such an approach would likely elevate Poprad hierarchically compared to nearby towns. Similarly, other amenities could also be re-evaluated. Although Poprad is the most populous and economically largest town in the Spiš region, it only emerged in its current form after World War II, through the gradual merging of five smaller historical towns (from 1946 to 1974). These towns were important economic and cultural centres of the region but never held significant administrative functions, which is why modern-day Poprad does not fulfil the attributes of either the current or historical regional seat.

For similar reasons, towns like Prievidza, Levice, Michalovce, and Považská Bystrica achieved relatively low values for the amenities index in the national context. On the other hand, some smaller towns, such as Rožňava, Ružomberok and Dolný Kubín reach a very high value of the index. By simply summing the weights of the present facilities and dividing

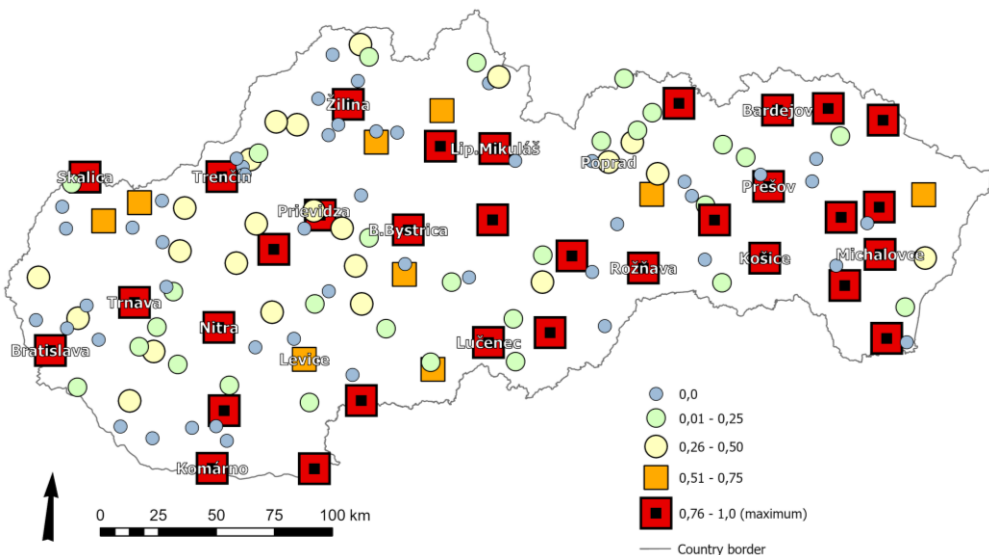


by the highest possible index value obtained for amenities in the national context (fig. 1), we found better amenities in some smaller towns compared to Slávik's (1991) results. In our study, towns like Šahy, Levoča, Hnúšťa, Revúca, and Bojnice showed improved position when it comes to amenities. Hospitals and, in some cases, the historical role of being a regional seat positively influenced these towns' rankings. On the contrary, towns like Tornaľa, Veľký Meder, Trenčianske Teplice, Sered', Kežmarok, Senica, and Modra ranked lower.

The regional approach offers different results. The number of towns with the highest value for the amenities index increased from 7 to 30 (fig. 2). This means that although 23 towns in Slovakia do not have all the monitored facilities, such facilities are also not available in the surrounding area. The absence of such amenities does not therefore reduce the town's hierarchical position within the region.



**Fig. 1.** Categories of towns by amenities (variant 1: national context)



**Fig. 2.** Categories of towns by amenities (variant 2: regional context)

A good example is the town of Kráľovský Chlmec (7,000 inhabitants), which offers only 3 out of 9 monitored facilities and has a relatively low amenities index in the national context. However, within 40 minutes by car, such facilities are also unavailable in the surrounding area. Therefore, the town's amenities index in the context of its region is 1, indicating that it holds the highest hierarchical position of all towns in the defined area. A similar situation occurred in smaller towns like Medzilaborce (5,800 inhabitants), Gelnica (6,000), Šahy (7,000), Štúrovo (9,500), and Svidník (9,500). All these towns are located in regions with several attributes of peripherality (Halás 2008, Stražovec 2024), confirming that even relatively small towns can serve as important regional centres in such areas (cf. Czapiewski, Bański, and Górczyńska 2016, Novotný, Csachová, Kulla et al. 2016, Steinführer, Vaishar, and Zapletalová 2016, Novotný, Kulla, Nestorová Dická et al. 2021). In the western part of Slovakia, a similar shift was observed in Skalica, but this is a town with a larger population (16,000).

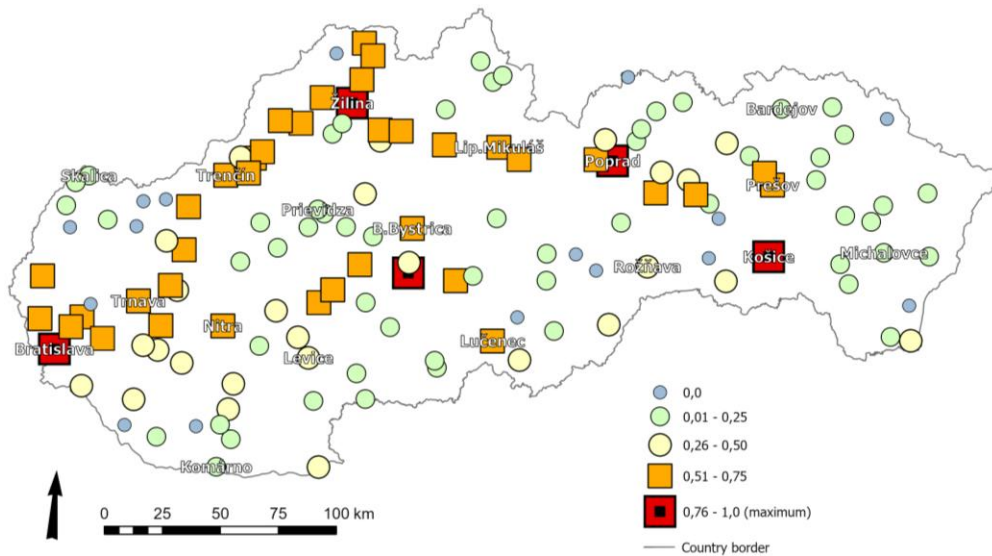
All of the mentioned small towns are also cores of functional urban regions according to Bezák (2000, 2014) and several of them also cores of functional commuting regions according to Halás et al. (2014) and Halás and Klapka (2024). This suggests that the urban system in the southern and eastern parts of Slovakia has certain specific characteristics compared to the western and northwestern parts. Towns that achieved the highest index values often have relatively low amenities index values in the national context. However, they do not have a town nearby that would have better amenities. From another perspective, this indicates the absence of selected amenities in several towns in this less developed part of the country. At the same time, it suggests the need for a more thorough examination of the issue with carefully selected attributes and spatial weighting of their values.

On the other hand, several towns with relatively high amenities index values at the national level achieved lower values at the regional level. An example is the town of Martin, because within the defined 40 minutes radius, there is the town of Žilina with a university and several faculties, whereas in Martin – the traditional centre of the Turiec region – only one, albeit well-established, faculty operates.

In the distribution of towns by transport potential, the influence of the location of pan-European transport corridors (TEN-T) is evident. These corridors spatially correspond to the northern connection between Bratislava and Košice, which has been politically and infrastructurally prioritized in Slovakia. Cities situated along depressions and river valleys in northwestern and northern Slovakia (including the middle and upper Váh River basin, the western part of the Spiš region, and the central part of the Kysuce region), which are located along the main railway corridor and the D1 and D3 highways, have high transport potential (fig. 3). This area also falls within the northern corridor region as defined by Lukniš (1985). Several studies that reflect transport infrastructure as a factor of regional development (Korec 2005, Halás 2005, 2008, Zubriczký 2019) also point to the continuing division of Slovakia as identified by Lukniš (1985) and suggest that regions in the northern corridor region are favoured over those in the south. The importance of long-distance rail transport is also emphasized by Seidenglanz et al. (2021), who show how long-distance rail transport in Central Europe is increasingly oriented towards hubs like Vienna or Munich. This, along with the delayed development and acceleration of rail lines in the west-east direction in Slovakia, is causing potential isolation for central and especially eastern Slovakia, further worsened by the lagging construction of highways and expressways compared to neighbouring countries. The real impact of the location on pan-European transport corridors will, in the future, depend partly on the overall competitiveness of Slovakia's higher-level transport infrastructure compared to neighbouring countries. On the other hand, for the regions in eastern Slovakia, a stabilizing Ukraine with a concluded conflict and deepening integration into European Union structures could represent an opportunity in terms of transport potential.

Several towns outside the main northern corridor, where both the primary railway and road networks overlap, also exhibit relatively high transport potential. Notably, Zvolen, Lučenec,

and Prešov stand out with relatively strong transport potential, as they are both railway and road hubs. However, the highest transport potential is seen in Bratislava, Košice, and Poprad, cities that have access to the highest categories of all transport modes. The highest category is also attained by Žilina and Zvolen, which are crucial road and railway junctions in the central parts of the corridor regions between western and eastern Slovakia. Both cities are also in proximity to international airports with potential civil transport, though without regular flights. On the other hand, the poorest transport accessibility is reflected in the low index values found in areas like the northern part of the Záhorie region and the Myjavská pahorkatina low hills area in the northwestern border of Slovakia, the Podunajsko, Hont and Gemer regions (southern Slovakia), the Upper Orava, Upper Spiš, Upper Šariš, and particularly in the Zemplín regions (northern, northeastern, and eastern Slovakia), and also in the Upper Nitra regions (central western Slovakia).



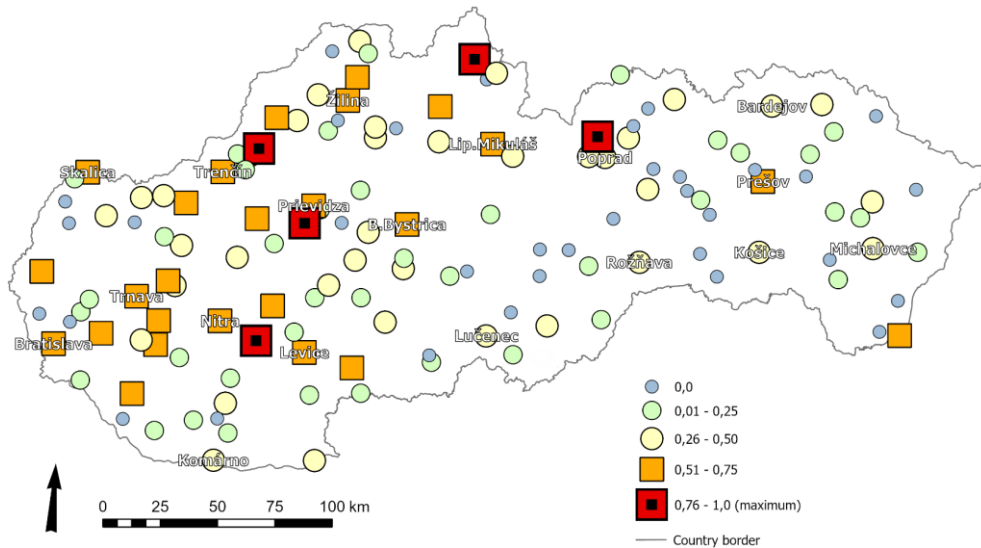
**Fig. 3.** Categories of towns by transport potential index

The highest values of the job accessibility index were recorded in several small towns with a strong industrial base (fig. 4). Such small towns in western Slovakia (Vráble, Nováky and Ilava) are located near larger towns. A different position is held by Námestovo in the far north of Slovakia. Given the high number of jobs relative to the total population, Námestovo can be expected to play an important role as an employment centre for a wider region. A specific position is held by the town of Vysoké Tatry – a key centre for tourism as well as climate therapy and treatment in Slovakia. Unlike the important industrial centres in the surrounding area, the economic base is formed by public and commercial services.

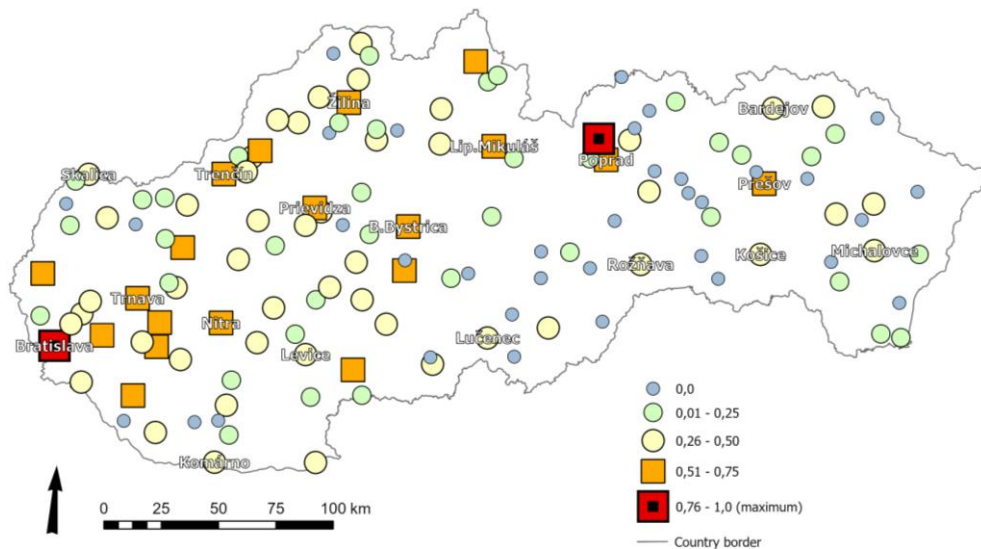
This indicator clearly highlights the dichotomy between the economically developed western and northwestern Slovakia and the underdeveloped southern and eastern Slovakia. All the towns from the first category and almost all the towns from the second category are located to the west of this dividing line (cf. Halás 2008). To the east of this line, there are only three such towns – Prešov, the third-largest town in Slovakia, and small towns like Čierna nad Tisou (in the southeasternmost part – border with Ukraine) as an important railway transshipment hub, and Dudince (in the southwest of central Slovakia) as the smallest, but important spa town. The second category also includes all the regional seats except Košice, which narrowly fall into the third category. This dichotomy both documents the economic underdevelopment of the southern and eastern regions and suggests population development trends. Novotný,

Pregi, and Novotná (2024) show that despite the relatively strong position of the Košice region within eastern Slovakia, migration from eastern Slovakia to the west is on the rise. A similar trend is observed in international labour migration (Beňová and Brocková 2022).

The values of the index of employment in retail and commercial services reflects the availability of jobs in this sector and, more importantly, indicates the concentration of retail and services. Higher values of the index suggest that a town serves as a service hub for certain catchment area. The spatial pattern of the distribution of this indicator's values confirms the clear dichotomy between the west and northwest on one side and the east and southeast on the other (fig. 5). The highest values were recorded in Bratislava and Vysoké Tatry. In the case of Vysoké Tatry, the services primarily relate to tourism. It is evident that the town holds a unique position in Slovak tourism, but it is debatable whether these commercial services fulfil the town's role as a service hub for its surrounding areas.



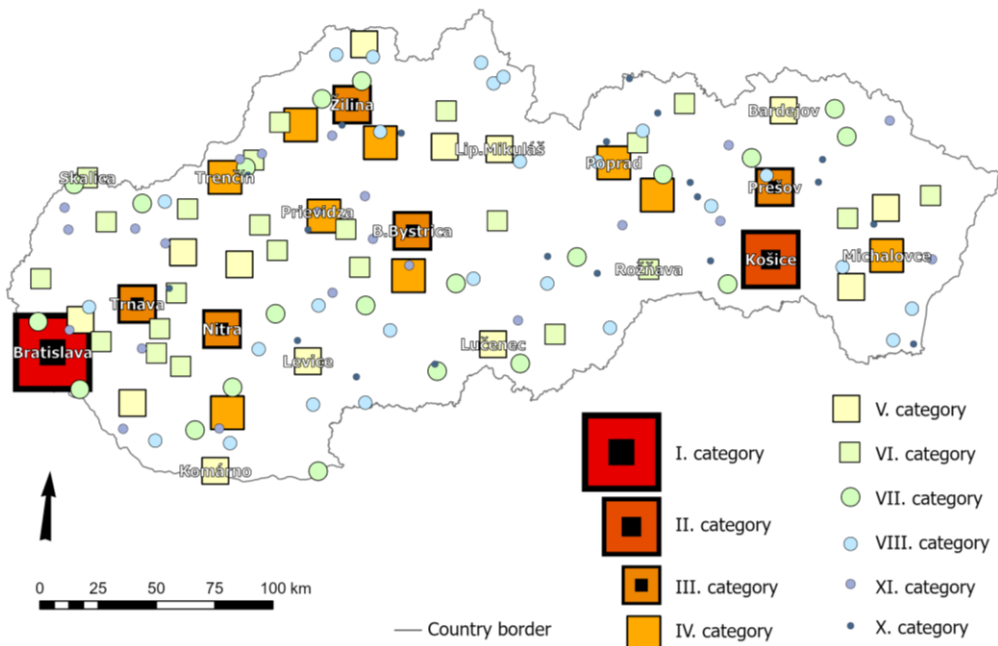
**Fig. 4.** Categories of towns by the job accessibility index



**Fig. 5.** Categories of towns by the index of employment in retail and commercial services

In contrast to the job accessibility index (fig. 4), the index of employment in retail and commercial services (fig. 5) clearly shows that higher values are primarily achieved by regional towns and some larger district towns (mainly in western Slovakia). This aligns with the assumption that the service function of these towns will naturally cover a relatively large catchment area.

Although the indices mentioned above suggest that the population size of towns may not be decisive for identifying their hierarchical structure, it is undoubtedly important. Its significance lies in the dynamic changes in population numbers that several towns in Slovakia have experienced in recent decades, partly due to the growing interregional migration. This migration, on the one hand, reflects the migratory attractiveness of towns, while on the other hand, it contributes to the redistribution of reproductive potential and human capital (Pregi and Novotný 2019, 2025, Novotný, Pregi and Novotná 2024). We classified towns into ten hierarchical levels based on the number of inhabitants using Jenks' natural breaks optimization (fig. 6), similarly to other subsequent hierarchizations, in order to easily identify changes resulting from the incorporation of the weights of individual indices.



*Fig. 6. Urban hierarchy by population size*

In the final outputs, we multiplied the population of towns by the average of the scaled values of the individual indices. This allows for the identification of differing hierarchical positions of towns with similar population sizes.

While we considered the towns' amenities in the national context (other indicators were only assessed in the national context), Level I represents the capital city Bratislava, and Level II represents Košice (fig. 7). These two cities have the highest values for transportation potential and equipment, but significantly differ in population size and employment indicators.

Level III includes all other regional seats except Trenčín. Level IV consists of larger district towns such as Martin, Poprad, and Zvolen. These towns lack several amenities attributes, but they have high transportation potential, except for Martin. Compared to the regional seats in higher levels, these towns also have smaller populations.

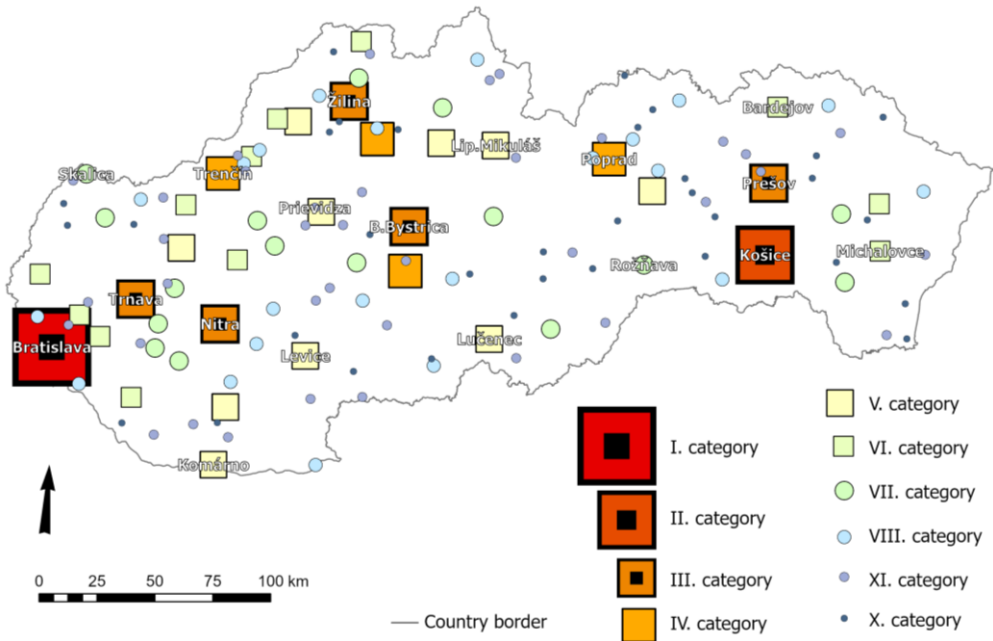
The towns of level V are still relatively well-equipped with a wide range of facilities, generally have significant transport potential, and good employment indicators. However, they lag behind the larger towns in terms of population. These towns include Prievidza, Piešťany, Komárno, Nové Zámky, Levice, Lučenec, Považská Bystrica, Ružomberok, Liptovský Mikuláš, and Spišská Nová Ves. The largest of these towns in terms of population is Prievidza, which, compared to towns with a similar number of inhabitants, is classified in a lower category. It is the centre of a region undergoing a difficult post-mining economic transformation. This is reflected in the poorer performance of employment indicators, as well as in the availability of facilities and transport potential.

On a national scale, it is evident that several larger towns have lagged behind their classification based on population size; however, relatively high employment indicators and good transport potential did not help smaller towns move significantly higher in the hierarchical order.

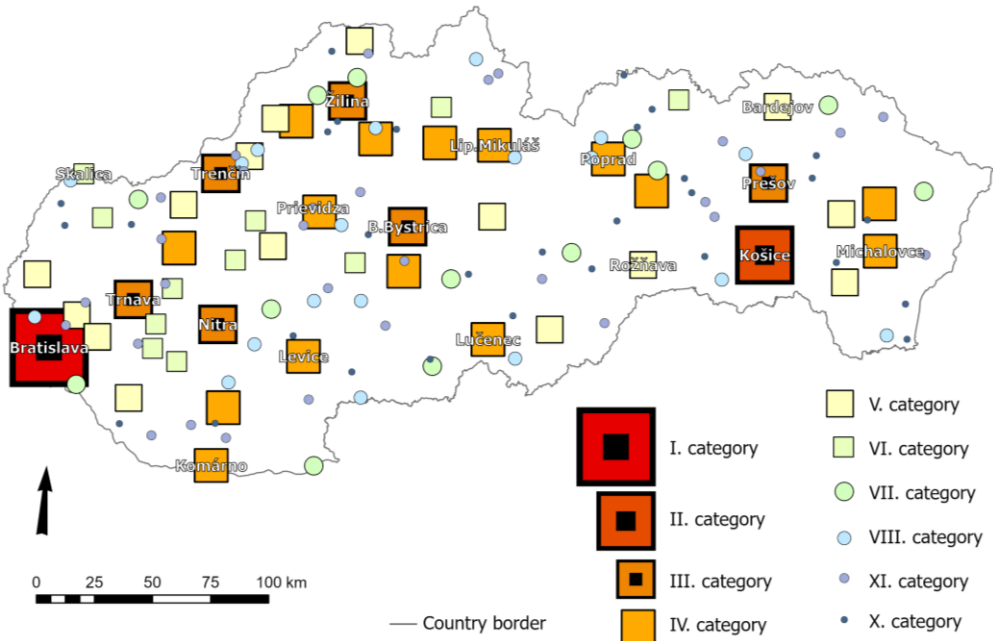
In identifying the hierarchical structure in a regional context, changes occurred primarily with towns that are more remote or peripheral in relation to the cities of Bratislava and Košice (fig. 8). Levels I and II remained unchanged, and Trenčín was also included in level III. All regional seat towns, except for Bratislava and Košice, now represent the third hierarchical level of towns in Slovakia. The fourth hierarchical level, compared to the national scale, has a richer representation. Several medium-sized district towns, particularly those located further from Bratislava and Košice, have been included.

Even in this variant, which allows isolated towns to rise to higher levels in the hierarchy, the justification for some towns as district seats has not been demonstrated. The district town of Poltár was classified into the lowest X category. District towns such as Tvrdošín, Sobrance, Medzilaborce, and Gelnica were classified into category IX despite their relatively good ranking in terms of amenities in the regional context. On the other hand, towns that are not district seats, such as Štúrovo, Šamorín (VII category), Kráľovský Chlmec, Šahy, Handlová, Filákov, Liptovský Hrádok, and Moldava nad Bodvou, recorded relatively strong positions in the urban hierarchy. Most of these towns are located in southern Slovakia, in an ethnically predominantly Hungarian area or along the ethnic border. This suggests the persistence of certain discrimination of southern areas in Slovakia's territorial-administrative division.

A comparison of the final rankings in the national and regional variants with rankings based on population (tab. 3) shows that while population size is an important indicator of a town's hierarchical position, it is not necessarily decisive. This is demonstrated by several relatively larger towns that were ranked in lower hierarchical categories in both the regional and, especially, national context. On the other hand, some of the smallest towns prove their position as regional or subregional centres with relatively higher rankings in the hierarchy. This raises the question of to what extent the population size of a town should influence the final hierarchical classification.



**Fig. 7. Comprehensive hierarchy of towns in the national context (variant 1)**



**Fig. 8. Comprehensive hierarchy of towns in the regional context (variant 2)**



**Tab. 3. Poradie miest podľa počtu obyvateľov a komplexnej hierarchizácie**

Town	Rank by population	Amenities index		Rank in hierarchy	
		National scale	Regional scale	National scale	Regional scale
Bratislava	1	1.00	1.00	1	1
Košice	2	1.00	1.00	2	2
Prešov	3	1.00	1.00	5	5
Zilina	4	1.00	1.00	3	3
Nitra	5	1.00	1.00	4	4
Banská Bystrica	6	1.00	1.00	6	6
Trnava	7	1.00	1.00	7	7
Trenčín	8	0.84	1.00	8	8
Martin	9	0.83	0.83	11	11
Poprad	10	0.37	0.44	9	9
Prievidza	11	0.37	1.00	19	12
Zvolen	12	0.83	0.83	10	10
Považská Bystrica	13	0.37	0.37	14	18
Nové Zámky	14	0.52	1.00	13	13
Michalovce	15	0.37	1.00	22	15
Spíšská Nová Ves	16	0.53	0.78	12	14
Komárno	17	0.83	1.00	17	20
Levice	18	0.37	0.71	20	19
Humenné	19	0.37	1.00	24	23
Bardejov	20	0.37	1.00	28	24
Piešťany	21	0.52	0.52	16	22
Ružomberok	22	0.68	1.00	18	17
Liptovský Mikuláš	23	0.68	1.00	15	16
Lučenec	24	0.52	1.00	21	21
Pezinok	25	0.28	0.28	26	28
Topoľčany	26	0.37	0.37	33	39
Trebišov	27	0.37	1.00	39	27
Dunajská Streda	28	0.37	0.37	23	25
Cadca	29	0.27	0.27	27	31
Dubnica nad Váhom	30	0.32	0.38	29	29
Rímskavá Sobota	31	0.52	1.00	36	30
Partizánske	32	0.37	1.00	48	37
Vranov nad Topľou	33	0.37	1.00	43	34
Saľa	34	0.16	0.16	42	49
Hlohovec	35	0.15	0.15	41	47
Senec	36	0.06	0.06	30	33
Brezno	37	0.37	1.00	47	38
Senica	38	0.28	0.75	45	40
Nové Mesto nad Váhom	39	0.37	0.44	25	26
Malacky	40	0.27	0.27	31	35
Snina	41	0.25	0.68	57	51
Doľný Kubín	42	0.52	0.78	40	42
Rožňava	43	0.53	1.00	34	32
Púchov	44	0.32	0.32	32	36
Ziar nad Hronom	45	0.37	0.37	35	43
Bánovce nad Bebravou	46	0.37	0.44	44	48
Handlová	47	0.15	0.40	73	63
Stará Ľubovňa	48	0.37	1.00	52	46
Sereď	49	0.16	0.16	37	44
Skalica	50	0.37	1.00	49	41
Kežmarok	51	0.37	0.44	51	53
Galanta	52	0.27	0.27	38	45
Kysucké Nové Mesto	53	0.06	0.06	46	50
Levoča	54	0.41	0.41	56	59
Detva	55	0.16	0.19	54	56
Samorín	56	0.16	0.16	55	58
Stupava	57	0.03	0.03	58	64
Sabinov	58	0.16	0.16	74	77
Zlaté Moravce	59	0.41	0.41	50	54
Bytča	60	0.06	0.06	53	57
Revúca	61	0.27	1.00	81	60
Holíč	62	0.06	0.16	82	81
Veľký Krtíš	63	0.34	0.65	64	62
Myjava	64	0.25	0.68	67	61
Nová Dubnica	65	0.02	0.03	61	67
Kolárovo	66	0.06	0.07	97	100
Moldava nad Bodvou	67	0.25	0.25	66	71
Svidník	68	0.37	1.00	65	55
Stropkov	69	0.06	0.16	85	83
Fíľakovo	70	0.06	0.11	77	79
Stúrovo	71	0.06	1.00	59	52

Town	Rank by population	Amenities index		Rank in hierarchy	
		National scale	Regional scale	National scale	Regional scale
Banská Štiavnica	72	0.30	0.30	68	73
Šurany	73	0.06	0.16	71	72
Modra	74	0.06	0.06	96	101
Tvrdošín	75	0.02	0.05	101	106
Krompachy	76	0.12	0.12	90	94
Veľké Kapušany	77	0.06	0.16	118	113
Stará Turá	78	0.06	0.07	94	99
Sečovce	79	0.02	0.02	112	116
Vráble	80	0.06	0.06	69	74
Veľký Meder	81	0.02	0.03	88	92
Svit	82	0.06	0.07	63	68
Námestovo	83	0.06	0.11	60	66
Krupina	84	0.15	0.18	83	86
Vrútky	85	0.06	0.06	70	75
Kráľovský Chlmec	86	0.15	1.00	103	70
Hurbanovo	87	0.06	0.07	105	108
Sahy	88	0.30	1.00	79	65
Trstená	89	0.15	0.28	87	87
Turzovka	90	0.06	0.06	123	123
Hriňová	91	0.03	0.04	115	118
Liptovský Hrádok	92	0.06	0.09	72	76
Nová Baňa	93	0.15	0.15	76	80
Tornala	94	0.02	0.04	99	102
Hnúšťa	95	0.15	0.28	110	109
Zeliezovce	96	0.06	0.14	104	104
Spíšská Belá	97	0.06	0.16	116	114
Krásno nad Kysucou	98	0.16	0.16	80	84
Veľký Šariš	99	0.03	0.03	89	93
Lipany	100	0.13	0.13	84	90
Nemšová	101	0.06	0.07	100	103
Turčianske Teplice	102	0.02	0.03	86	91
Svätý Jur	103	0.03	0.03	92	96
Sobrance	104	0.15	0.40	106	97
Gelnica	105	0.25	0.99	114	85
Medzilaborce	106	0.15	1.00	120	88
Rajec	107	0.06	0.06	117	119
Zarnovica	108	0.02	0.02	78	82
Vrbové	109	0.06	0.06	102	107
Ilava	110	0.15	0.15	62	69
Sládkovičovo	111	0.15	0.15	91	95
Gabčíkovo	112	0.03	0.03	129	133
Poltár	113	0.06	0.11	128	127
Dobšiná	114	0.06	0.08	130	129
Nesvady	115	0.00	0.00	126	126
Bojnice	116	0.12	0.33	93	89
Gbely	117	0.02	0.07	127	128
Saštín-Stráže	118	0.02	0.07	132	131
Kremnica	119	0.15	0.15	109	112
Sliac	120	0.00	0.00	107	110
Brezová pod Bradlom	121	0.03	0.06	131	132
Strážske	122	0.02	0.07	119	120
Nováky	123	0.02	0.07	95	98
Turany	124	0.06	0.06	113	117
Medzev	125	0.06	0.06	139	139
Trenčianske Teplice	126	0.00	0.00	108	111
Giraltovce	127	0.02	0.02	125	125
Leopoldov	128	0.00	0.00	98	105
Vysoké Tatry	129	0.12	0.15	75	78
Spíšské Podhradie	130	0.03	0.03	124	124
Hanušovce	131	0.03	0.03	133	134
Tisovec	132	0.06	0.16	135	130
Timače	133	0.02	0.02	122	122
Čierna nad Tisou	134	0.00	0.00	111	115
Spíšské Vlachy	135	0.00	0.00	121	121
Jelšava	136	0.03	0.05	138	138
Podolíneč	137	0.06	0.16	137	136
Rajecké Teplice	138	0.03	0.03	134	135
Spíšská Stará Ves	139	0.06	0.16	140	140
Modry Kameň	140	0.06	0.11	141	141
Dudince	141	0.00	0.00	136	137



## Conclusions

By quantifying selected attributes of amenities, jobs, and transport accessibility characteristics into four different indices, we obtained indicators that formed the basis for the hierarchical categorization of towns in Slovakia. The average of these values was multiplied by the population of individual towns, and based on that, towns were classified into ten hierarchical levels. The result is two variants of the hierarchical structure, which differ in the evaluation of town amenities and institutions. Variant 1 is based on the amenities index calculated for the entire country. It can be considered important primarily for identifying nationally significant centres, i.e., towns in the highest hierarchical levels. Variant 2 is based on comparing the facilities of individual towns with those of towns within a 40-minute driving distance. This helps better identify towns that may play an important role as regional centres, even though they may not appear significant from a national perspective. Differences in both variants point to differences in the settlement system in various parts of Slovakia, while also confirming that in peripheral regions, even small towns often play a crucial role as important regional centres. Conversely, in the areas surrounding the largest towns, even relatively larger towns by population remain overshadowed in terms of hierarchical importance by their larger neighbours.

We classified towns into hierarchical levels using Jenks' optimization of natural breaks, which allowed us to achieve hierarchical levels that contain towns with the most homogeneous values within each level, while being as distinct as possible between levels. This also creates a foundation for identifying potential centres for the purposes of the considered territorial-administrative reform at different hierarchical levels. Our results suggest that the classification of towns as either country or district seats does not always correspond to their position as supra-regional and regional centres from a national perspective, but at the regional level it does in case of county seats, as all of them are classified in the top three hierarchical levels, and there are no other towns in these three levels.

We also identified several district towns that are in the lowest levels of the urban hierarchy. On the other hand, several towns that are not district seats in terms of the current territorial division were classified into higher levels. Examples include Štúrovo, Šahy, and Kráľovský Chlmec. These towns are also cores of functional urban regions in several delimitations. The current territorial-administrative division of Slovakia has been in place since 1996. Our findings suggest that, even after 30 years, it often does not align with the functional relationships in space, and it seems that the discrimination of southern areas persists. In these areas, there is the highest concentration of towns placed in higher levels of the urban hierarchy, forming cores of functional urban regions, yet they are formally not district seats.

The results of our analysis could also be roughly compared with the hierarchical results according to Slávik (1991). Although these comparisons should be interpreted with caution, as different indicators were used in the evaluation, it is evident that the hierarchical system of towns is a dynamic phenomenon that has undergone several changes since the end of the socialist period, while the main features (the bipolar regional system, the differences between the west and northwest on one hand and the south and east on the other) persist.

Our study contributed to filling the research gap in the area of the urban hierarchy in Slovakia, but it certainly does not exhaust the topic. Rather, it points to the possibilities and challenges for further research. The findings could be refined by reconsidering or expanding the range of input factors (e.g., the number of commuters, the number of public transport connections, environmental burdens, etc.) or considering their internal structure (e.g., the number of hospital beds or hospital categorization, court categorization, schools by the number of students or classes, etc.). It would also be useful to explore the size of the catchment area not only using data from census attendance but also from mobile operators (cf. Šveda and Barlík 2018,

Halás 2025). The sharp boundaries based on distance or time, within which certain attributes were either assigned or not assigned to the town, should also be reconsidered. Our classification, moreover, focuses only on towns, while Slavík (1991) also demonstrates that several communities without town status play role of central settlements. To refine the classification at lower levels, it may be relevant to include attributes such as non-hospital healthcare facilities, outpatient doctors in communities, primary and art schools, or joint municipal offices. From this perspective, our study, particularly the regional approach, can be viewed partially as a pilot study and a starting point for further research on urban or, more generally, municipal hierarchy.

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