



Original scientific paper

Received: November 30, 2020

Reviewed: February 24, 2021

Accepted: March 19, 2021

UDC: 911.372.7:331.041

<https://doi.org/10.2298/IJGI2101075Z>



CONCEPT OF POLYCENTRICITY—THE DIFFERENCES BETWEEN DEVELOPMENT POLICIES AND SPATIAL REALITY

Vedran Živanović^{1*}, Mila Pavlović¹, Aleksandar Kovjanić¹, Dragutin Tošić¹, Filip Krstić¹

¹University of Belgrade, Faculty of Geography, Belgrade, Serbia; e-mails: vedran.zivanovic@gmail.com; mila.pavlovic2@gmail.com; kodza90@hotmail.com; dragutin.tosic@gmail.com; filipkrstic88@gmail.com

Abstract: Contemporary scientific literature and strategic documents suggest the concept of polycentricity as a key factor and the aim of regional development policies. One of the aims of this study is to analyze spatial relations between the nodal regions and to determine (calculate) the level of polycentricity in the region of Vojvodina (Northern Serbia). By quantifying spatial relations in the region (using selected methods), we pointed out the relevance of regional development policies, i.e., the extent to which the proposed measures for reducing regional inequalities are in line with the direction of contemporary spatial relations in the region of Vojvodina. We have used four different methodological tools: rank-size rule, urban primacy index, index of functional centrality, and commuting patterns (levels of functional dependence). The obtained results identified the existence of morphological polycentricity, but also the growing domination of the cities of Novi Sad and Belgrade in regulating and managing spatial and functional relations in the region of Vojvodina. These results are not completely in line with the development directions declared in the strategic documents. Our approach focuses on assessing the influence of the main nodal (sub)centers in managing further spatial and functional relations in the region of Vojvodina.

Keywords: functional polycentricity; morphological polycentricity; functional urban areas; region of Vojvodina

Introduction

The concept of polycentricity considers the existence of spatial distribution and functional relations among multiple nodal centers in a particular region. Contemporary studies in regional geography have shown that a high level of polycentricity exist in highly developed urban and regional systems (González-González & Nogués, 2016; Meijers & Burger, 2010). Burger, van der Knaap, and Wall (2014) and Rauhut (2017) pointed out the functional synergy among interconnected urban centers, as one of the basic benefits of polycentrism. Based on scientific findings and their conclusions, the concept of polycentricity has become one of the most important tools in regional development strategies, from micro to macro regional levels (Giffinger & Suitner, 2015). It seeks to achieve two basic goals: to increase the spatial and functional cohesion of the region and to reduce interregional developmental disparities.

*Corresponding author, e-mail: vedran.zivanovic@gmail.com

Contemporary science recognizes two types of polycentricity: morphological and functional (Aydan, 2018; Burger, de Goei, van der Laan, & Huisman, 2011; Burger & Meijers 2012; De Goei, Burger, Van Oort, & Kitson, 2010; Hanssens, Derudder, van Aelst, & Witlox, 2013; Salvati, Ferrara, & Chelli, 2018; Van Oort, Burger, & Raspe, 2010, etc.). Morphological polycentricity basically refers to the existence (plurality) and distribution of urban centers in a particular region, as well as their ranking according to internal issues (number of cities in the region, population size of the cities, the spatial distance between them, individual participation in certain economic indicators of regional development, etc.). In other words, internal characteristics of urban centers are in the focus of morphological approach, while all the connections and relations between them are omitted. The tendency toward a balanced distribution and importance of all urban centers in the regional development of certain area is the essence that distinguishes the concept of morphological polycentricity from other theories dealing with spatial-functional relations between the cities. On the other side, functional polycentricity of a specific region is reflected in the consistency of connections and relations between the cities in the area. The stronger relation in a specific region, the stronger polycentricity level is achieved. Different types of interactions between the cities are taken as criteria for calculating functional polycentricity of the region: daily commuting of labor, pupils and students, telephone connections, business cooperation of certain economic subjects, traffic, trade, transport flows, etc. (Boussauw et al., 2018; Burger et al., 2011; Konjar, Lisec, & Drobne, 2010; Olsson, 2016; Vasanen, 2013).

Vojvodina is a region characterized by a morphological polycentrism, with Novi Sad as the largest and the first city in the urban hierarchy (Table 2 and Figure 2). On the other side, the existence of a large number of cities at the second and third level in urban hierarchy (see chapter Spatial-urban structure of Vojvodina region) represent an excellent basis for achieving a high level of functional polycentrism. A balanced spatial distribution of urban centers may ensure the overall development of the region i.e., may have a positive effect on the development of underdeveloped sub-regions (Živanović, Tošić, Nikolić, & Gatarić, 2019). "Compared to the other regions of Serbia today, Vojvodina has the best polycentric settlement network conditioned by favorable morphological distribution of settlements, high degree of urbanization, low rate of mobility of daily migrants, i.e., relatively good distribution of economic activities located in smaller settlements, which keep people in local environment" (Nevenić, 2013, p. 81). Krunic (2012a, p. 16) has come to similar conclusions: "A polycentric and territorially balanced network of settlements was formed in the region of Vojvodina, in which Novi Sad took a central position, while urban centers of subregional significance were formed at the regional periphery: Subotica, Kikinda Zrenjanin, Vršac, Pančevo, Sremska Mitrovica, and Sombor. These cities have a key role in the process of differentiation and simultaneous integration of settlements system in the region of Vojvodina, i.e., the basis of its polycentric development."

This paper analyzes the structure of morphological polycentricity in the region of Vojvodina, the level of achieved polycentric development, as well as the direction of further territorial and functional evolution of the region. This paper uses different methodological tools for calculating both types of polycentricity (morphological and functional): rank-size rule method and urban primacy index, Schmooks' model, for calculating functional centrality of individual settlement, and determining functional dependency of individual settlement and analyzing commuting pattern of the region.

The leading objective of the paper is to determine whether and to what extent functional polycentrism is developed in the region of Vojvodina. In the strategic documents, polycentrism has

been proclaimed as the most important tool in achieving the final goal of spatial development—reduction of regional inequalities. The applied methodology and obtained results of this paper can answer some of the important questions: whether and to what extent functional polycentrism is achieved in the region of Vojvodina, whether and to what extent the objectives of the regional spatial plans are in line with the actual directions of spatial and functional development of this region, what are the most dynamic areas in Vojvodina region, which areas of this region need proactive assistance of the State and Province for the purpose of economic and demographic revitalization and reduction of its underdevelopment, etc. The authors will try to answer these research question in the chapter Discussion and conclusions.

The reference strategic, planning, and development documents whose goals were compared with the obtained results of this research are Spatial Development Strategy of the Republic of Serbia: 2009–2013–2020 (Vlada Republike Srbije, Ministarstvo životne sredine i prostornog planiranja, 2009), Strategy of sustainable urban development of the Republic of Serbia until 2030 (Official Gazette of the Republic of Serbia, 2019), Regional Spatial Plan of Autonomous Province of Vojvodina (Pokrajinski sekretarijat za urbanizam, graditeljstvo i zaštitu životne sredine, 2011), The Law on spatial plan of the Republic of Serbia from 2010 to 2020 (Official Gazette of the Republic of Serbia, 2010), and Spatial Plan of the Republic of Serbia for 2021–2035 (Vlada Republike Srbije, Ministarstvo građevinarstva, saobraćaja i infrastrukture, 2020).

Spatial-urban structure of Vojvodina region

Compared to the other regions of Serbia, Vojvodina has had different socio-historical development. Until 1918, the region of Vojvodina was a part of Austro-Hungarian monarchy, which had a clearly formulated policy of spatial and functional organization of this area. By conducting a planned development there have been formed a morphologically polycentric settlement network characterized by highly populated and functionally developed rural settlements, as well as by a relatively large number of cities at a small spatial distance. With its central position in the region, Novi Sad stands out as the dominant regional center (Ćurčić, 1985). In the second half of 20th century, “urbanization process in the settlement network in Vojvodina has conditionally taken place in two stages. The early stage, after the Second World War until the beginning of 1980s, was characterized by polycentric polarization in which, besides Novi Sad and Subotica, other towns/cities, equal by demographic size, were: Zrenjanin, Pančevo, Sombor, Kikinda, and Vršac. In the second stage, lasting longer than the first one, the settlement network of Vojvodina has developed under the influence of monocentric polarization in which Novi Sad has a dominant role, while other, once developed urban centers, have begun to lag behind. This is particularly pronounced in towns in Banat: Kikinda, Vršac, and to some extent also Zrenjanin” (Krunić, 2012b, pp. 25–26).

In the focus of this research is a settlement, as the basic spatial unit of research. By applying the selected research methods at the settlement level, the most precise data of the state of spatial-functional relations in the region can be obtained. There are 467 settlements in Vojvodina region, distributed in 46 municipalities, classified into two categories: urban and other. However, not all the settlements have the same functional significance or role in the regional development process. As it was pointed out in the Spatial Development Strategy of the Republic of Serbia: “The city is the carrier of regional development in the Republic of Serbia” (Vlada Republike Srbije, Ministarstvo životne sredine i prostornog planiranja, 2009, p. 183), and as such it will be observed in this research

as well. In the interpretation of the obtained results, special attention will be paid to the cities which are marked as the centers of functional urban areas in all of the five relevant strategic documents. These eight cities are classified into the three different categories of the hierarchy of functional urban areas (Figure 1):

- Novi Sad—the center of functional urban area of international importance;
- Subotica, Sombor, Sremska Mitrovica, Zrenjanin, Pančevo, and Kikinda—the centers of functional urban areas of national importance; and
- Vršac—the center of functional urban area of local importance.

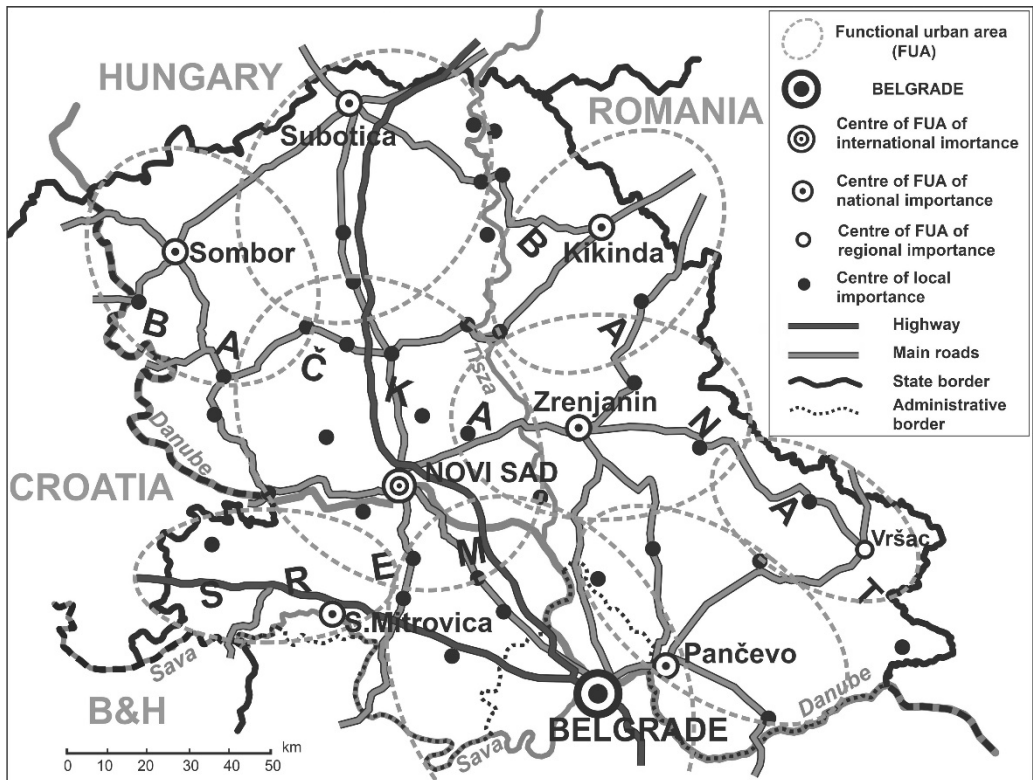


Figure 1. Spatial relationship of the largest cities and the most important roads in the region of Vojvodina.

Functional urban areas are the basic territorial level of analysis and regional planning in the development and strategic documents. These documents are objectives for the comparison with the results of our research (the list of the strategic documents can be found in the next chapter). The above mentioned eight cities, as carriers of regional development, will be in the focus of the analysis of the obtained results, especially in the model related to the determination of the functional dependence of the settlements. This model, in the most precise way, shows the degree of the achieved and the directions of further development functional relations in the region. Since the significant number of settlements in Vojvodina are located in the gravitational zone of Belgrade (especially in the eastern and south-eastern Srem and southern west and west Banat) (Filipović,

2020), in the analysis of the spatial structure of Vojvodina special attention is going to be paid to the functional influence of Belgrade in the studied area.

Methodology and data

For the purpose of this paper we have used four analytical methods, which represent an integral part in the analysis of many researches in the field of regional geography and planning (Aydan, 2018; Đerčan et al., 2017; Filipović, 2020; Krunic, 2012a, 2012b; Nevenić, 2013; Živanović et al., 2019). The aim is to use those methods which will represent Vojvodina's urban structure in the most efficient way, as well as the horizontal (spatial) and vertical (functional) hierarchy of the settlements and their interrelation. The final result of using these selected methods will show the extent to which morphological and functional polycentrism has been developed and what are tendencies of the past and the direction of the future development of spatial and functional relationships in Vojvodina region. Methods that are used in this paper are: rank-size rule and urban primacy index, Schmook's model for the centrality of the settlements, and functional dependency model for analyzing commuting patterns of the region. In the analysis, we were using (published and unpublished) results of the 2011 Census of Population, Households, and Dwellings in the Republic of Serbia (Statistical Office of the Republic of Serbia, 2013, 2014a, 2014b, 2017, 2018).

Rank-size rule method and urban primacy index

Rank-size rule is one of the most applicable methods for calculating the level of morphological polycentricity (monocentricity). It has been applied in urban geography since the 1960s. This method provides information about the hierarchy of settlements in one administrative unit, usually based on the analysis of demographic and economic data (Aydan, 2018; Burger & Meijers, 2012; Đerčan et al., 2017; Sinclair-Smtih, 2015; Živanović et al., 2019).

The rank-size rule method is based on a regularity observed in the distribution of settlements by their population size (Zipf, 1949) according to which the probability of occurrence of a settlement of any size is inversely proportional to its size (Zipf's law). According to rank-size rule method, it can be expected that one city in a country or region, sorted by population size, is going to have as many inhabitants as the largest city divided by the city's ordinal number in a ranking of cities. It is mathematically expressed by the Equation (1):

$$S_n = S_1/n \quad (1)$$

where S_n is expected population of the city, S_1 is population of the largest city, and n is rank of the city. By applying this method, the settlements are ranged from the largest to the smallest, and the size and rank of population of each settlement are plotted on the y- and x-axis of the chart using logarithmic scaling. The x-axis represents the logarithmic values of the ranking of the settlement by size and y-axis represents the logarithmic value of the population number of the settlement. The calculated values at the x- and y-axis are forming a straight line of regression, and the inclination of this line (β) is used as a measure of the level of polycentricity/monocentricity. The case that $\beta = 1^2$ is an ideal situation where the concentration forces are balanced with the

²Although the slope value is always negative, from the practical reasons there have been used positive values.

decentralization forces (reference β value 1). Therefore, the slope of the regression line is compared with the reference value. A flatter slope of the line (the slope β value < 1) indicates a polycentric region, while a steeper slope of the line (inclination β value > 1) indicates a monocentric region (Aydan, 2018; Burger et al., 2014; Meijers, 2008).

The index of urban primacy will be used to determine the morphological monocentricity/polycentricity in the region of Vojvodina. In the developing countries, compared to the other cities in urban hierarchy, the capital city stands out in terms of population size. This phenomenon was noticed even before the Second World War and was called The law of the primacy city. It was explained as a consequence of the political and economic situation in the country (Đerčan et al., 2017; Živanović et al., 2019). There are two ways to calculate this index. It is calculated as the ratio of the number of inhabitants of the first (G_1) and the second (G_2) city according to the population size:

$$I_1 = G_1/G_2 \quad (2)$$

In the scientific practice, urban primacy index is often calculated as a ratio between the population number of the first and the next three cities in urban hierarchy:

$$I_2 = G_1/(G_2 + G_3 + G_4) \quad (3)$$

For the purpose of this research, urban primacy index will be calculated and analyzed for the region of Vojvodina, and we are going to use formula 3. Urban primacy index is considered to be pronounced if calculated value is greater than 2.

Schmook's model for the centrality of the settlements

This model is based on the number and proportion of employees in the tertiary-quaternary sector of economy. More precisely, this model calculates a deviation of employee's participation in the tertiary-quaternary sector of economy in the certain settlement from the same indicator at the regional level. The pattern for the calculation is the following:

$$C = An \cdot (TQn/An - TQr/Ar) \quad (4)$$

where An is the total population in the settlement, TQn is the total of the economically active population in tertiary-quaternary sector of economy in the settlement, TQr is the total of the economically active population in tertiary-quaternary sector of economy in the region, Ar is the total of the economically active population in the region (Đerčan, 2014; Lazarević, Ivanović, Ristić, Marjanović, & Miličević, 2020; Schmook, 1968). This method is used to determinate a variety of features in regional urban network: level of development of the single settlement, the position of the settlement in the functional hierarchy of the region, the importance of settlement in the spatial integration of the surrounding area.

Functional dependency model for analyzing commuting patterns of the region

Analyzing the commuting system of a certain region is one of the most dominant methods in the delineation of nodal region and determining its level of polycentricity. Daily migrations patterns were used as one of a basic tool in determining the level of polycentricity in the UK, Sweden, the Netherlands, Slovenia, Poland, Belgium, etc. (Bański & Czapiewski, 2015; Boussauw et al. 2018; Burger et al., 2014; Karlsson & Olsson, 2006; Konjar, Lisec, & Drobne, 2010).

In this paper, we have analyzed spatial commuting patterns in order to determine the dominant directions of intraregional functional flows and whether or not functional polycentricity has been established in the region of Vojvodina. We have used the model of functional dependence, i.e., the classification of settlements in Vojvodina region according to the functional dependence from the labor center. The centers of eight functional urban areas, as well as the city of Belgrade, were observed as the main working centers toward which a large number of daily migrants of Vojvodina commute. Each settlement is classified into one of the seven categories of functional dependence (Table 1). Functional dependence is calculated by comparing the total number of daily migrants and the number of employees in the settlement. The percentages in Table 1 show the share of commuters in the total number of employees in the settlement. This method shows the extent to which population of a settlement depends on the function of work located in another settlement (most often in one of the functional urban area's centers). This model was first used by Tošić (1999), and later it was used in modified forms for analyzing almost all the settlements in Serbia (Filipović, 2020; Krunić, 2012a; Milošević, 2016; Nevenić, 2013).

Table 1
Level of functional dependency from the working centers

% of daily migrants (commuters)	Level of functional dependency
70–100	Fully dependent
50–70	Very strong dependency
30–50	Strong dependency
20–30	Medium dependency
10–20	Low dependency
5–10	Very low dependency
0–5	Independent

Note. Adapted from "Prostorno funkcijnski odnosi i veze u mreži naselja Vojvodine" [Spatial-functional relations and links in the network of settlements of Vojvodina], by N. Krunić, 2012a, University of Belgrade, Faculty of Geography, Belgrade, p. 217.

Main goals of regional development in reference strategic documents

The obtained results will be compared with the guidelines and goals of regional development prescribed in the planning documents. For precise understanding of planning and strategic documents, some of their most important determinants will be presented here. The concept of polycentricity is in the core of the planned regional development of all the five strategic documents. The Spatial plan of the Republic of Serbia emphasizes the general principle of spatial development "polycentric territorial development, with an emphasis on the role of cities and functional urban areas, as well as strengthening relations between the village and the city" (Official Gazette of the Republic of Serbia, 2010, p. 27). Solving a problem of uneven regional development in envisaged in a similar way "by applying the principles of decentralization and polycentrism in which larger cities as: Subotica, Sombor, Sremska Mitrovica, Kikinda, Zrenjanin, Pančevo, and Vršac are going to have the role of 'development engine' or focal points, around which smaller municipalities will be grouped, forming development regions on the entire territory of the Vojvodina. The city of Novi Sad will have the role of a development center at the intersection of corridors X and VII with the assumed functional connection with the city of Belgrade, which will make this area one of the 'gates' in this part of Europe" (Official Gazette of the Republic of Serbia, 2010, p. 43). Polycentricity is included as one of the basic principles of spatial development of Serbia in the draft of the Spatial plan of the Republic of Serbia, until 2035.

Even in the most important regional spatial plan (Spatial plan of the Autonomous Province of Vojvodina) polycentricity was chosen as a basic principle of spatial development. The main goal of

the spatial development of the Autonomous Province of Vojvodina is: “sustainable spatial-functional development based on the model of functional urban areas, which will be an instrument of more balanced spatial development” (Pokrajinski sekretarijat za urbanizam, graditeljstvo i zaštitu životne sredine, 2011, p. 83). The most important operational goals include (among others):

- networking of functional urban areas in aim of reducing regional development disparities;
- networking and better connecting the centers of functional urban areas; and
- networking and better connecting of functional urban areas on the territory of Vojvodina region with the neighboring functional areas.

Similar development plans are formulated in the Spatial Development Strategy of the Republic of Serbia: 2009–2013–2020 (Vlada Republike Srbije, Ministarstvo životne sredine i prostornog planiranja, 2009) and in the Strategy of Sustainable Urban Development of the Republic of Serbia until 2030 (Official Gazette of the Republic of Serbia, 2019). The main goal of development of functional urban areas in Serbia is to determine, organize, and connect functional urban areas as a basis for balanced regional development (Vlada Republike Srbije, Ministarstvo građevinarstva, saobraćaja i infrastrukture, 2020).

Results

Table 2 shows the ratio of the population number of the eight largest cities in Vojvodina region (eight centers of the functional urban areas) in 2011, and the number of inhabitants that these cities should have according to the idealized rank-size rule method. Novi Sad stands out according to the population size and it is about two and a half times bigger than the first next city in the urban hierarchy—Subotica. Subotica and Zrenjanin have fewer inhabitants than the number provided by the rank-size rule, but from the fourth city in the hierarchy, a real number of inhabitants is higher than “expected”. This ratio of the actual and hypothetical population number indicates that the dominance of Novi Sad in the area of Vojvodina is not expressed to a large extent, such as, for example, Belgrade in the hierarchy of urban centers in Serbia (Đerčan et al., 2017; Živanović et al., 2019).

Table 2
Rank-size rule method for eight largest cities in the region of Vojvodina in 2011

Serial number	City	Population in 2011	Population according to the rank-size rule
1	Novi Sad	231,798	231,798
2	Subotica	97,910	115,899
3	Zrenjanin	76,511	77,266
4	Pančevo	76,203	57,949.5
5	Sombor	47,623	23,179.8
6	Kikinda	38,065	12,877.67
7	Sremska Mitrovica	37,751	8,278.5
8	Vršac	36,040	2,897.48

Note. Data on population are adapted from *Population census, 2011: Comparative overview of the number of population in 1948, 1953, 1961, 1971, 1981, 1991, 2002 and 2011*, by Statistical Office of the Republic of Serbia, 2014a (<https://pod2.stat.gov.rs/ObjavljenePublikacije/Popis2011/Knjiga20.pdf>).

These assumptions were confirmed by the calculation of urban primacy index. For the region of Vojvodina in 2011 it was 0.94. Higher than „expected“ population number, according to the rank-size

rule method, in the cities of Pančevo, Zrenjanin, Sombor, Kikinda, Sremska Mitrovica, and Vršac, indicate a relatively balanced spatial distribution of the population in urban hierarchy, which is one of the most important preconditions for achieving polycentricity (both morphological and functional).

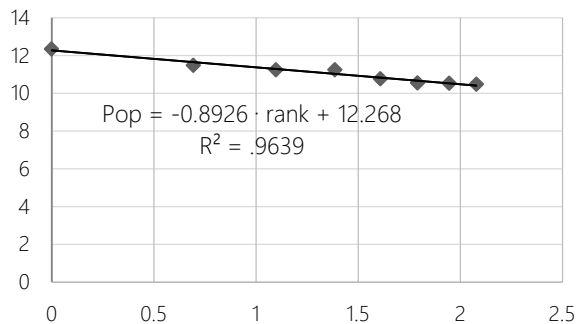


Figure 2. The results of rank-size rule method.

chapter Methodology and data). The results of these two methods clearly depict the spatial-urban structure of Vojvodina region—it is a morphologically polycentric region, with a mild demographic domination of Novi Sad.

The same method for determining the level of morphological monocentricity/polycentricity has been used in many other respective scientific researches (Adolphson, 2009; Meijers, 2008; Parr, 2004). Adhering to this view, Burger and Meijers (2012, p. 1135) “use the rank-size distribution of the nodality scores in an urban system to assess the degree of morphological polycentricity and the rank-size distribution of the centrality scores in an urban system to assess the degree of functional polycentricity (in the Netherlands). The major indicator is the slope of the regression line that best fits these rank–size distributions. The flatter the slope of this line is, the more polycentric the region. Conversely, the steeper the slope of this line is, the more monocentric the region.”

According to Figure 3, one spatial regularity is noticed in the horizontal distribution of the functional centrality of the settlements—the highest values of functional centrality are noticed in the most developed settlements (cities), and in those characterized by a large number of inhabitants. These settlements represent the cores of concentration for the most developed industries and therefore tertiary and quarterly sectors of economy are the most dominated in it. Novi Sad is distinguished from the other cities in the region by several times larger value of functional centrality than the second city in the urban hierarchy. The values of the functional centrality of Novi Sad is 18,884 index points, while the index of others centers of functional urban areas has a several times lower value: Subotica (3,542), Pančevo (3,384), Sombor (1,493), Sremska Mitrovica (1,438), Zrenjanin (1,211), Vršac (361), and Kikinda (–178). Measured by the level of functional centrality, Vojvodina belongs to the highly monocentric regions. High values of centrality of sub-urban settlements of Novi Sad (Figure 3) are also a result of its polarization effect. Because of the vicinity of Novi Sad, these settlements are in the zone of very strong functional influence, which is confirmed by a large number of commuters (Figure 4) in the structure of economically active population.

Figure 2 shows the regression line calculated on the basis of logarithmic values of the ranking of settlement by its size (y-axis) and population number (x-axis). The slope of the regression (β value) is calculated for eight cities that are the centers of functional urban areas. A value of 0.893 indicates that the eight analyzed cities have morphological polycentric structure. This domination of Novi Sad is not so pronounced (according to this indicator), since β value is very close to the limit value (β equals 1, see

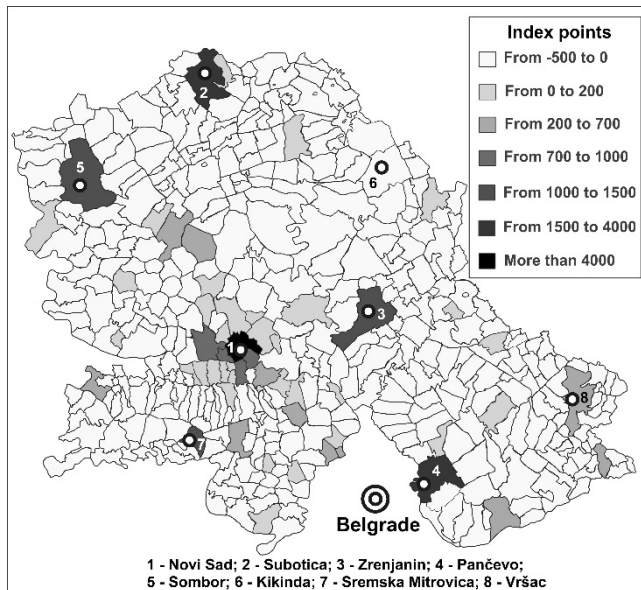


Figure 3. The level of functional centrality of the settlements in the region of Vojvodina in 2011. Data used for presentation of the results are from *Population Census, 2011: Economically active population that perform occupation, at the settlement level* [Unpublished data], by Statistical Office of the Republic of Serbia, 2017.

There are various forms of spatial-functional relations between the cities with high values of functional centrality and their urban surroundings that are affecting the creation of a regional urban system with emphasized hierarchy. There are several areas in Vojvodina with a small spatial (horizontal) distance between the cities characterized by high value of functional centrality (south Bačka and northeast Srem). As a result of such spatial relationships in south Bačka and northeast Srem sub-regions a multi-nodal and functionally polycentric urban system has been created. Northeast Srem is the only sub-regional territorial unit in Vojvodina, where the spatial continuum of settlements with a high value of functional centrality has been achieved. On the other side, in east and north Banat, as well as in the central and north Bačka there are no spatially continuous urban systems. These sub-regional units are characterized by monocentric, multifunctional development, realized by the influence of a single, dominant city (Sombor, Subotica, Kikinda, and Vršac).

Subotica and Sombor are the cities with a significant role in reducing uneven spatial development in Bačka sub-region. The high values of functional centrality of these cities indicate the existence of sufficient functional capacity for sustainability and development of border areas toward Hungary and Croatia. According to the level of functional centrality, Pančevo, Zrenjanin, and Vršac are the most developed cities of Banat sub-region and Sremska Mitrovica is the dominant settlement of Srem sub-region. In the functional structure of Vojvodina region, all these cities represent sub-regional poles of growth and development. Due to the large spatial distance among these cities, the interrelation between them is functionally insufficient. The high values of functional centrality of Ruma, Novi Banovci, Nova Pazova, and Indija are of great importance for achieving functional polycentricity in the east Srem sub-region. These settlements are located on the most dynamic developmental axis in Serbia, Novi Sad–Belgrade. Spatial distance between Novi Sad and Belgrade is only 80 km, and the cities are interconnected by highway, regional roads, railway, and the Danube River.

Figure 4 shows the concentration of settlements with a high degree of functional dependence in the vicinity of the largest urban centers. This is particularly present in sub-urban areas of Sombor, Subotica, Kikinda, Vršac, and partially Sremska Mitrovica. These cities and their surroundings are differentiated into the independent functional urban areas, outside the influence zone of other cities. There is no functionally more developed settlement within a 45-minute-drive radius, which makes them an independent urban system—they do not have strong functional interaction with other urban systems. Due to the long spatial distance and functional isolation from the main metropolitan area in Vojvodina, spatial planners have significant challenges in implementing appropriate development policies that will facilitate economic cooperation and connection between these isolated cities and others developed sub-regions. In the example of these five cities the first discrepancy can be seen between the directions of development prescribed in the strategic documents and the spatial reality in Vojvodina region. Strategic documents envisage a “networking” of neighboring functional urban areas, but it is obvious that possibilities for this type of spatial integration are minimal. Their mutual distance exceeds the strength of their functional impact, which is the best seen in the fact that there are the zones of settlements with low rates of functional dependence between them. Krunić (2012b, p. 28) came to the similar results: “greater zone of periphery has been created where the distance between centers is greater than their functional capacities, e.g., to the south-west of Subotica–Kikinda line and in Zrenjanin–Vršac–Pančevo triangle.” Such difficulties for reducing regional inequalities are also present worldwide. “While European spatial planners often cherish this positive side of small and medium-sized cities (such as lower housing costs, accessibility of green space, strong territorial identities, and feelings of belonging), the fear of not being able to withstand the competition from large metropolises in the long run because of a lack of agglomeration economies leads to a conundrum for planners” (Boussauw et al., 2018, p. 2).

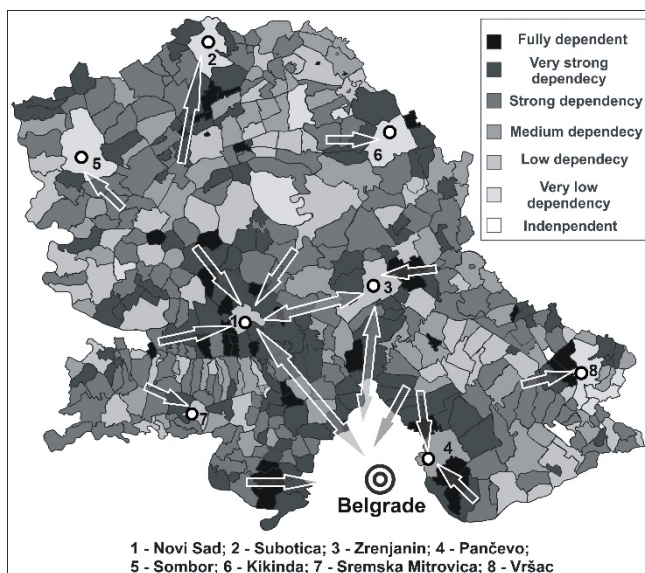


Figure 4. Commuters' direction and level of functional dependency of the settlements in the region of Vojvodina, in 2011 (the arrows in the figure show the dominant directions of daily migrations). Data used for presentation of the results are from *Population Census, 2011: Daily migrations of the active population* [Unpublished data], by Statistical Office of the Republic of Serbia, 2018.

At the same time, in the spatial structure of Vojvodina we can distinguish several spatially connected zones characterized by extremely high rates of functional dependence. These zones are characterized by a high frequency of commuters. In the west-east direction, this zone consists of the following subregional units:

- Southeast Srem—a part of the daily urban system of Belgrade. This part of Srem region includes settlements of Pećinci and Ruma municipalities, which are partially functionally oriented toward Belgrade (Filipović, 2020);
- Gravity area of Novi Sad. This is the largest individual gravitational area in the region of Vojvodina, elongated in the southeast direction, toward the city of Belgrade;
- East Srem—the most dynamic development axis in Serbia, the area between Belgrade and Novi Sad. This zone is recognized as “the belt of the most intensive development, i.e., a unique functional region created by influential spheres of the cities of Belgrade and Novi Sad” (Official Gazette of the Republic of Serbia, 2010); and
- Southwestern Banat—an area in the triangle of Zrenjanin, Pančevo, and Belgrade. The concentration of settlements with a high degree of functional dependency occurs as a consequence of the overlapping of functional influences of these three cities.

These four sub-regional units represent the zone of the most intensive commuting in the region of Vojvodina. Daily migrations from this zone are mainly oriented toward Novi Sad, Zrenjanin, Belgrade, and Pančevo, so the phenomenon of functional polycentricity in the region of Vojvodina can be discussed only in the quadrangle of these cities. The intensity of functional influence of these cities in the 21st century shows a tendency of increase (Filipović 2020; Krunic, 2012a), which leads to a stronger spatial overlapping of their functional influence.

The third spatial pattern of grouping of the settlements with a high rate of functional dependence can be seen along important regional roads. They are characterized by a linear spatial concentration and are especially noticeable in the north of Novi Sad, south of Subotica and the southern Banat, between Pančevo, and Vršac. The linear concentration of a large number of settlements with a share of daily migrants larger than 50%, in the territory northern of Novi Sad and southern of Subotica is spatially coinciding with the direction of the highway E75. Pančevo and Vršac are located on the most important international road in the subregion of Banat: Belgrade–Timisoara, which affects the increase of the spatial mobility of the population of the settlements in this area, as well as the appearance of high rates of functional dependence. This confirms the concentration of population and economic activities along the most important roads in Vojvodina region, which leads to the spatial integration under the influence of the largest urban centers.

Discussion and conclusion

Based on the obtained research results, it can be determined that the concept of polycentrism in the region of Vojvodina is present in its morphological form. The polycentrism in Vojvodina is reflected in the existence of a number of city centers, which generally function as independent urban systems. By comparing the results of the rank-size rule method and the urban primacy index with the data from the tables in the appendix, we can observe a uniform spatial distribution of the largest cities, with a slight population dominance of Novi Sad. The value of urban primacy index of 0.94 confirms these claims.

In the spatial-urban structure of Vojvodina, Novi Sad stands out with its central position, as well as the strongest gravitational influence zone (Figure 3). The values of the index of functional centrality confirm the functional dominance of Novi Sad in the urban hierarchy of Vojvodina region.

The functional influence of Novi Sad on the surrounding territory is so dominant, that this is the only city whose functional effects influence the increase of the index of functional centrality in the settlements of its suburban zone (see Figure 3). The values of this index for the other seven cities indicate that they do not have sufficient functional capacity to affect a wider area of their gravitational influence. This is particularly related to the cities of Sombor, Vršac, Sremska Mitrovica, and Kikinda (the last mentioned city has negative values of functional centrality index, as a consequence of the high share of primary and secondary activities in the economic structure).

In terms of the intensity of spatial relations represented by daily migrations, the zone in the quadrangle of Novi Sad–Zrenjanin–Pančevo–Belgrade clearly stands out, compared to the other areas in the region of Vojvodina (Figure 4). This part of the region is under the direct (simultaneous) functional influence of the four mentioned cities, and this is why, in the terms of the direction of daily migrations, we can talk about a certain type of functional polycentrism in this area. Although the City of Belgrade is not located within the boundaries of the Autonomous Province of Vojvodina, its functional capacity greatly influences spatial relations in this region (Filipović, 2020; Matijević, 2009). Previous researches (Filipović, 2020; Krnić 2012a; Matijević 2009) have proved the growing influence of Novi Sad and Belgrade in the functional structure of Vojvodina. Spreading of functional influence of these cities is expected in the following period, which will increase the regional development inequality between this and the other areas in Vojvodina region. Interpreting the obtained results, other parts of the regions will continue to develop in the same way as before: independently, under the functional influences generated by individual nodal centers.

In the five analyzed strategic documents (listed in chapter Methodology and data), the polycentricity is listed as a main model and a goal in the process of reducing regional development inequality. In this kind of prediction of the direction of regional development, the problem lies in the incomplete interpretation of the concept of polycentrism. None of the documents states which type of polycentricity is discussed in it (whether morphological or functional, which are analyzed in detail in this paper in the chapter Introduction). Morphological polycentricity is a static spatial category, derived from the internal characteristics of settlements (population number, number of employees, economic structure of population, etc.), and as such it cannot be the goal of regional development policies. On the contrary, morphological polycentricity is a reflection of the “geographical reality” of the region. The existence of morphological polycentricity, as it is presented in the region of Vojvodina, is a basic precondition for the development of functional polycentricity. Due to such insufficient terminological precision, the analysis of the defined and operational goals of strategic documents cannot answer whether these goals have actually already been realized (given the existence of morphological polycentricity in the region of Vojvodina), or have yet to be achieved (functional polycentricity)?

In order to achieve polycentricity, strategic documents especially emphasize the necessity to interconnect the already existing functional urban areas. According to the strategic documents, polycentricity will be achieved by networking of functional urban areas, which is also the basis for balanced regional development. In addition to the fact that the networking of functional urban areas is set as a goal of regional development, the strategic documents do not emphasize the ways in which this type of spatial integration can be achieved. The analysis of spatial relations, represented through the degrees of functional dependence of settlements, as well as the other analysis on a similar topic (Đerčan, 2014; Filipović, 2020; Krnić 2012a, 2012b; Nevenić, 2013) leads to the conclusion that networking of functional urban areas is one more difficult goal to achieve. Spatial-functional relations in Vojvodina, outside the quadrangle Novi Sad–Zrenjanin–Pančevo–Belgrade, is taking place within the spatially individualized functional urban region created around

the cities of Sombor, Subotica, Kikinda, Vršac, and Sremska Mitrovica. The distance between these cities is greater than the real possibility of their spatial-functional integration.

On the other side, there are areas in Vojvodina region that are outside the sphere of influence of one of the eight functional urban areas. These areas are predominantly agricultural and economically underdeveloped, without concrete steps towards the revitalization (area of eastern and southern Banat, as well as northern Banat and eastern Bačka-southwest of the line between Subotica and Kikinda). When it comes to reducing regional inequalities in Vojvodina region, strategic documents should pay much more attention to the socio-economic revitalization of these passive areas, instead of predicting objectively unattainable scenario of spatial networking the functional urban areas. In that sense, authors believe that in the process of the reduction of regional development disparities in Vojvodina, it is crucial to create a more favorable economic environment in the areas that are outside the influence zone of the functional urban areas. In that way, local gravity centers (centers of local importance in Figure 1) would get the roles of microdevelopmental nucleus and could influence the revitalization of their gravitational zone, as well as the spatial unification of socio-economic component of the development in the entire region.

Acknowledgements

This paper presents the results of research on project No. 176008, financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

References

- Adolphson, M. (2009). Estimating a Polycentric Urban Structure. Case Study: Urban Changes in the Stockholm Region 1991–2004. *Journal of Urban Planning and Development*, 135(1), 19–30. [https://doi.org/10.1061/\(ASCE\)0733-9488\(2009\)135:1\(19\)](https://doi.org/10.1061/(ASCE)0733-9488(2009)135:1(19))
- Aydan, N. S. (2018). Monocentric or polycentric? Defining morphological structure of NUTS-2 regions of Turkey from 2000 to 2016. *Geographica Pannonica*, 22(1), 1–13. <https://doi.org/10.5937/gp22-15726>
- Bański, J., & Czapiewski, K. (2015). A Vision of the Polycentric Development of the Mazovia Region in Poland. *Geographical Journal*, 67(4), 301–321. Retrieved from https://www.igipz.pan.pl/tl_files/igipz/ZGWIRL/Banski/Banski_Czapiewski_GC.pdf
- Boussauw, K., Van Meeteren, M., Sansen, J., Meijers, E., Storme, T., Louw, E., . . . Witlox, F. (2018). Planning for agglomeration economies in a polycentric region: Envisioning an efficient metropolitan core area in Flanders. *European Journal of Spatial Development*, 69, 1–26. <http://doi.org/10.30689/EJSD2018:69.1650-9544>
- Burger, M. J., de Goei, B., van der Laan, L., & Huisman, F. J. M. (2011). Heterogeneous development of metropolitan spatial structure: Evidence from commuting patterns in English and Welsh city-regions, 1981–2001. *Cities*, 28(2), 160–170. <https://doi.org/10.1016/j.cities.2010.11.006>
- Burger, M., & Meijers, E. (2012). Form Follows Function? Linking Morphological and Functional Polycentricity. *Urban Studies*, 49(5), 1127–1149. <https://doi.org/10.1177/0042098011407095>
- Burger, M. J., van der Knaap, B., & Wall, R. S. (2014). Polycentricity and the Multiplexity of Urban Networks. *European Planning Studies*, 22(4), 816–840. <http://dx.doi.org/10.1080/09654313.2013.771619>
- Ćurčić, S. (1985). Proces sekundarne urbanizacije u Vojvodini [The process of secondary urbanization in Vojvodina]. *Research Review of the Department of Geography, Tourism and Hotel Management*, 15, 103–116.
- De Goei, B., Burger, M. J., Van Oort, F. G., & Kitson, M. (2010). Functional Polycentrism and Urban Network Development in the Greater South East, United Kingdom: Evidence from Commuting Patterns, 1981–2001. *Regional Studies*, 44(9), 1149–1170. <https://doi.org/10.1080/00343400903365102>
- Đerčan, B. (2014). *Sistem naselja u Sremu* [System of the settlements in Srem]. (Doctoral dissertation). Retrieved from <https://nardus.mpn.gov.rs/bitstream/handle/123456789/1735/Disertacija.pdf?sequence=5&isAllowed=y>

- Derčan, B., Radaković, M., Ostojić, M., Mirković, M., Obrenov, S., & Vozar, J. (2017). Urban hierarchy in Serbia. *Research Reviews of the Department of Geography, Tourism and Hotel Management*, 46(1), 11–24. <https://doi.org/10.5937/ZbDght1701012D>
- Filipović, M. (2020). *Dnevni migracioni sistem Beograda* [Daily migration system of Belgrade] (Unpublished doctoral dissertation). Faculty of Geography, University of Belgrade, Belgrade.
- Giffinger, R., & Suitner, J. (2015). Polycentric Metropolitan Development: From Structural Assessment to Processual Dimensions. *European Planning Studies*, 23(6), 1169–1186. <https://doi.org/10.1080/09654313.2014.905007>
- González-González, E., & Nogués, S. (2016). Regional polycentricity: an indicator framework for assessing cohesion impacts of railway infrastructures. *European Planning Studies*, 24(5), 950–973. <https://doi.org/10.1080/09654313.2016.1142506>
- Hanssens, H., Derudder, B., Van Aelst, S., & Witlox, F. (2013). Assessing Functional Polycentricity of the Mega-City-Region of Central Belgium Based on Advanced Producer Service Transaction Links. *Regional Studies*, 48(12), 1939–1953. <https://doi.org/10.1080/00343404.2012.759650>
- Karlsson, C., & Olsson, M. (2006). The identification of functional regions: theory, methods, and applications. *The Annals of Regional Science*, 40, 1–18. <https://doi.org/10.1007/s00168-005-0019-5>
- Konjar, M., Liseč, A., & Drobne, S. (2010). Methods for delineation of functional regions using data on commuters. In M. Painho, M. Yasmina Santos, & H. Pundt (Eds.), *13th AGILE International Conference on Geographic Information Science* (pp. 1–10). Retrieved from http://agile2010.dsi.uminho.pt/pen/ShortPapers_PDF/93_DOC.pdf
- Krunić, N. (2012a). *Prostorno funkcijski odnosi i veze u mreži naselja Vojvodine* [Spatial-functional relations and links in the network of settlements of Vojvodina] (Unpublished doctoral dissertation). Faculty of Geography, University of Belgrade, Belgrade.
- Krunić, N. (2012b). Spatial-functional organization of settlements in Vojvodina. *Spatium*, 28, 23–29. <https://doi.org/10.2298/SPAT1228023K>
- Lazarević, E. V., Ivanović, M., Ristić, D., Marjanović, M., & Miličević, M. (2020). Small Urban Centres as Drivers of Daily Migrations and Agents of Transformation of Rural Hinterland: Example of Blace Municipality. In A. Krstić-Furundžić & A. Djukić (Eds.), *Handbook of Research on Urban-Rural Synergy Development Through Housing, Landscape, and Tourism* (pp. 71–93). Hershey, PA: IGI Global.
- Matijević, D. (2009). *Prostorno-funkcionalna povezanost naselja opštine Stara Pazova sa urbanim sistemom Beograda* [Spatial-functional connection of the settlement of the municipality of Stara Pazova with the urban system of Belgrade]. Belgrade, Serbia: Geographical Institute "Jovan Cvijić" SASA.
- Meijers, E. (2008). Measuring polycentricity and its promises. *European Planning Studies*, 16(9), 1313–1323. <https://doi.org/10.1080/09654310802401805>
- Meijers, E. J., & Burger, M. J. (2010). Spatial Structure and Productivity in US Metropolitan Areas. *Environment and Planning A: Economy and Space*, 42(6), 1383–1402. <https://doi.org/10.1068/a42151>
- Milošević, Z. (2016). *Nodalni centri – determinanta održivog razvoja sistema naselja Zlatiborskog okruga* [The nodal centres – determinant of sustainable development of system settlement of the Zlatibor district] (Doctoral dissertation). Retrieved from <https://nardus.mpn.gov.rs/handle/123456789/6574?show=full>
- Nevenić, M. (2013). *Funkcionalno urbani region instrument policentričnog prostornog razvoja Srbije* [Functional urban region the instrument of polycentric spatial development of Serbia] (Doctoral dissertation). Retrieved from <https://nardus.mpn.gov.rs/handle/123456789/5346>
- Official Gazette of the Republic of Serbia. (2010). *Zakon o prostornom planu Republike Srbije od 2010. do 2020. godine* [The law on the spatial plan of the Republic of Serbia from 2010 to 2020]. Retrieved from <https://www.mgsi.gov.rs/sites/default/files/ZAKON%20O%20PROSTORNOM%20PLANU%20RS%20OD%2010%20DO%202020.pdf>
- Official Gazette of the Republic of Serbia. (2019). *Strategija održivog urbanog razvoja Republike Srbije, do 2030. godine* [Sustainable urban development Strategy of the Republic of Serbia until 2030.]. Retrieved from <https://www.mgsi.gov.rs/cir/dokumenti/urbani-razvoj>
- Olsson, M. (2016). Functional regions in gravity models and accessibility measures. *Moravian Geographical Reports*, 24(2), 60–70. <https://doi.org/10.1515/mgr-2016-0011>
- Parr, J. (2004). The Polycentric Urban Region: A Closer Inspection. *Regional Studies*, 38(3), 231–240. <https://doi.org/10.1080/003434042000211114>

- Pokrajinski sekretarijat za urbanizam, graditeljstvo i zaštitu životne sredine. (2011). *Regionalni prostorni plan Autonomne Pokrajine Vojvodine* [Regional spatial plan of Autonomous Province of Vojvodina]. Retrieved from https://www.zavurbvo.co.rs/images/planovi/rppapv/RPP_APV-za_Web.pdf
- Rauhut, D. (2017). Polycentricity – One concept or many? *European Planning Studies*, 25(2), 332–348. <https://doi.org/10.1080/09654313.2016.1276157>
- Salvati, L., Ferrara, A., & Chelli, F. (2018). Long-term growth and metropolitan spatial structures: an analysis of factors influencing urban patch size under different economic cycles. *Geografisk Tidsskrift-Danish Journal of Geography*, 118(1), 56–71. <https://doi.org/10.1080/00167223.2017.1386582>
- Schmook, G. (1968). Wiskundig afgebakene ommelanden en hinterlanden van de Belgische steden op de basis van geselectioneerde diensten uit de tertiare sector. *Periodical K.N.A.G. (Koninklijk Nederlands Aardrijkskundig Genootschap), Geografisch Tijdschrift, Nieuwe Reeks*, Deel II, Nr.4.
- Sinclair-Smith, K. (2015). Polycentric development in the Cape Town city-region: Empirical assessment and consideration of spatial policy implications. *Development Southern Africa*, 32(2), 131–150. <https://doi.org/10.1080/0376835X.2014.984378>
- Statistical Office of the Republic of Serbia. (2013). *2011 Census of Population, Households and Dwellings in the Republic of Serbia: Book 11. Daily Migrants: Data by municipalities/cities*. Retrieved from <https://publikacije.stat.gov.rs/G2013/Pdf/G20134016.pdf>
- Statistical Office of the Republic of Serbia. (2014a). *2011 Census of Population, Households and Dwellings in the Republic of Serbia: Book 20. Comparative overview of the number of population in 1948, 1953, 1961, 1971, 1981, 1991, 2002 and 2011: Data by settlements*. Retrieved from <https://pod2.stat.gov.rs/ObjavljenePublikacije/Popis2011/Knjiga20.pdf>
- Statistical Office of the Republic of Serbia. (2014b). *2011 Census of Population, Households and Dwellings in the Republic of Serbia: Book 15. Industry: Data by municipalities and cities*. Retrieved from <https://publikacije.stat.gov.rs/G2014/Pdf/G20144002.pdf>
- Statistical Office of the Republic of Serbia. (2017). *2011 Census of Population, Households and Dwellings in the Republic of Serbia: Economically active population that perform occupation, at the settlement level* [Unpublished raw data].
- Statistical Office of the Republic of Serbia. (2018). *2011 Census of Population, Households and Dwellings in the Republic of Serbia: Daily migrations of the active population* [Unpublished raw data].
- Tošić, D. (1999). *Prostorno-funkcijski odnosi i veze u nodalnoj regiji Užica* [Spatial-functional relations in nodal region of Užice] (Unpublished doctoral dissertation). Faculty of Geography, University of Belgrade, Belgrade.
- van Oort, F., Burger, M., & Raspe, O. (2010). On the Economic Foundation of the Urban Network Paradigm. Spatial Integration, Functional Integration and Complementarities within the Dutch Randstad. *Urban Studies*, 47(4), 725–748. <https://doi.org/10.1177/0042098009352362>
- Vasanen, A. (2013). Spatial Integration and Functional Balance in Polycentric Urban Systems: A Multi-Scalar Approach. *Tijdschrift voor Economische en Sociale Geografie*, 104, 410–425. <https://doi.org/10.1111/tesg.12029>
- Vlada Republike Srbije, Ministarstvo životne sredine i prostornog planiranja. (2009). *Strategija prostornog razvoja Republike Srbije: 2009 - 2013 - 2020* [Spatial Development Strategy of the Republic of Serbia: 2009 - 2013 - 2020]. Retrieved from http://www.apps.org.rs/wp-content/uploads/strategije/Strategija_PROSTORNI%20RAZVOJ%20Republike%20Srbije.pdf
- Vlada Republike Srbije, Ministarstvo građevinarstva, saobraćaja i infrastrukture. (2020). *Prostorni plan Republike Srbije od 2021. do 2035. godine* [Spatial Plan of the Republic of Serbia for 2021–2035]. Retrieved from <https://www.mgsi.gov.rs/lat/dokumenti/rani-javni-uid-povodom-izrade-prostornog-plana-republike-srbije-od-2021-do-2035-godine>
- Zipf, G. K. (1949). *Human Behavior and the Principle of Least Effort: An Introduction to Human Ecology*. Cambridge, UK: Addison-Wesley Press.
- Živanović, Z., Tošić, B., Nikolić, T., & Gatarić, D. (2019). Urban System in Serbia – The Factor in the Planning of Balanced Regional Development. *Sustainability*, 11(15), 4168. <https://doi.org/10.3390/su11154168>