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FUNCTIONAL DEPENDENCE OF SETTLEMENTS AND ITS DEMOGRAPHIC COMPONENT IN THE TRANSITION PHASE OF THE DAILY URBAN SYSTEM

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Abstract: The transition period of post-socialist cities brought significant demographic and spatial changes within their daily urban systems (DUS). Functional transformations of the core, as well as functionally dependent settlements in the mentioned systems, had a significant impact on the daily mobility of the population. For the purposes of this paper, the example of Belgrade was taken as the core of the most significant DUS on the territory of Serbia, and beyond its borders. As a research time frame the focus is on the first intercensal period of the 21st century, taking into account social and economic changes in that period. The daily mobility of the labor force was used as a relevant indicator of the functional manifestation of the work center and the functional direction of the residential settlement. A model of the spatial manifestation of the workforce daily mobility was used as a basis for researching the structure, changes, and determining the boundaries of the territorial scope of the DUS. Based on the presented results, dynamic changes within the DUS of Belgrade were determined, which are manifested through an increase in its spatial and population coverage, as well as through the changes in the degree of functional dependence of the settlements that participate in it. Conclusions were drawn on the connection between the transformation of the DUS and its demographic component, as well as the factors that initiate the investigated changes.

Keywords: daily urban system; transition; functional dependence; labor force; demographic component

1. Introduction

The transition of society in general as well as the spatial-demographic and socio-economic transformation of post-socialist cities, also led to changes in the system of settlements, the cores of which were represented by these cities. At the very end of the 20th century, the countries of Central and Eastern Europe (CEE) were faced with the process of transition from a centrally planned economy toward a market economy and the integration with the European Union (EU). Both processes affected the polarization and geographically differentiated the pattern of regional development in favour of metropolitan areas (Gorzelać, 2020; Miletić, 2022; Zeković, 2008). The concentration of population and activities is mainly based in large cities and

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their surroundings, with the capital city often standing out among them. The strategic importance of the knowledge-based economy, innovation, and the information technology sector goes together with the relatively successful post-socialist urban and economic transformation (Kopáček et al., 2021; Malý & Krejčí, 2022). Tertiariation, the relocation of large industrial plants outside the boundaries of urban cores, the shutdown of unprofitable ones, and the formation of new poles of economic activity concentration, significantly influenced the change in the scope and direction of the population daily mobility.

Daily migrations (commuting) represent population as well as cultural and socio-economic connections between the residence area and the work area of daily migrants (commuters), with many causes and consequences on both areas. Taking into account that the process of commuting, especially of the labor population, is tightly connected with demographic and economic development, traffic, settlements, as well as the labor market development, and the real estate market, it has broad implications in all the spheres of life and work, both for the population of residential areas and the population of work areas (Lukić, 2008). Work-commuting flows provide the possibility, which did not exist in the past, to live at a notable distance from the place of work. One of the most important determinants is the size of the city, so in the largest agglomerations impacts are felt over long distances through this form of population mobility. At the same time, a significant population flow is created in the city itself as well as in its surroundings (Aguilera Arilla et al., 2010).

The daily urban system (DUS) is made up of commuters and a regional entity that encompasses the space that unites the origins of daily mobility of the population. They are dynamic, diversified, and unique forms of manifestation of relations and connections between urban settlements and local or regional environments, which are the product of specific demographic, geographical, economic, and social conditions (Tošić, 2012). The development of DUSs (in which they have become synonymous with local urban labor markets) is correlated with the increased mobility of the population and the determination of employees to live outside the urban core where the functions of the labor market remain (van der Laan, 1998). The size of a DUS can vary in different geographical contexts depending on the transport infrastructure, the historical formation of the settlement network, the mobility of the population, etc. They represent theoretically clearly defined functional entities based on everyday relationships and daily routines (Malý & Krejčí, 2022). The DUS is used as a relevant analytical and planning framework, especially in the case of the urban environment (de Graaf, 2019; Kunc et al., 2012).

The two main types of DUSs manifestation are monocentric systems consisting of one center and a field of influence and polycentric systems made up of several, usually hierarchically graded centers and their surroundings. Polycentricity represents a predisposition to reduce the time required for commuting, which should lead to greater efficiency in the functioning of the urban system (Clark & Kuipers-Linde, 1994; Tošić, 2012). The second half of the 20th century is considered to be the key period of more intensive introduction of quantitative methods in the analysis of urban regions. Quantitative methods are primarily related to the degree and processes of population and employee concentration, the functional structure of the center and periphery, population density and commuting which are the most relevant indicators for distinguishing urban regions (Gajić et al., 2018; Živanović et al., 2020). Geographical disciplines are increasingly faced with the challenge of managing the complexity of DUSs. The conclusion from numerous studies is that the motive of work plays a dominant role in the structure and strength of the DUS and that its importance goes far beyond the majority share in the absolute number of trips between settlements (de Graaf, 2019).

EU planning documents, at the macro level, set polycentricity as the main tool of balanced spatial development and the task of the integrated spatial development strategy in overcoming regional disparities (European Commission, 1999; Territorial Agenda, 2020). On the other hand, the planning practice at the metropolitan level is experiencing significant changes in understanding the concept of polycentricity and importance of the scale of DUSs. From a planning and policy perspective, a DUS is a platform on which the positive effects of polycentric systems should be generated in order to become a fully developed polycentric urban region (Malý & Krejčí, 2022; Parr, 2004).

2. Specificities of spatial coverage

The City of Belgrade is a special territorial unit established by the Constitution of the Republic of Serbia (Ustav Republike Srbije, 98/2006) and the Law on Territorial Organization of the Republic of Serbia (Zakon o teritorijalnoj organizaciji Republike Srbije, 129/2007, 18/2016, 47/2018, 9/2020). The specificity of the City of Belgrade as a separate territorial unit is that it is simultaneously a local self-government unit, a NUTS 2 region, and a NUTS 3 area in the same administrative-territorial framework.

The City of Belgrade area (Figure 1) with 17 city municipalities and 157 settlements is divided into three units with different demographic, physiognomic, and functional features (Spalević, 2013). These are the urban core, i.e., the Belgrade settlement (389.1 km²), the peri-urban belt (641.3 km²), and the suburban belt (2,204.5 km²). The core includes the entire territory of six city municipalities (Vračar, Zvezdara, Novi Beograd, Rakovica, Savski Venac, and Stari Grad) and part of four city municipalities (Voždovac, Zemun, Palilula, and Čukarica) with 1,166,763 inhabitants according to the 2011 Census. The peri-urban belt consists of the immediate surroundings of the core with the remaining 19 rural-urban settlements from the aforementioned four city municipalities and 133,232 inhabitants. The suburban area is represented by the territory of seven city municipalities (Barajevo, Grocka, Lazarevac, Mladenovac, Obrenovac, and Sopot) where, according to the same source, 359,445 inhabitants lived (Statistical Office of the Republic of Serbia [SORS], n.d.).

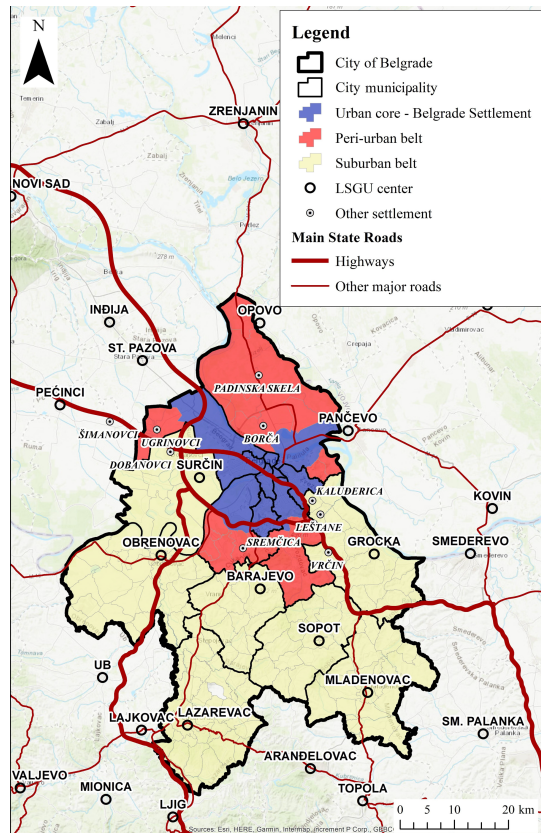


Figure 1. City of Belgrade—territorial units, local self-government units (LSGU) centers, and important settlements.

In the influential sphere of Belgrade, there are cities/municipalities (LSGU) in the immediate vicinity of the administrative territory of the city, in the outer ring (Figure 1), with which they have intensive functional connections: Pančevo, Smederevo, Pećinci, Ruma, Stara Pazova, Smederevska Palanka, Lajkovac, and others (Filipović, 2020; Ilić, 1970; Matijević, 2009; Miletić & Drobnjaković, 2015; Nevenić, 2013). The period of transition affected the mentioned municipalities in different ways and therefore influenced the trends within the system. While negative trends prevailed in one group of municipalities (primarily oriented toward industry), new development poles were formed on the other's territory. In the spatial-functional organization of Serbia, a belt of the most intensive development is distinguished—a unique functional region formed by the influential spheres of the City of Belgrade and the City of Novi Sad, of exceptional importance for the positioning of this entirety and Serbia in the interregional framework (Zakon o Prostornom planu Republike Srbije od 2010. do 2020. godine, 88/2010). On the whole, the territory covered by the DUS of Belgrade can be considered as a noticeable population concentration. For other parts of Serbia, depopulation trends that have been going on for many years are characteristic, while there are positive changes in the observed territory. Between 2002 and 2011, the number of inhabitants of all system settlements, together with the core, increased by more than 60,000 (Filipović et al., 2022).

The Belgrade area is a space with the most suitable conditions for creating a large agglomeration of population and activities, for connecting and unifying the network of cities and settlements over a larger area (Veljković et al., 1995) due to the favorable geographical and traffic location; benefits of natural potentials for different forms of land use; and the contact position between the areas of different economic-geographic entities. Therefore, the great gravitational influence and reach of the Belgrade agglomeration as a complex and dynamic system of urban settlements exceeds national borders (Tošić & Krunić, 2005).

Economic structure transformation at the end of the 20th century, both on the territory of Serbia as well as in Belgrade, was initiated primarily by non-economic factors (Vojković et al., 2010). Deindustrialization, expressed through the reduction of employment and decline in production activity, is a consequence of the multi-year economic blockade and impaired business conditions. At the beginning of the 21st century, a decade later than the countries of CEE, Serbia is entering a period of intensive transitional reforms of a different character (political, economic, sociological, ecological, etc.), but the starting points in all aspects of socio-economic and spatial system in Serbia, and thus in Belgrade, was different compared to other post-socialist countries (Miletić et al., 2009). The destruction of the production sector that began in the last decade of the 20th century was additionally emphasized by the recession of production, the industry spatial structure transformation, the collapse of former large economic systems, the continuous trend of decreasing employment, and increasingly pronounced social differences (Grčić & Ratkaj, 2006). In the mentioned period, the role of Belgrade in the international framework was significantly reduced due to unfavorable political and economic circumstances. Within Serbia, it maintained the continuity of development as a demographic, economic, and spatial development pole, following the pattern of changes like other capitals of post-socialist EU member states. A favorable combination of development factors and positive reactions to reform processes marked the metropolises as leaders in the transition process (Gorzela, 1998; Slaev et al., 2018; Zeković, 2008). Bearing in mind all of the above, especially the growing importance of Belgrade in the geosystem of Serbia, the growth of its DUS was expected. In addition, changes in the territorial distribution of economic activities, i.e., the reduce of the old working centers and the formation of new concentration poles, influenced changes in the direction and extent of the daily mobility of the population.

3. Methodology and data

As a basis for this research, a model of the spatial manifestation of daily labor force mobility was used (Tošić, 1999). When defining it, the author did not intend to give a universal model of DUSs, but he believed that its application can contribute to the induction of relevant theoretical assumptions for the delimitation of urban systems in Serbia (Tošić & Nevenić, 2007). Through numerous scientific and professional research, this has been proven and applied in the majority of settlements in Serbia (Drobnjaković et al., 2014; Filipović, 2020; Filipović et al., 2013; Krunić et al., 2009, 2011; Regionalni prostorni plan opština Južnog Pomoravlja, 83/2010; Regionalni prostorni plan Timočke krajine (Borski i Zaječarski okrug), 51/2011; Regionalni prostorni plan za područje Kolubarskog i Mačvanskog upravnog okruga, 11/2015; Regionalni prostorni plan za područje Zlatiborskog i Moravičkog upravnog okruga, 1/2013; Tošić et al., 2009; Živanović et al., 2021, and other). It is based on research into the spatial manifestation of daily mobility and its impact on the socioeconomic transformation of the city region and its regional system, so that, in addition to the demographic, it also has functional and spatial components, unlike previously used models (Krunić, 2012a). The author himself suggested supplementing the model with indicators of daily mobility of population based on central functions, in order to increase the degree of precision in determining the territorial scope of DUSs and in determining spatial-functional connections and relationships in them (Tošić, 2012). Based on that, the model was also applied in a modified form, on different territorial scopes and with added structural components (Filipović, 2020).

Previous experiences during the basic components of DUSs (demographic, spatial, and functional) research (Krunić, 2012a, 2012b; Tošić, 1999, 2012, and other) have shown that, for the development of models of their manifestation and duration, the most relevant indicators are the layout and functional direction of work centers and residential areas, as well as the number and structures of commuters. The facts on which the basic hypothesis in the formation of the model is based also highlighted that:

- the intensity and directions of daily mobility, on the one hand, and the spatial distribution of settlements of commuters origin and destination, on the other, give the possibility to determine borders, i.e., spatial coverage of DUSs;
- the areas of functional influence of the city center are determined by gathering and integrating the territories of settlements with similar migration characteristics; and
- the DUS internal differentiation is based on the intensity of daily mobility.

According to the basic model, by processing matrix-structured statistical data, seven indicators of demographic components of the spatial-functional expression of DUSs model are generated. Of these, four represent directly obtained or derived demographic indicators from the population census, while the remaining three indicators show the relations of the mentioned indicators in order to define the functional dependence and orientation of settlements. The basic ones are: live and work—shows the number of active residents who perform an occupation in the place of residence; number of workers—shows the total number of settlement workers, which represents the sum of the number of active residents who perform occupations at the place of residence and active residents who perform occupations outside the place of residence; the number of commuters—shows the total number of employed residents of the settlement, who perform occupations outside the place of permanent residence; number of commuters to the work center—shows the number of active residents of the settlement, who come to perform their occupation in the observed work center. The focus of this research is on the changes in the mentioned relations, therefore, it is necessary to single them out and present them separately.

The general functional dependence of the settlement represents the ratio of the daily emigrants number to the settlement workers total number. This relation is an indicator of the centrality of the work function, that is, its dependence on other work centers. It can be mathematically represented by Equation (1):

$$\text{GFD} = C_t / W_t * 100 \quad (1)$$

where GFD is the general functional dependence of the settlement, C_t is the total number of employed commuters from the settlement, and W_t is the total number of workers from the settlement.

The functional orientation of the settlement represents the ratio of the number of commuters from the settlement in the work center to the total number of commuters from the settlement. It is an indicator of functional orientation toward a specific work center and as such can be represented by Equation (2):

$$\text{FO} = C_c / C_t * 100 \quad (2)$$

where FO is the functional orientation of the settlement, C_c is the number of commuters from the settlement in a certain work center, and C_t is the total number of employed commuters from the settlement.

Functional dependence on a specific work center represents the ratio of the number of commuters who travel to the observed work center and the total number of settlement workers. This relation is an indicator of functional dependence on the center of work (Equation 3).

$$\text{FDC} = C_c / W_t * 100 \quad (3)$$

where FDC is the functional dependence of the settlement on the center of work, C_c is the number of commuters from the settlement in the center of work, and W_t is the total number of workers from the settlement. This relation is also the basic indicator on which the model is based, defining the boundaries of the DUS, as well as the zones of different influence within the system itself.

Based on the grouping of settlements with a similar volume of daily labor mobility, the fields of influence of the labor centers are distinguished. Based on the intensity of daily interaction, within the field, Tošić (1999) differentiated the following zones:

- Zone of intense influence, where more than 70% of employees commute daily to the center;
- Zone of strong influence, where 50–70% of employees commute daily to the center;
- Zone of medium influence, where 30–50% of employees commute daily to the center;
- Zone of weaker influence where less than 30% of employees commute daily to the center.

Most often, they are connected to the zones of higher influence, or they are enclaves within them and do not have to be connected to each other. Three subgroups are distinguished within this category:

- settlements where 20–30% of employees commute daily to the center;
- settlements where 10–20% of employees commute daily to the center;

- settlements where 5–10% of employees commute daily to the center.
- The periphery of the DUS where less than 5% of employees commute daily to the center.

These categorized values of the share of commuters, who travel to the work center every day in the total number of workers, according to their place of residence, are qualified by the appropriate name that suggests their dependence on the function of work (Table 1).

Table 1. Degree of functional dependence on the work center

Commuters (%)	Work centers area of influence	Degree of the settlement functional dependence
70–100	Zone of intense influence	Totally dependent
50–70	Zone of strong influence	Extremely highly dependent
30–50	Zone of medium influence	Highly dependent
20–30		Medium dependent
10–20	Zone of lower influence	Low dependent
5–10		Extremely low dependent
0–5	Periphery of the DUS	Independently

Note. Adapted from *Prostorno funkcijski odnosi i veze u mreži naselja Vojvodine* [Spatial-functional relations and links in the network of settlements of Vojvodina; Unpublished doctoral dissertation] (pp. 216–217), by N. Krunić, 2012a. University of Belgrade, Faculty of Geography.

From the beginning, research on commuting on the territory of Serbia has been characterized by numerous methodological problems and limitations (Lukić, 2008, 2011; Stamenković, 1996). Due to the limitations in the availability of data on daily mobility at the settlement level, a special processing of the SORS (n.d.) was used as the main source of data. Due to the specificity of the period and changes in the first decade of the 21st century, data from the 2002 and 2011 Census were used and their changes were analyzed. Taking into account the purpose and basic principles of the model, as well as the precision of the available data, only the data on the daily mobility of the employed population were analyzed.

4. Results

Belgrade, as the largest urban settlement in Serbia, represents the backbone of the development of both its region and its surroundings, and is the most significant factor in the spatial transformation. The basic element of the attractiveness of Belgrade is the degree of daily mobility of the other settlements' active population that have the settlement of Belgrade as their final destination. Based on that, DUS which has the Belgrade settlement as its work center was analyzed.

According to the 2002 data, 88,448 workers migrated daily to Belgrade, as the core of DUS (Figure 2A). That number made up 18.8% of the total number of employed persons on the territory of the city core. The workers came from a total of 351 settlements, which represented an average of 252 commuters per settlement.

In 2002, the zone of intensive influence of Belgrade DUS consisted of 13 settlements from which 32,750 commuters came. On average, 2,519 active residents working in this group came from one settlement. Of the total number of settlements, 3.7% were completely dependent, and the share of workers coming from them in the total number was 37%.

In 2002, from 28 settlements of the zone of strong influence, 24,711 active residents migrated daily to Belgrade. On average, 883 commuters came from one settlement. These extremely dependent settlements represented 8% of the total number, and 27.9% of the total number of commuters came from them.

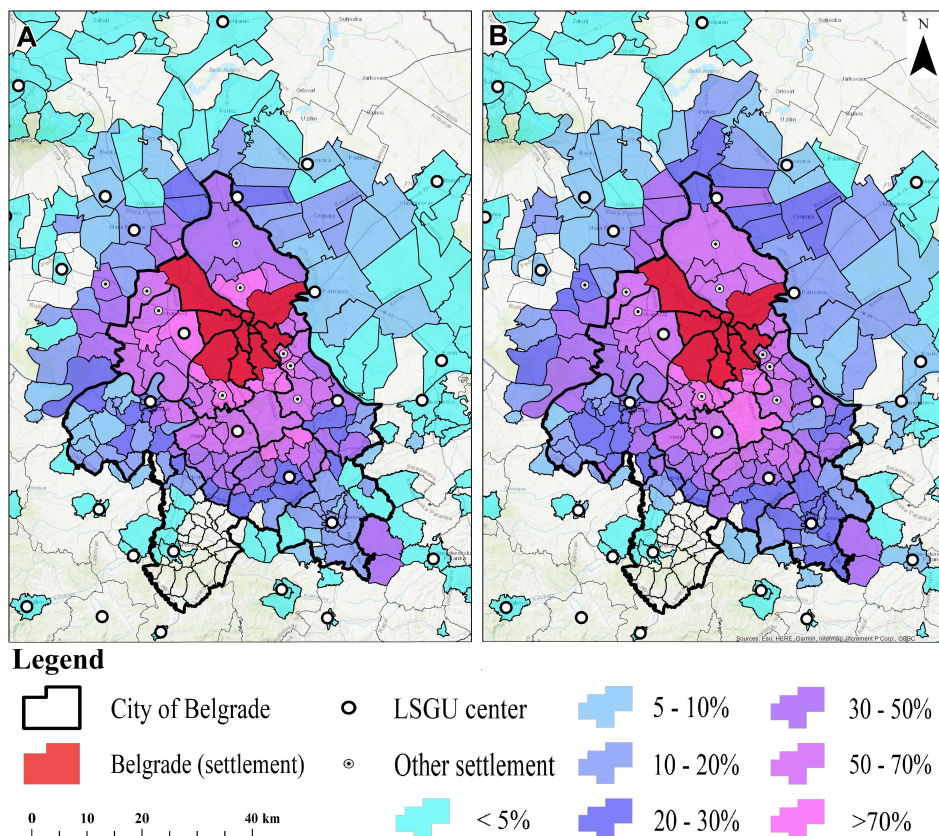


Figure 2. Daily urban system of Belgrade in 2002 (A) and 2011 (B).

Note. Data in figure are calculated based on *Dnevni migracioni sistem Beograda* [Daily migration system of Belgrade; Unpublished doctoral dissertation] (pp. 107–109), by M. Filipović, 2020. University of Belgrade, Faculty of Geography.

The zone of medium influence was represented by 29 settlements from which 10,733 workers came. An average of 370 active residents who perform an occupation, per settlement, migrated to Belgrade daily. Highly dependent settlements accounted for 8.3% of the total number, and 12.1% of all commuters came from them.

In total, the zones of lower influence consisted of 94 settlements with 15,736 active residents who worked in Belgrade (Medium dependent: average per settlement 237 commuters, 6.8% of the total number of settlements, 6.4% of all commuters; Low dependent: average 122 commuters, 11.4% of settlements, 5.5% of commuters; Extremely low dependent: average 173 commuters, 8.5% of settlements, 5.9% of commuters).

The periphery of the system in 2002 consisted of 187 settlements, from which 4,518 commuters came. On average, 24 active residents from one settlement in the periphery were employed in Belgrade. This group made up 53.3% of the total number of settlements, and the share of commuters coming from them in the total number was 5.1%.

According to 2011 data, 107,879 workers migrated to Belgrade daily, which accounted for 20.8% of the total number of employed persons on the territory of the settlement (Figure 2B). The DUS of Belgrade was represented by 358 settlements, and according to one of them, the average number of commuters was 301.

The zone of intensive influence of the Belgrade DUS consisted of seven settlements with 12,302 commuters who worked on the territory of the city core. The average of 1,757 active residents of those settlements migrated to Belgrade per day. Fully dependent settlements accounted for 2% of the total number, and 11.4% of the total number of commuters came from them.

In 2011, the zone of strong influence spread over 34 settlements, from which 46,241 inhabitants worked on the territory of Belgrade. On average, 1,360 workers migrated from one settlement of the zone of strong impact per day. Settlements of this group, that is, extremely dependent ones, represented 9.5% of the all DUS settlements, and the share of commuters coming from them amounted to 42.9% of the total number.

The total of 11,861 active residents who worked on the territory of Belgrade migrated daily from the zone of medium influence. This group consisted of 40 settlements, and on average, from one of them, 297 workers came to Belgrade. The share of highly dependent settlements in the total number was 11.2%, and 11% of all migrants came from them.

In 2011, the zones of weaker influence were spread over a total of 130 settlements, from which 22,707 active residents who perform occupations migrated to Belgrade daily (Medium dependent: average per settlement 299 commuters, 11.2% of the total number of settlements, 8.5% of all commuters; Low dependent: average 211 commuters, 11.5% of settlements, 8% of commuters; Extremely low dependent: average 100 commuters, 13.7% of settlements, 4.5% of commuters).

A total of 147 settlements formed the periphery of the Belgrade DUS in 2011 and 14,768 commuters came from that area. This set of independent settlements represented 41.1% of the total number, and the share of commuters coming from them was 13.7% of the total number.

Changes in the Belgrade DUS are characterized by an increase in the number of commuters as well as in donor settlements. The number of residents who worked on the territory of the Belgrade settlement, but lived in another settlement, in the observed period increased by 19,431 or 22% (Table 2). The share of these migrants in the total number of employed persons on the territory of the core increased by 2%, while the average number of commuters per settlement increased by 49.

Table 2. Changes in the daily urban system of Belgrade 2002–2011

Commuters (%)	Index of change in the number of commuters	Change in the number of commuters	Change in the number of migrant donors settlements	Change in the average number of migrants per settlement
70–100	37.6	–20.448	–6	–762
50–70	187.1	21.530	6	477
30–50	110.5	1.128	11	–74
20–30	161.1	3.467	16	–8
10–20	177.9	3.793	1	90
5–10	94.4	–289	19	–73
0–5	326.9	10.250	–40	76
Total	122.0	19.431	7	49

Note. Data in table are calculated based on *Dnevni migracioni sistem Beograda* [Daily migration system of Belgrade; Unpublished doctoral dissertation] (pp. 110), by M. Filipović, 2020. University of Belgrade, Faculty of Geography.

The most significant changes within the DUS of Belgrade were recorded in the zone of intensive and the zone of strong influence. The number of commuters who came from the zone of intense influence decreased in the observed period by 20,448 or 62.4%. This zone consisted of six fewer settlements, while the average number of migrants coming from one of them decreased by 762. On the other hand, the number of commuters coming from the strongly affected zone increased by 21,530, i.e., 87.1%. The zone consisted of six more settlements than in 2002, and the average number of migrants increased by 477. It was these two zones that replaced as the most influential zones in the system. While 37% of all commuters came from settlements in the zone of intense influence in 2002, that share decreased to 11.4% in 2011. On the other hand, the share of commuters from settlements in the zone of strong influence increased from 27.9% in 2002 to 42.9% in 2011, making it the most influential zone in the DUS.

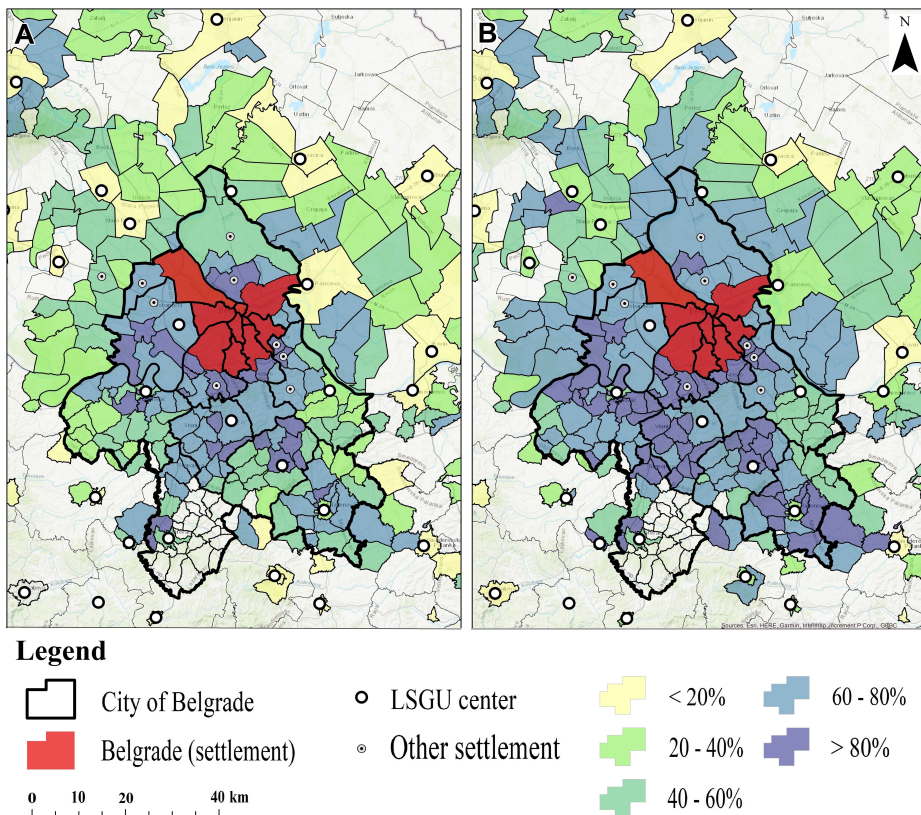


Figure 3. Settlements of the DUS of Belgrade according to general functional dependence in 2002 (A) and 2011 (B).

Between 2002 and 2011, the settlements of the Belgrade DUS, according to general functional dependence, experienced an intensive transformation (Figure 3). The share of settlements with a higher degree of functional dependence increased significantly, while the share of less functionally

dependent settlements decreased with the same intensity. The biggest change was observed in the category of settlements with over 80% of commuters in the working contingent of residents, whose number increased by 41 in the mentioned period, and also in the second group a significant increase was observed with 26 settlements more than in 2002 (Table 3).

Table 3. Settlements of the Belgrade DUS according to general functional dependence 2002–2011

%	2002		2011		Change in the number of settlements	Index of change
	Number of settlements	% of the total settlements number	Number of settlements	% of the total settlements number		
80–100	29	8.1	70	19.6	41	241.4
60–80	73	20.4	99	27.7	26	135.6
40–60	78	21.8	70	19.6	–8	89.7
20–40	71	19.8	50	14.0	–21	70.4
0–20	107	29.9	69	19.3	–38	64.5

Note. Data in table are calculated based on *Daily migrants by settlements 2002–2011* [Unpublished raw data], by SORS, n.d.

In the observed period, most of the settlements of Belgrade DUS increased the degree of their general functional dependence. The highest degree of transformation, according to the indicator of functional dependence, was observed in the settlements of peripheral city municipalities, as well as in the municipalities in the contact zone of the administrative area of Belgrade. An increase in the share of commuters was observed in most of the settlements of the municipalities: Mladenovac, Obrenovac, Lazarevac, Pančevo, Sopot, and Stara Pazova. Process of locating certain work functions in settlements with the primary residential purpose in the immediate vicinity of Belgrade (Vrčin, Kaluderica, Pinosava, Beli Potok, and others) had an effect on reducing the indicators of functional dependence. Also, the formation of the Surčin municipality and the location of administrative functions in its municipal center had a significant impact. The increase in functional dependency in the majority of the settlements of the Belgrade DUS was influenced by the negative consequences of the transition period on the work centers in its administrative area and in the immediate vicinity (Mladenovac, Pančevo, etc.), as well as the general trend of increasing the daily mobility of the population.

Table 4. Settlements of the Belgrade DUS according to functional direction 2002–2011

%	2002		2011		Change in the number of settlements	Index of change
	Number of settlements	% of the total settlements number	Number of settlements	% of the total settlements number		
70–100	54	15.1	32	8.9	–22	59.3
40–70	47	13.1	63	17.6	16	134.0
20–40	41	11.5	79	22.1	38	192.7
10–20	45	12.6	82	22.9	37	182.2
0–10	171	47.8	102	28.5	–69	59.6

Note. Data in table are calculated based on *Daily migrants by settlements 2002–2011* [Unpublished raw data], by SORS, n.d.

The transformation of settlements' functional orientation in the DUS, in the period between 2002 and 2011, was reflected in the increase in the number of settlements in the middle categories of this indicator (Table 4). The number of settlements with more than 70% of commuters employed in Belgrade decreased by 40.7%, while the number of settlements with less than 10% of commuters directed to Belgrade decreased by 40.4% in the mentioned period. A significant increase was observed in the remaining categories, whereby the number of settlements that had between 20 and 40% of commuters employed in Belgrade almost doubled compared to 2002.

The increase in the degree of orientation of the commuters contingent toward Belgrade in the period from 2002 to 2011 was particularly pronounced in larger and more distant city centers, which by nature have a small number of actual commuters employed in Belgrade (Figure 4). In addition to them, a significant increase in the share of employees in Belgrade among commuters was observed in settlements that, until the observed period, gravitated to closer, more important centers of work (Pančevo, Mladenovac, Obrenovac, and others).

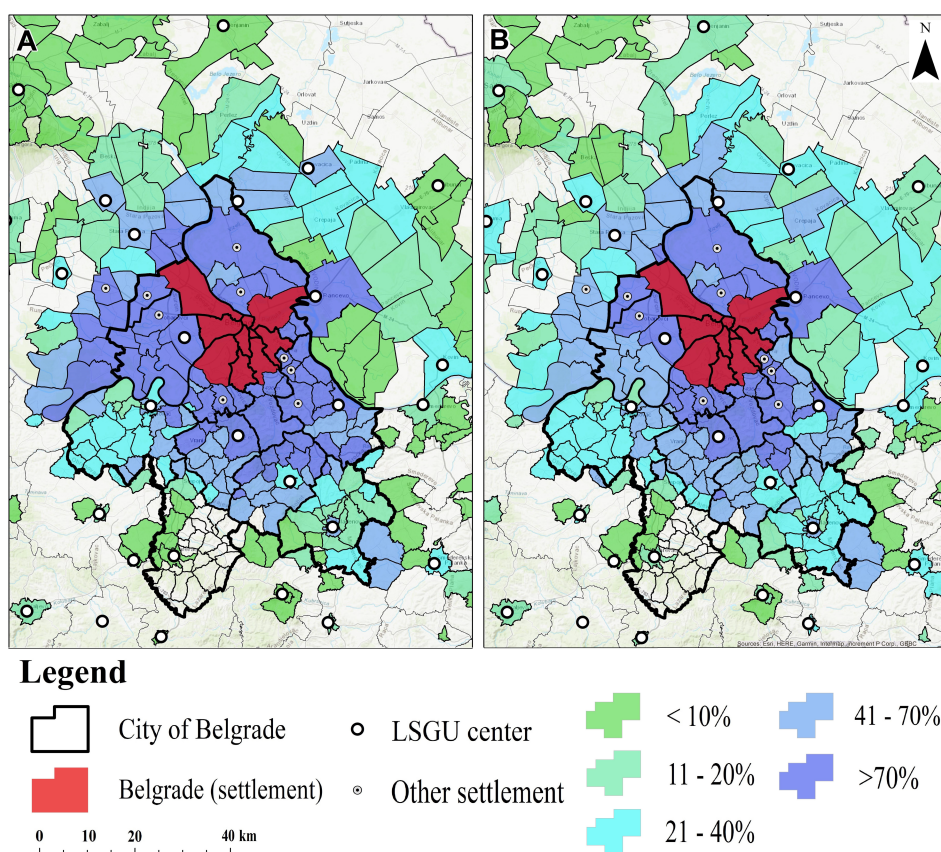


Figure 4. Settlements of the Belgrade DUS according to functional direction in 2002 (A) and 2011 (B).

5. Discussion and conclusion

The City of Belgrade, as the capital city and the administrative-political and socio-economic center, represents the core of the most significant DUS on the territory of Serbia and beyond its borders. In the observed period from 2002 to 2011, the economic and social transition at the level of the entire country was reflected in the population and spatial coverage of the Belgrade DUS. The number of inhabitants of the settlement itself, after decreasing in the last decade of the 21st century, increased by 4.2% in the observed period, whereby the increase was achieved, above all, thanks to the migration component. Changes in the DUS are characterized by population growth and expansion of spatial coverage, which are reflected through the increase in the number of commuters from other settlements, employed in Belgrade, as well as the increase in the number of donor settlements. Overall, the transformation of the Belgrade DUS in the observed period is reflected in the increase of all the indicators of daily mobility. Among the zones of influence of Belgrade, the most significant role was played by the settlements with a large number of commuters in the immediate vicinity (Borča, Kaluđerica, Sremčica, Pančevo, Surčin, etc.) on drastic changes in the share of the total daily movements. On the other hand, the role of the work center for commuter residents of the Belgrade settlement was taken over by new zones of concentration of economic activities outside the urban core, primarily in the highway area in the Srem part (Surčin, Dobanovci, Šimanovci, Krnješevci, Pećinci, etc.).

Within the Belgrade DUS, in addition to changes in the core itself, in the first decade of the 21st century, significant transformations of the settlements that represented the providers of commuters, i.e., their place of residence, took place. According to the data of both censuses, Borča stood out as the most significant "reservoir" of commuters employed on the territory of the Belgrade settlement (Filipović, 2020). In this urban settlement of the municipality of Palilula, in the observed period, a significant increase in the number of inhabitants, as well as the total number of economically active persons performing occupations, was observed. As a result, the number of Borča residents who worked on the territory of the core increased. Opposite to Borča, Kaluđerica, as the second most important residential area for commuting workers in Belgrade, had a different course of transformation. In the observed period, Kaluđerica experienced significant population growth, as well as an increase in the labor contingent, while a slight decrease was observed in the number of commuters employed on the territory of the Belgrade settlement. The strengthening of the work function in the administrative center of the municipality of Grocka was also reflected in the increase in the directed functional dependence of other settlements of the municipality, among which, in addition to Kaluđerica, Leštane, and Vrčin played a significant role. Of particular note is the reflection of the transition process on the transformation of Pančevo, as a settlement within the DUS of Belgrade. The weakening of the work function on the territory of the once strong industrial center manifested itself through a significant increase in the contingent of commuters employed in Belgrade. Similar tendencies were observed in Mladenovac. The tendency to decrease the number of employees in Belgrade was also observed in Srem settlements, such as Novi Banovci and Nova Pazova, primarily due to the increased concentration of economic activities in their immediate vicinity, i.e., in the highway zone. The formation of the separate municipality of Surčin in 2004 had a significant impact on the direction of daily mobility of the settlements of this municipality. Most of them (Dobanovci, Jakovo, Boljevci, Bečmen, Progar, and Petrovčić) experienced a decrease in the number of employees in Belgrade, while the same number increased in the municipal center, but at a lower intensity compared to population growth. Settlements such as Sremčica and Ugrinovci retained

the status of significant "reservoirs" of commuters employed in Belgrade with population growth, while Padinska Skela, with the weakening of the function of work on its territory, increased its dependence on Belgrade in the observed period.

In addition, the territorial scope of the Belgrade DUS was expanded in the observed period. One of the results of the transition negative effects on the territory of the whole Serbia was an increase in the number of commuters on the territory of the capital (Filipović, 2020). The decrease in employment opportunities, not only in smaller settlements, but also in larger cities, led to their more intensive involvement in daily interaction with Belgrade through labor force mobility.

Every form of social and economic transition leads to a series of directly or indirectly caused changes. Such is the case with DUSs and the complex set of relationships and connections within it, primarily between the core and other settlements. The study of the DUS is based on the observation and monitoring of the two most significant spatial-functional phenomena, obtained through demographic indicators. The first is the attractive function of the center of work, i.e., the core of the DUS, and the second is the functional dependence of the settlements that form the observed system. While the attractive function of the core is simpler to observe, the functional dependence of other settlements in the system can be observed from several aspects. In the foreground is the direct dependence of each settlement on the very core of the observed DUS. In addition, the settlement may be partially dependent on the core of another DUS, as well as another settlement or center of a higher order in the observed system. Also, through the analyzed parameters, it is possible to determine the degree of functional independence of the settlement.

The application of the model of spatial manifestation of daily labor mobility on the example of Belgrade gave results on different levels. A late transition, compared to other post-socialist cities, determined the beginning of the 21st century as a turning point in trends within its DUS. Demographic, economic, political, and other conditions in which the entire country found itself, also influenced the changes in Belgrade and its surroundings. By analyzing the basic and additional indicators provided by the model, a clear picture of the functional dependence of settlements in the influential sphere of the capital was obtained. By combining the indicators used, it is possible to determine the extent and zones of the DUS, as well as to determine overlapping zones with other influences. In addition, with demographic indicators, and in the spirit of striving toward polycentric regions, it is possible to define new and potential work centers within the existing daily urban systems.

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