

Research Article

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Functional typology of settlements in the Srem region, Serbia

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Abstract: The development of the functional settlement typology methodology is of academic and practical importance as it incorporates the social, economic, and demographic dimensions of regional development. Rural settlements are seen as a base for labor; traditional urban centers have become a base for commuters, while at the same time, new economic centers are emerging where capital investment is accumulating. This article presents the research conducted in the Srem region (located in the province of Vojvodina) to determine the functional typology of the settlement, which is of social, economic, and demographic importance for the region itself and for Serbia as a whole. This well-known immigration area in Serbia has been inhabited for centuries for its specific economic and political reasons. The very intensive economic activities of the last two decades have been influenced by development investments and contributed to the functional transformation of the settlements. The census data from 2022 make it possible to determine a functional typology of settlements in the Srem region using the factor method (principal component analysis). The article aims to explain the basic characteristics of functional types of settlements and to determine the mechanisms of their territorial distribution, which would be helpful in the future planning and organization of local and regional development of the Republic of Serbia.

Keywords: investments, population, gravitational zones, economic base, development pole, urban centers

1 Introduction

The typological classification of settlements according to functional characteristics is an important factor in regional geographic analyses and is considered a significant and very complex problem in contemporary geography [1–5]. The functional typology of settlements in the field of economic geography studies has led to the actualization of a number of complex issues related to the application of appropriate development measures, institutional support, and innovative solutions to the problem of balanced regional development.

Different scientific interpretations of the term typology pose a methodological dilemma, as it is not entirely clear whether this term refers to a scientific discipline, a method, or one of the basic principles of the theoretical–methodological procedure [6,7]. According to Weber [8], there can be no ideal type of social phenomenon since an idealized conceptual construction is nowhere to be found in empirical reality. According to McKinney's definition [9], typology is a pragmatic system of characteristics that is formed as a unique conceptual pattern. Each type thus represents a construction of diagnostic features and variables in which empirical data are of crucial importance. According to Todorović [10], typology represents a collection of general methods and specific techniques of system analysis, synthesis, identification, optimization, and other methodological procedures. The basic function of the process of defining types is to bring the apparent concreteness to the level of an imaginary, unified order on which various scientific predictions, simulations, and projections can be made based on the recognition of certain factors. In this study, the functional typology of settlements in the Srem region has a hypothetical character, on the basis of which we can predict future trends of change.

If we start from the fact that each space is specific and has certain unique characteristics, it is obvious that there is a gap in the literature in explaining universal facts when it comes to determining the functional typology of settlements. The most common gap in the literature relates to

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the emergence of new functions of settlements resulting from modern development processes (digitalization, use of home-based work, etc.). By using statistical data on the values of the basic functions of the settlement and by approximating the values of the specific functions of the settlement, it is possible to compensate for the lack of the aforementioned gap in the literature [11,12].

The study of the functional typology of settlements requires a more detailed analysis of the structures of the working population and its activities, the employment rate, the proportion of highly qualified workers, and the migration coefficient. According to Grčić [13], the functional typology of settlements can be determined on the basis of two concepts. The first is the concept of the economic base of the population, i.e., it is based on the structure of the working population by activity. This type of typology is based on the principle of dominant activity (function). The second is the concept of central places, which is based on the functional dependence and functional stability of settlements. This approach is of particular importance for the study of settlements in the Srem region, which have a high proportion of commuters in the working population and a high degree of “functional dependence” [14].

Based on the model of the functional typology of settlements, a real picture emerges of the significant change resulting from the changes in the economic development of the Srem region. This refers to the loss of agrarian characteristics of settlements due to the development of industry and services, i.e., to the formation of four basic functional types of settlements: (1) the rural settlement type, (2) the mixed settlement type, (3) urban centers, and (4) investment centers. So, the main task of this study is to examine how the earlier development phases of the Srem region have affected the distribution of settlements according to functional characteristics and to determine the patterns according to which the functional settlement types differ in 2022.

1.1 Study area

The Srem region is located in the southern part of the Serbian province of Vojvodina and comprises seven municipalities (Šid, Indija, Sremska Mitrovica, Irig, Ruma, Stara Pazova, and Pećinci) with functional centers (Figure 1). According to the 2022 census, 282,547 inhabitants lived in 109 settlements in a total area of 3,485 km² [15]. Due to the natural characteristics of the terrain, the area is agricultural, but the number of inhabitants in urban settlements is increasing for economic reasons. The urban centers are functional centers for the rural settlements that are migrating to them. All settlements in the Srem region are

economically oriented toward the capital of the Republic of Serbia, Belgrade, and the capital of the Province of Vojvodina, Novi Sad (distances of less than 100 km). The influence of gravitational centers is a good basis for the study of daily interactions between the settlements of the Srem region among themselves [16,17] and with larger cities in the inter-regional environment [18].

The disintegration of the SFR Yugoslavia in the 1990s led to an economic collapse, which also affected the functional development of settlements in the Srem region. Large state-owned factories, which formed the backbone of industrial development during the socialist period, went bankrupt in the 1990s, leading to an increase in unemployment and economic decline in the urban settlements [19,20]. After the democratic changes in 2000, the process of economic transition began, which contributed to the creation of new economic patterns. The modern phase of development is based on foreign direct investment and contributes significantly to the economy of the Srem region becoming a stable system. Industrial workers found their jobs in private companies and continued the tradition of industrial development that has existed here for a long time, such as metal processing, wood, plastic, and paper industries. Foreign direct investment influenced the emergence of industrial zones, especially in the urban settlements in the eastern part of the Srem region [21]. The geographical location and proximity to Belgrade have been crucial for the development of logistics and distribution centers in the eastern part of the region, which has led to the development of other industries, while the western part of the region remains without significant investment. In economic terms, the Srem region represents a significant part of the modern axis of economic development in Serbia (transportation-integrated area of industrial zones from the city of Belgrade to the city of Novi Sad). The physical and geographical characteristics of the terrain have influenced the emergence of a strong agro-industry, while the favorable infrastructural connections have influenced the existence of a strong industrial base. These are the main reasons why this research is conducted in the Srem region in order to determine the impact of (domestic and foreign) development investments on the functional differentiation of settlements and the changing dynamics and spatial patterns of their gravitational zones [18].

2 Methods

Theoretical models for the study of the functional typology of settlements can be considered within the framework of

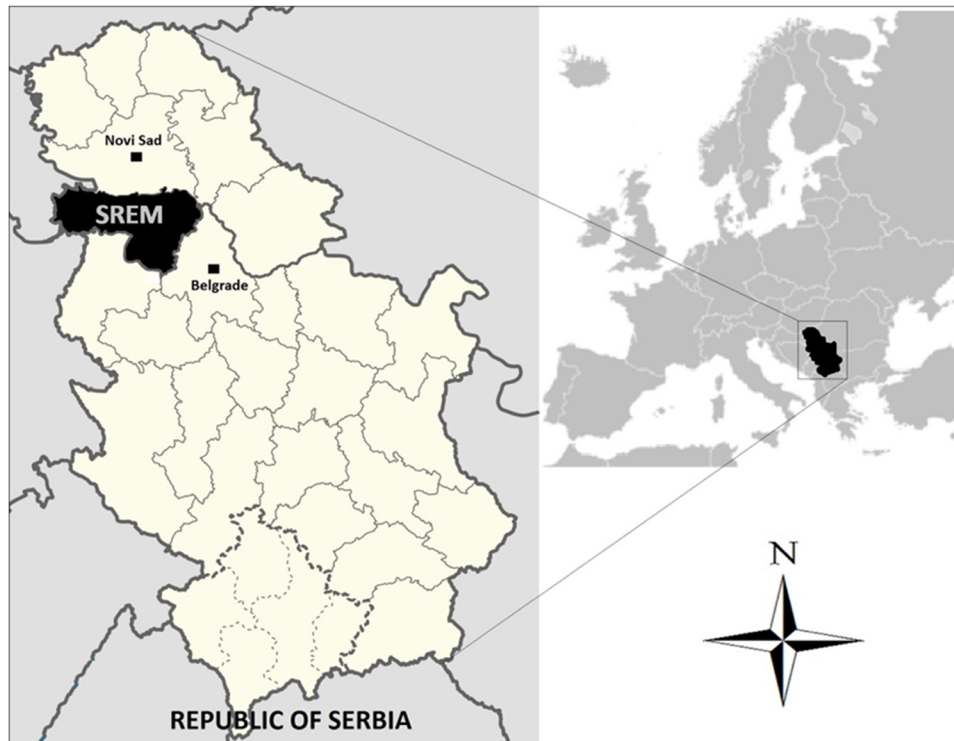


Figure 1: Study area.

two approaches. The first is contained in the deterministic understanding of the causality of socio-geographical and physical-geographical spatial features (ecologism), while the second approach refers to the importance of the economic factor and behavioral relationships to the chosen activity of the population. The functional typology of settlements is to a certain extent determined by regional natural features, but the main causes of dynamics are determined by social factors. Therefore, modern concepts of functional typology of settlements are based on models based on robust data, which allows them to be relevant in the creation of development policies and applied scientific conclusions [5,14,22–25]. In this study, the functional typology represents a quantitative-operational classification of settlements in the Srem region.

The most common indicators of the development of the labor function and the importance of labor centers in the Serbian geographical literature are the structure of the working population by activity [13,26], the share of the agricultural population in the total working population [27,28], and the concentration and structure of urban functions [29–31]. Functional typologies have been performed using various methods, most commonly the Thenar diagram model [13,26,29] and functional dependencies of settlements [13,14], while the more complex methods are based on shift-share analysis [32,33] and the factor method [13,24,25].

2.1 Factor analysis of the functional typology of settlements

The definition of functional settlement types using the factor analysis method requires a suitable selection of diagnostic indicators that describe the differentiation of settlements on the basis of functional characteristics. In this study, the analysis of diagnostic indicators (basic indicators) of functional characteristics of settlements was carried out on the basis of statistical indicators of the 2022 census [15]. Based on the chosen methodological approach, an insight into the functional typology of settlements in the Srem region is possible on the basis of ten basic indicators (share of the economically active population, share of the highly skilled labor force, labor force of the primary economic sector, labor force of the secondary economic sector, labor force of the tertiary economic sector, labor force of the quaternary economic sector, employment rate, unemployment rate, migration coefficient, and total population). The share of the working population in the total population represents the labor resource, while employment by the economic sector provides an insight into the economic structure of the settlement. Employment and unemployment rate are the basic social variables, while the share of highly qualified workers provides information on the educational characteristics of the settlement. The

migration coefficient is the ratio between the number of commuters and the total number of employees, while the total population in the settlements determines the demographic centers. The ten variables listed above can be used to determine the economic, social, demographic, and educational components of the settlement. Considering that the functional typology of the settlement was established on the basis of the statistical indicators of the 2022 census and is the result of processes that took place several decades earlier, the results of previous studies were included in the investigation [14,16–18,32,34–36] in order to substantiate the modern process of functional transformation.

The Kaiser–Meyer–Olkin indicator for the adequacy of the sample in this study is 0.813, while the value of the Bartlett test for sphericity in this study is $p = 0.00$. The above basic indicators provide an insight into the structural physiognomy, degree of organization, and dynamics of the functional characteristics of the settlements of the Srem region.

The following methodological approach consists of grouping settlements in the Srem region according to similar diagnostic features, which form the basis for the formation of functional types. However, the basic problem in defining functional types is the selection of input variables that determine the attributes, properties, and characteristics of the settlements studied. There are various models of factor analysis, but the algorithm of principal component analysis (PCA) proves to be the most suitable for solving the problem of functional typology of settlements [13,24,25]. The PCA method is based on the assumption that a high degree of correlation between two or more variables leads to their replacement by a common indicator. This methodological procedure enables a unique quantitative formulation of hidden structures, i.e., new diagnostic indicators representing a complex of combined variables that are not accessible to direct observation.

The mathematical procedure of PCA can be simplified by six phases [6,24,25,37,38]:

1. *Determination of the initial matrix of spatial information*, in which the number of columns m corresponds to the number of basic indicators and the number of rows n corresponds to the number of settlements in the Srem region.
2. *Calculation of the standardized spatial information matrix* (Z), which represents the number of standard deviations in relation to the mean, is mathematically expressed as follows: $Z = \frac{X - \bar{X}}{Q}$, where $\bar{X}$ is the mean value of the variable X , while the determinant Q means the value of the standard deviation.
3. *Calculation of the correlation coefficient matrix of the basic indicators* (r_{ij}) is based on the Pearson correlation coefficient: $r = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{NQ_x Q_y}$, where $\bar{x}$ and $\bar{y}$ are mean values and Q_x and Q_y are standard deviation of variables x and y , while N represents the total number of settlements in the Srem region.
4. *The classification of the factors and the creation of the matrix of factor loadings* are done by PCA. The process of PCA consists of formulating a linear combination of variables that explains most of their variance. The factor loadings for the principal component can be calculated according to the following equation: $a_{ij} = \frac{\sum_{i=1}^m r_{ij}}{\sqrt{\sum_{i=1}^m \sum_{j=1}^m r_{ij}^2}}$, on the basis of which we can conclude that factor loadings represent correlation coefficients between a certain variable and composite factors.
5. *The analysis of the rotations of the matrix of factor loadings* is in most cases performed using a technique known as varimax (variance maximization), i.e., a variant of orthogonal rotation in which the ratio of the factor axes does not change (they remain orthogonal). The result of this rotation is a “refined” factor structure, as certain variables that are difficult to interpret are eliminated.
6. *The calculation of factor scores* is expressed by spatial data, on the basis of which the factor value interprets the degree of connection between each settlement and the respective factor. Although all basic indicators are involved in the formation of the factor score, their influence varies depending on the respective factor loadings.

It is very important that the correlation coefficient matrix is not singular, that its inverse matrix exists [39]. In addition, the Ward method of hierarchical clustering with square Euclidean distance was applied in this study [40]. In this way, different groups with minimum internal variances were separated. The Ward method is characterized by the expressed minimum sum of squares, since at the beginning of the algorithm each settlement represents a separate group, which is a necessary condition for the definition of functional settlement types in this study. The lack of hierarchical grouping methods means the lack of a predefined number of homogeneous groups on the basis of which the factor loadings are interpreted. In this study, the number of groups was determined using the “Scree” diagram, in which the number of groups is plotted on the abscissa and the change in the distance value (the diffusion coefficient) on the ordinate (Figure 2).

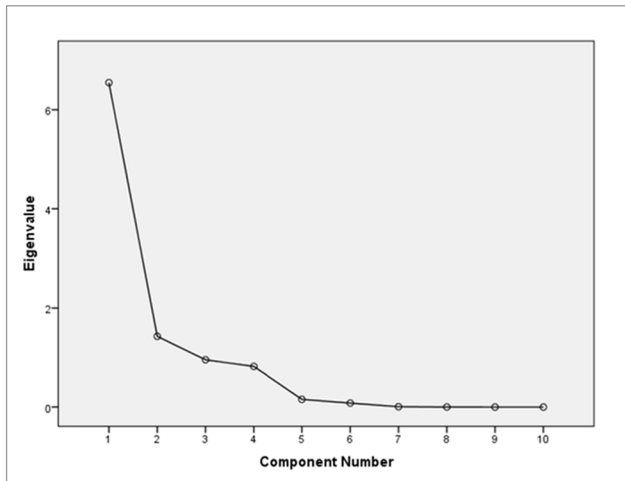


Figure 2: “Scree” diagram of the functional typology of settlements in the Srem region.

3 Results and discussion

The importance of PCA results lies in the selection of a sufficient number of factors that can explain a significant part of the variability. The procedure for selecting the number of factors consists of analyzing the characteristic roots (λ) and the “Scree” diagram. The characteristic root explains the variance of all basic indicators of the functional typology of the settlement, which is explained by the isolated factor. Mathematically, it represents the product of part of the explained variance and the total number of basic indicators. Based on the results of the PCA, four factors were filtered out as part of the factor model, explaining 97.6% of the total variance. By extracting four factors, the prerequisites for defining an identical number of characteristic functional settlement types were created. In the “Scree” diagram (Figure 2), the significant differences in the values of the characteristic roots can be recognized by the breaks in the curve. It is obvious that the first point at which a reduction in the number of factors is possible is between the third and fifth components.

The extracted factors were evaluated before and after rotation using the Varimax method. Varimax rotation was performed to optimize the factor structure and contributes to the partial uniformity of the extracted factors (Table 1). The first factor in the unrotated matrix explains 65.5% of the total variance, while in the rotated matrix, the percentage of explanation drops to 63.9%. It can be seen that the values of the total variance of the fourth factor in the unrotated and the rotated matrix are identical and amount to 97.5%.

The value of the correlation between all variables and the rotated factors is expressed by the rotated matrix of factor loadings. Since there is no agreement on the threshold value of factor loadings above which a significant correlation between variables and factors can be established, absolute values of more than 0.400 were considered relevant in this study, which corresponds to a moderate correlation [6,41,42]. The use of the Varimax rotation method reduced the possibility of factor loadings with absolute values higher than moderate (>0.400) of the same variable in two or more factors (Table 2).

By interpreting the derived factors, it was possible to define suitable functional settlement types in the Srem region. The isolated functional settlement types are based on the basic typological characteristics (factor 1 = type 1) and reflect the specific characteristics of the settlement system under investigation.

The most important factors that have influenced the functional transformation of settlements in the Srem region are the processes of industrialization, agricultural overpopulation, the proximity of the two largest urban agglomerations in Serbia (Belgrade and Novi Sad), then the good orientation of rural settlements in relation to the urban center, constant migration, good transport connections and the possibility of using various means of transport [14,17]. Exploring the functional typology and gravity zones of settlements helps to understand the specific relationships and connections of settlements with gravity centers. Accordingly, Ćurčić [43] linked the settlements of the Srem region with the gravitational zones of Belgrade, Novi Sad, and

Table 1: Significance of selected factors in unrotated and rotated matrix of factor loadings

Component	Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative%	Total	% of variance	Cumulative%
1	6.549	65.495	65.495	6.385	63.853	63.853
2	1.428	14.284	79.779	1.309	13.085	76.938
3	0.955	9.555	89.334	1.036	10.356	87.294
4	0.822	8.218	97.551	1.026	10.257	97.551

Table 2: Rotated component matrix of factor loadings*

Variable	Component			
	1	2	3	4
Share of the working population	0.993	−0.014	−0.070	0.081
Share of the highly skilled labor force	0.116	−0.011	0.041	0.992
Labor of the primary economic sector	0.915	0.268	−0.196	0.002
Labor of the secondary economic sector	0.179	0.961	−0.012	0.098
Labor of the tertiary economic sector	0.216	0.961	0.021	0.068
Labor of the quaternary economic sector	0.135	0.957	−0.087	0.023
Employment rate	0.765	0.028	−0.049	0.267
Unemployment rate	−0.532	0.301	−0.091	0.091
Migration coefficient	−0.065	−0.144	0.984	0.042
Total Population	−0.058	−0.012	0.994	0.075

*Rotation method: Varimax with Kaiser normalization. High loads are presented in bold italics.

Šabac, based on the grouping of settlements according to meso- and micro-gravitational zones. In this way, he came to the conclusion that the gravitational affinity of the settlement to the central settlement is directly related to the degree of economic development of the settlement. Economically more developed settlements are therefore proportionally more connected to the central settlement. In this study, the classification into four functional settlement types (rural type, mixed type, urban centers, investment centers) is harmonized with the previously defined basic indicators dealing with the economic activities, the mobility factor of the population, and the population size of the settlement.

The rural settlement type is spatially the most widespread and explains 63.9% of the total variance of the variables. The rural settlement type is very characteristic of Serbia [10] and indicates the dominant representation of agricultural production. Traditionally, a high percentage of the working population is engaged in agriculture, which leads to a negative correlation with the level of unemployment [33]. The large volume of agricultural production in rural-type settlements is reflected in high values of agricultural potential and low values of production efficiency [20].

The mixed settlement type is characterized by a high degree of positive correlation with employees in non-agricultural activities and explains 13.1% of the total variance of the variables. The population of the mixed settlement type is most frequently employed in the work zones of the Srem region and performs labor-intensive activities [18].

Urban centers are the functional settlement type that explains 10.4% of the total variance of the variables. These are the largest settlements in the Srem region (Sremska Mitrovica, Ruma, and Indija) and represent administrative, educational, health, and economic centers of the region. In addition to the basic functions, this type of settlement fulfills several specific functions related to the cultural and historical heritage of the region. The urban centers have a pronounced tourist function (particularly pronounced manifestation and cultural tourism), a cultural function (preservation of local traditions), a political function (centers of local and regional administration), and represent settlements with a particularly high migration coefficient. Commuters from the urban centers of the Srem region go to larger centers (Belgrade, Novi Sad), with which they are well connected by transport, and to the work zones of other settlements in the region [14,17,18,44].

Investment centers are a functional settlement type that explains 10.3% of the total variance of the variables and is positively correlated with highly qualified workers. Investment centers are settlements that represent “new” centers of economic activity (Stara Pazova and Nova Pazova) located in the eastern part of the Srem region. Since 2000, the aforementioned settlements have attracted a significant share of foreign direct investment and are considered part of the “development pole” not only of Srem, but also of the entire Republic of Serbia [17,18,33].

The new concept of economic development based on investment is very different from the earlier “traditional” concept, which was limited to agriculture as the main activity in rural settlements and to industry and services in urban centers. As a result of modern economic trends, two other functional settlement types have emerged in the Srem region (in addition to the traditional rural settlements and urban centers): (1) the mixed settlement type, which emerged as a result of the transformation of the traditional rural settlement type; and (2) the investment settlement type, which is directly related to the locational advantages and needs of foreign investors [45].

Previous studies on the functional typology of settlements in the Srem region have shown an intensive transformation process [2,14,43,46,47]. Under the influence of the economic activities of the settlements, the Srem region underwent a certain functional transformation. After the democratic changes in 2000, the process of attracting foreign direct investment began in the Srem region in response to the problems of the national economy, such as the lack of development investment, the decline of state and public enterprises, and the high unemployment rate. The territorial distribution of investment projects began to be based on the geography of the settlements. In those parts of the

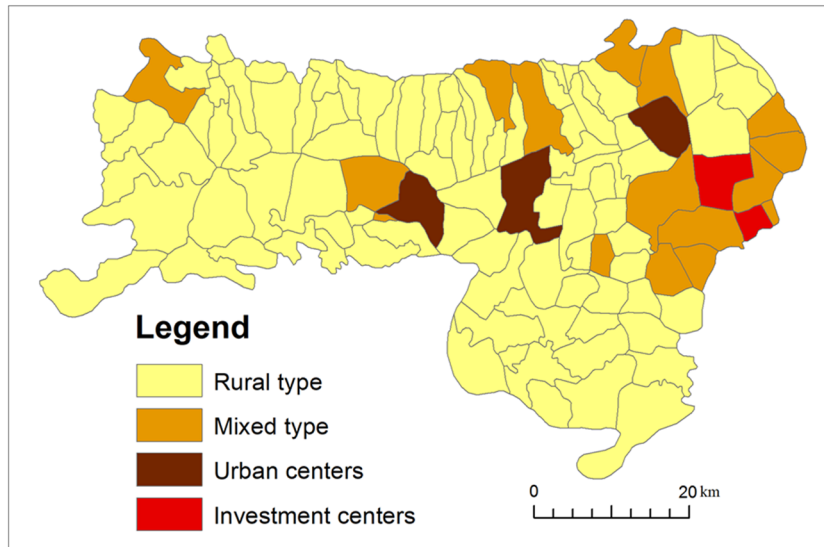


Figure 3: Functional typology of settlements in the Srem region.

Srem region where the frequency of investment was higher, greater functional changes were also recorded in the settlements. Comparative locational advantages (transport infrastructure, functional work zones, market) became decisive for the investment decision, while the demographic and administrative characteristics of the settlements, which were decisive in the socialist economic model, were neglected. This led to a polarization of economic growth in the settlements of the eastern part of the Srem region, while the former leading economic centers of the Srem region (Sremska Mitrovica and Ruma) fell into an unfavorable position. During the socialist period, Sremska Mitrovica and Ruma, due to their administrative functions and demographic potential, were the carriers of economic activities in the planned organization of the economy. After the change of the social system, the development of economic activities was determined by the needs of the market, which shifted the development centers of the Srem region to the east, to Belgrade. This has contributed to the fact that the economy in Sremska Mitrovica and Ruma has developed more slowly compared to the settlements in the eastern part of the region, and the functional structures of the settlements have changed less. In the settlements of Stara Pazova and Nova Pazova, agriculture and small businesses accounted for the largest share of overall economic growth during the socialist period, while the share of large industrial enterprises was significantly lower. Under the conditions of a free market economy, however, comparative locational advantages come to the fore, making the above-mentioned settlements investment centers. In accordance with the fact that the settlements of the eastern part of the Srem region are undergoing the greatest functional transformation

thanks to the largest number of investment projects, some of them (Stara Pazova and Nova Pazova) can be considered the “modern poles of economic development” of the Srem region (Figure 3).

4 Conclusion

The settlements of the Srem region are under the influence of dynamic economic development, which leads to a functional transformation of the settlements, which change from agricultural to industrial and service-oriented settlements with their own variants. The development and equipment of industrial zones in the area under consideration have influenced the attraction of investments. With large investments, individual settlements in the Srem region are becoming part of the development axis, together with the contact part of the city of Belgrade and the city of Novi Sad, as the two largest markets in the Republic of Serbia. Within the modern development concept of the Republic of Serbia, rural settlements in the Srem region are undergoing the greatest economic transformation, which is reflected in the restructuring of activities and functional transformation of settlements. The settlements defined as investment centers in the eastern part of the Srem region have significantly influenced the change of the economic base and the functional transformation of the settlements in their immediate vicinity, while this process has not taken place as intensively in other parts of the Srem region.

The contribution of this study is to present the contemporary socio-political, demographic, and socio-economic consequences of the differentiation of functional settlement types. It has also partially revealed the relationship between population mobility, social and economic behavior patterns, regional inequalities, and the overall economic development of the Srem region, thus providing a clearer insight into the current process and complex mechanisms of functional settlement change. This research could be extended to other regions of Serbia, and similar research could be conducted in other countries that show the same or similar patterns of demographic and socio-economic development. The main contribution of this research lies in the explanation of the multiple effects of functional change in the settlement system, which can be used in the development of strategic documents of local policy, spatial planning, and practical organization of settlements.

Future trends in capital investment should focus on the sustainability and uniformity of regional development. An even and planned concentration of economic activities reduces spatial polarization and increases the effect of depolarization. The thesis about the process of depolarization is supported by the fact that in recent years, the work zones have been increasingly concentrated in the greater part of the Srem region and not only in the eastern part. Based on all these facts, the tendencies of even economic development are set as one of the priority goals of the future economic-geographical study and spatial planning of the Srem region.

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