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## **POPULATION DENSITY GRADIENT AND ITS CHANGES IN THE REGIONS OF THE LARGEST CITIES IN THE SLOVAK REPUBLIC**

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**Abstract:** The paper is focused on detailed examination of population decentralization trends, projected in the spatial structure of cities and their hinterlands. For this specific purpose, we have chosen to analyze changes in the population density gradient between city and its suburban hinterland. For our study, we have chosen hinterlands of the four largest cities in Slovakia (Bratislava, Košice, Prešov and Žilina), dividing them into concentric zones, according to increasing distance from the historical centre of the aforementioned cities..

**Key words:** population density change, city, hinterland

### **Introduction**

Slovak cities and its hinterlands have gone through various significant demographic changes in recent decades. Population decentralization from compactly built-up core cities to suburbia has become especially interesting and current topic for geographic research in Slovakia after the arrival of the new millennia. It has since become closely bound with terms like suburbanization or suburban growth respectively.

Population stagnation or even population decline is in general a problem concerning both larger as well as smaller cities. It is interesting, that many times it's the case of natural decline ongoing together with migration decline. This decline is particularly evident in the historical city centers. Large portion of this change could be attributed to the transfer of commercial and administrative functions. Their growing concentration is pushing former residential function outwards to the more remote parts of the cities (e.g. housing estates from socialist era) or even beyond the borders of inner cities, to neighbouring villages and municipalities in the hinterland. Many authors agree, that the rise of population decentralization in the end of the 20th century, recorded in almost all larger cities influenced by socialism, is the result of long-term suppression of

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demand for housing away from densely inhabited inner cities (Borén & Gentile, 2007; Heikkilä & Kaskinoro, 2009).

Residential, commercial and also industrial decentralization, in the extent in which it is observed today, is a new phenomenon for former socialist countries. That's why the analysis of population redistribution has become very popular and fruitful topic for many scientific branches in the recent years in Slovakia.

Generally speaking, it is the analysis of suburbanization process, as the most specific of transformation impacts in post-socialist countries, that prevails among both foreign and domestic scientific literature. Suburbanization as a part of urban development is often understood as a certain quantitatively observable phenomenon. This led to creation of several concepts and models, where the most known is the one created by the team of Dutch urban scientists led by Klaasen and Van den Berg (Klaasen & Scimemi, 1981; Van den Berg et al., 1982). According to this model urban development has some specific and also periodic regularities. It has development stages which follow in given order, led by urbanization and followed by suburbanization, dezurbanization and ending up with reurbanization in this exact order. However, empirical studies showed that the chronological aspect of this concept was actually recorded only by very limited number of cities, which lead to the very detailed critique of this model (e. g. Champion, 2001; Storper & Manville, 2006; Fishman, 2005). But, if we take the chronological aspect out of the equation, the identification of individual stages itself provides us with very valuable tool for quantitative analysis of urban processes.

As for post-socialist countries, the analysis of suburbanization, as one of the types of urban development, is present in multitude of scientific articles among which we could name authors from Czech Republic (e. g. Sýkora, 2001; Musil, 2001; Sýkora & Ouředníček, 2007), Poland (Parysek, 1995) or Hungary (Kok & Kovács, 1998). The topic of morphological, structural and demographical changes in the suburban areas is also popular in Slovak literature with emphasis on the largest Slovak cities – Bratislava (Zubriczký, 2005; Slavík & Kurta, 2007; Novotný, 2011) and Košice (Dická, 2006, Spišiak & Kulla, 2008). Research in Slovakia was mostly oriented on the analysis of population numbers and its changes, population growth dynamics, migration etc.

One of the alternative methods of examination aimed at population redistribution was introduced in our previous report (Hudec & Tóth, 2012), where we used the Hoover index of population concentration analysis. We came to a conclusion, that the group of functional urban regions of the ten largest Slovak cities has

undergone some kind of stagnation or consolidation phase regarding spatial distribution of population in the last decade of the 20th century, whereas the first decade of the 21th century has been already characterized by clear prevalence of decentralization tendencies.

With the following article we would like to link up with our previous research and focus on detailed examination of population decentralization trends projected in the spatial structure of cities and their hinterlands. For this specific purpose, we have chosen to analyze changes in the population density gradient between city and its suburban hinterland. This indicator indirectly demonstrates different tendencies of population growth related to changing distance from city centre.

### **Research aim and methods**

The main aim of our research is to identify and evaluate recent changes in the population density gradient in the hinterlands of four largest cities in Slovakia. The period of our observation is delimited by two points in time, year 1991, when the post-socialist transition started and more recent year 2010. Partial aim is the actual application of aforementioned method of urban-rural gradient, which has been adopted from foreign researches.

#### *Urban- rural gradient*

The analysis of urban-rural gradient represents developed approach to the research of the differences between urban and rural pole in the spatial continuum (Kroll & Kabisch, 2011). This type of gradient has been widely used to characterize spatial distribution of certain phenomenon in the given area. From demographic point of view, it has been mostly employed to study population density, average size of households or average age of population alternating from urban core to suburban hinterland or prevalingly rural ring (Zheng, 1991; Kasanko et al., 2006).

The key methodological task is to collect the necessary statistical data for the smallest aerial units possible and subsequent delimitation of the ring which would adequately represent the size of the hinterland. The following division of the ring to concentric zones should always fit the requirements for the most detailed analysis of the chosen variable.

Calculation of variable value for the particular concentric zone:

$$x_j = \frac{1}{A_j} \sum_{i=1}^n A_{i,j} \cdot x_i \quad (1)$$

where  $x_j$  is the value of the chosen variable in the concentric zone j,  $A_j$  is whole area of the zone j,  $A_{i,j}$  is the area of the spatial unit i in the zone j and  $x_i$  is the value of the chosen variable in the spatial unit i.

This methodology presumes, that there is no diversity between the variables within chosen spatial units (therefore it is necessary to pick as smallest units as possible). It is important to note that shape and number of the chosen spatial units do affect the outcome of the research, as well as the fact, that urban regions do not facilitate the same continuance of characteristics in all directions from the urban core. Mentioned approach is rather generalizing and more suitable for studying rather monocentric regions than those where identification of more urban cores is possible (Kroll & Kabisch, 2011).

In the geographic provenience of Central and Eastern Europe, this method was used by German authors Franziska Kroll and Nadja Kabisch, who employed it to study and compare changes between 1995 - 2005 in German urban regions of Hamburg and Munich from former Federal Republic of Germany, and on the other side Halle and Leipzig as representatives from former German Democratic Republic. While Hamburg and Munich were both dealing with constant population increase during the observed period, urban regions of Halle and Leipzig were in contrary recording population losses. From the population density point of view, Hamburg and Munich recorded growth in their values mainly in the more distant hinterland and decrease in more central parts of the city, whereas Halle and Leipzig were characterized by severe decrease of population density in the zones dominated by large scale housing estates in the inner city inherited from socialism era.

In this regard, we could expect that Slovak urban regions would follow similar trajectory as German cities affected by socialism, but as we are going to discover, the development of major cities in Slovakia has rather different nature.

#### *Spatial framework and data*

Population density gradient was examined in four major Slovak cities (Bratislava, Košice, Prešov, Žilina) and their hinterlands. We have chosen these

cities because they represent four different regional units with distinctive features (Figure 1).

Inspired by the method used by German authors Kroll & Kabisch (2011) we delimited the hinterlands with radius of 30 km from historical city center. This spatial extent has been chosen as the compromise by which we were able to incorporate the majority of municipalities that belong to functional urban regions (FURs) of the respective cities. By FUR, we understand the regional system FUR – 91 B delimited by Bezak (2000). Units from this system are in Slovak scientific literature often considered as the most suitable spatial framework, which, in contrast to official administrative division of Slovak Republic, respects spatial behavior of population with the highest rate of coherency.

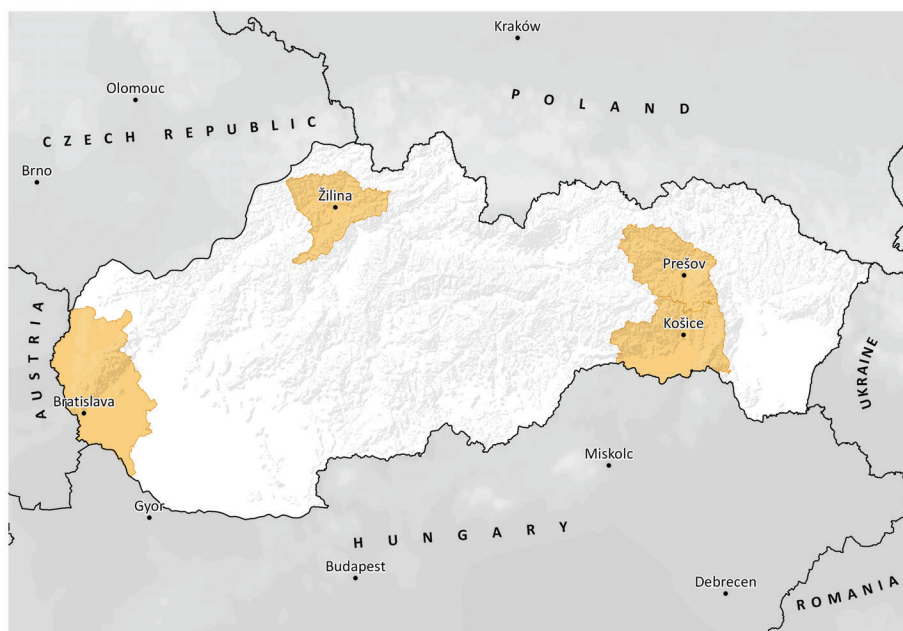


Figure 1. Examined functional urban regions (in amber) within the Slovak Republic. Source of data: Bezák 2000

We have subsequently divided hinterlands of chosen cities into 11 ring-shaped concentric zones, whereas the first zone defined by compact build-up was delimited with 5 km radius from the city center and other 10, mostly suburban zones with radius of 2.5 km. As for the center points of the concentric rings for all four observed urban regions, we have decided to prefer historical aspect

instead of the economic. It was a logical choice, because when dealing with population decentralization, it would not only be questionable, but also vague to choose otherwise. Central points were set in the historical cores of studied cities, which positions are explicit. Particular position of centroids is presented in the table 1.

Areas of individual municipalities were calculated based on ArcGIS 9.3 software with regard on the latest territorial changes. When analyzing population density changes on a long-term basis (often characterized by rapid changes), it is important to choose spatially stable units. It was the reason why we preferred using the total area of municipalities and no to limit our examination only on build-up areas. Build-up areas of municipalities located in suburban zones cannot be considered as stable in the long-term aspect. This could lead to severe misinterpretations in our research. Total area of municipalities is relatively stable even if subdued to sporadic areal changes.

Table 1 Position of centroids for considered cities

|            |  |
|------------|--|
| Bratislava | Franz Liszt Square (former Railway Station Square) |
| Košice     | Square of Liberty                                  |
| Prešov     | Crossroad of Main, Levočská and Sabinovská Street  |
| Žilina     | Marianské Square                                   |

Statistical data used for population density calculation in individual concentric zones were collected from regular evidence of population and are adapted from published and unpublished materials of Slovak Statistical Office. It is also important to note, that period of 1991 to 2010 has been chosen, because in the time of finishing our research, it was still impossible to obtain detailed population data about municipalities from the most recent national census of 2011.

### Research hypothesis

Table 2 gives us the summary of population development in studied cities and their hinterlands<sup>2</sup>. It is obvious, that studied cities do not belong to the same size category, only Prešov and Žilina are comparable in this regard. But if we focus on comparison of population living in their hinterlands, they become more similar. Rate of population growth recorded during period of 1991 and 2010 is an important point for the aim of this study. As we can see from the table, Bratislava and Košice, two most populous cities, registered slight population

<sup>2</sup> By hinterland, we understand delimited area in the radius of 30 km from historical centre of a core city and within the reach of FUR.

decrease at the end of studied period, whereas Prešov and Žilina in contrary registered slight increase. On the other hand, population development in their respective hinterlands has quite clear tendency of rather rapid growth, only with the exception of Žilina.

Of course, it would be inaccurate to trivialize population development during almost two decades. Therefore we try to remind and summarize findings from various authors who dealt with population redistribution of FUR in Slovakia (e.g. Novotný, 2010; Bezák, 2011; Novotný, 2011; Tóth, 2011; Hudec & Tóth, 2012). In the beginning of the 90s growth of larger cities at the expense of their hinterlands (centralization of population) was still predominant. In fact it was a continuing tendency from previous periods, characterized by central planned block of flats construction, which continued till the first half of 90s. After that, state changed its construction politics and country as a whole started to feel the outcomes of the economical and social transformation.

The second half of this decade was characterized by some sort of stagnation within changes of population distribution, only Bratislava and Košice, two primary cities in Slovakia, were recording some signs of emerging decentralization of population.

However, the first decade of the 21th century brought population growth into the hinterlands of all larger urban regions in Slovakia. It was often accompanied by a loss in the number of population living in the inner cities (decentralization of population).

Table 2 Population development of studied cities in the period of 1991 to 2010

|            | Population<br>(1991) | Population<br>(2010) | Growth rate (%)<br>(1991 -2010) |
|------------|----------------------|----------------------|---------------------------------|
| City       |                      |                      |                                 |
| Bratislava | 442197               | 431 061              | -2,52                           |
| Košice     | 235 160              | 233 880              | -0,54                           |
| Prešov     | 87 765               | 91 193               | 3,91                            |
| Žilina     | 83 911               | 85 252               | 1,60                            |
| Hinterland |                      |                      |                                 |
| Bratislava | 153 452              | 180 161              | 17,41                           |
| Košice     | 99 716               | 113 778              | 14,10                           |
| Prešov     | 104 501              | 124 696              | 19,33                           |
| Žilina     | 131 342              | 136 602              | 4,00                            |

Source of data: Historical lexicon of municipalities in the Slovak Republic 1970-2001 and Balance of population in the Slovak Republic 2010

The aim of this article is to investigate deeper, to reveal other population patterns than just to articulate whether a FUR is centralizing or decentralizing.

Using the change of population density in the chosen urban regions as the research tool, we tried to analyze the spatial aspect of population growth. By dividing urban regions into concentric zones according to the growing distance from the urban core, we were able to differentiate a structure of population changes within these regions.

Results of this analysis should be able to provide us with slightly generalized overview about different rates of population growth throughout the urban region and how it changes with growing distance from urban core or whether it is possible to identify a certain pattern.

In the simplest meaning of the word, we could expect that with prevailing decentralization tendencies within all studied urban regions, the concentric zone or zones incorporating compact build-up areas of inner city would face decrease or stagnation of population density and concentric zones further away would register its increase. The question in this regard remains, how would intensity of this expected increase change with growing distance from the city center?

We have decided to approach this question from geographical (spatial) point of view. Assuming that the most of employment opportunities are usually located in the urban core, we suggested that the intensity of population decentralization should be inversely proportioned to growing distance<sup>3</sup> (longer commuting) into the urban core. In other words, the more remote a concentric zone from the urban core is, the less it would be attractive for immigrants and logically, there also should be lower intensity of population density growth.

This rather basic research hypothesis reflects the main essence of population decentralization tendencies. Vast majority of migration within FUR do not interrelate with employment change (or with the change of workplace), but rather with change of marital, family or social status. This in particular applies to families (especially those with more children). After reaching certain standard of living, they often move to seek higher environment quality and less densely populated areas. Mentioned attributes could be found in the suburban zone. Since we assume that there is no significant distinction between closer and more

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<sup>3</sup> Of course it is necessary to highlight the crucial factor of main traffic lines, alongside which zones of suburbanization are pulled further into a hinterland, as well as other factors, which can directly or indirectly affect the intensity of decentralization, such as availability of land, developer's activity, areal plan of municipalities, quality of residential infrastructure, landscape aesthetics etc. Our methodology however respects space as continuous and using other than Euclidian distance would necessarily bring up creation of corridors. For this reason we have to understand that used method is rather generalizing, illustrative, not aspiring to grasp the total reality.



remote suburban hinterland regarding their offer of rural environmental advantages, we have concluded this dispute with following statement: *The most important factor in the process of making the „where to live“ decision is the distance from workplace or other targets of daily commuting.*

It is necessary to point out, that even despite the fact that studied cities do not belong to the same settlement-hierarchic level and they differ from one another in various characteristics (e.g. settlement structure, topography, regional demographic features), we thought that our aforementioned assumption of decreasing attractiveness with increasing distance, would be fulfilled to a certain level by every single studied urban region. As we are going to show in the following analysis, this assumption was confirmed only partially.

## Results

The figures 2 - 5 illustrate the changes in population density during the period between 1991 and 2010 in four examined urban regions. Apparently, even at first glance, all examined cities create a heterogeneous system regarding the population density. Similarities may be found only in case of central circles within 5 km radius, basically suffered by stagnation of the urban development. Another situation occurs in farther areas, which are much more differentiated.

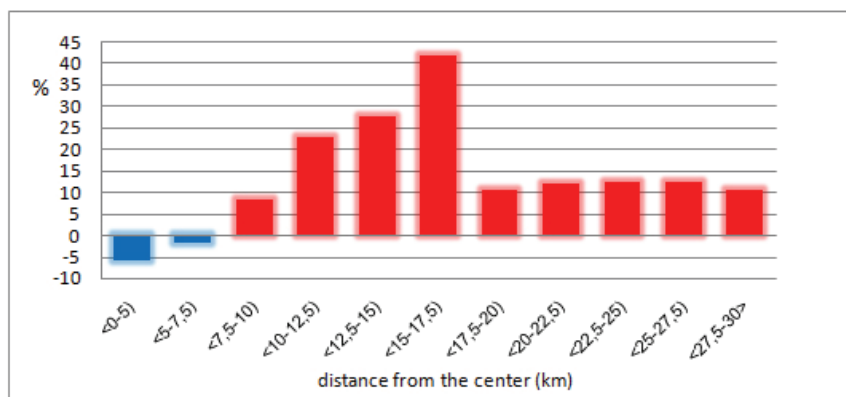


Figure 2. Population density changes in the urban region of Bratislava between 1991 and 2010

\*- the value may be distorted due to the small spatial extent of the particular zone

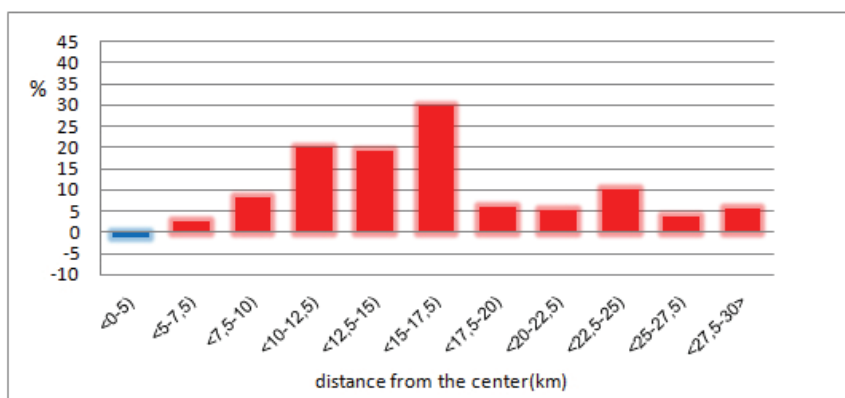


Figure 3. Population density changes in the urban region of Košice between 1991 and 2010

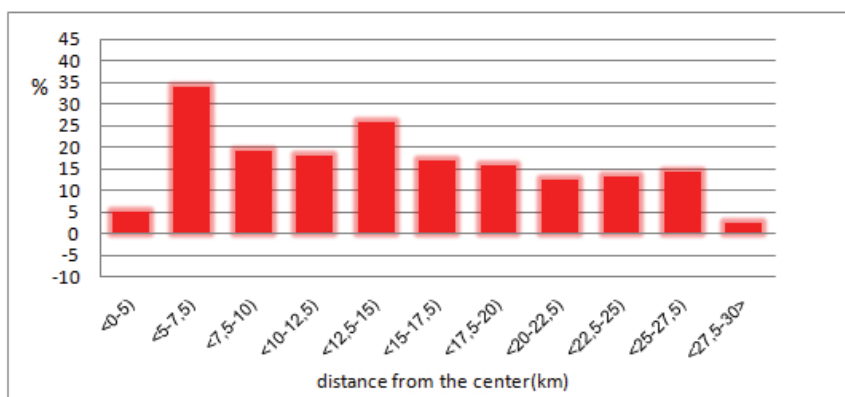


Figure 4. Population density changes in the urban region of Prešov between 1991 and 2010

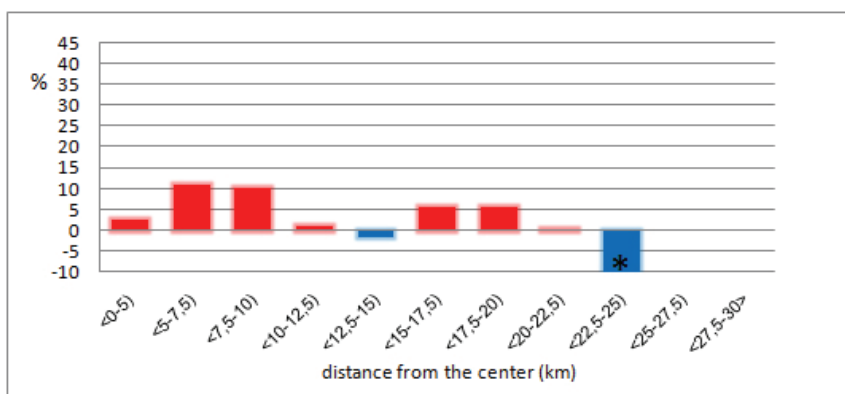


Figure 5. Population density changes in the urban region of Žilina between 1991 and 2010

As for our most essential findings, urban regions of Bratislava and Košice have been proved to have significantly analogical processes of population density changes in space. The values per each ring slightly increases with the increasing distance from the defined center until the line representing the 17.5 km distance radius. In more distant areas, the changes intensity declines and stabilizes eventually. The peak values, representing the most essential changes in the population density, emerge from 10 to 17.5 km distance radius, which is a bit more distant than expected. However, it is necessary to note, that the spatial extent of boroughs is much wider in case of Bratislava, so some intersects with other rings occur and thus, the boundary between country and urban environment is more distant than central circle.

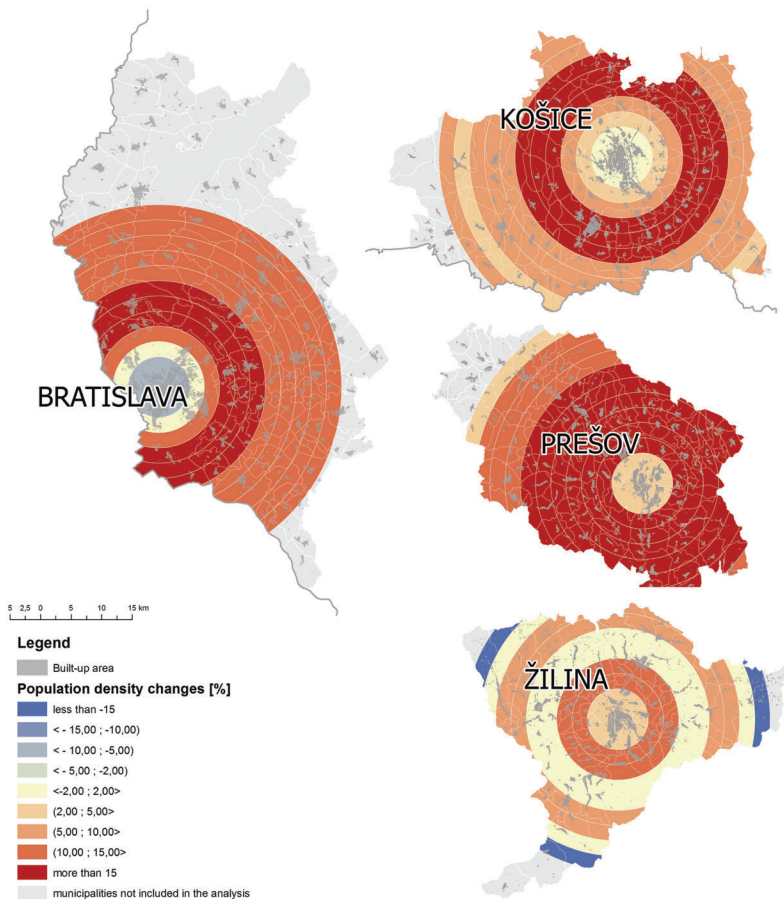


Figure. 6. Population density changes in respective functional urban regions.  
(Source: Slovak Statistical Office, own research)

Unlike abovementioned, the situation in Prešov urban region has shown noticeable growth of population density in exposed period and the peak is related to the nearest ring from the center. The values decrease towards the outer boundaries of urban region and thus our assumption was entirely verified in that case.

### **Conclusion**

By examining population density change in selected urban regions, broken down into equidistant multiple-buffer rings, we have attempted to analyze the spatial differentiation of population growth. Based on the respective demographic data, core cities were expected to show decreasing or stagnating trends of population density while the decentralization intensity would be generally inversely proportional to increasing commuting distance. This would eventually cause, that the more distant the buffer ring would be, the lesser intensity of population density growth we could expect. Since the set of examined urban regions consists from regions within different hierarchical levels and with different residential features, topography or regional demographic distinctness, a slightly different spatial organization of population density changes was expected.

The research only partially verifies our hypothesis. First, hinterlands in the urban regions of Bratislava and Košice show surprisingly similar spatial organization of population density changes. Closer buffer rings have greater values of population density growth than distant ones whereas the peak emerges in the mean distance. Second, the results in case of Žilina urban region are severely affected by physical geography, especially by radially arranged river valleys of Žilina basin, so the spatial organization of population density change seems irregular.

Third, our hypothesis is fully verified only in case of Prešov hinterland, where the decreasing growth of population density changes according to increasing distance from the city has met our assumption.

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