

MEASURING THE SPATIAL CONCENTRATION OF HIGHLY EDUCATED POPULATION: THE EXAMPLE OF THE REPUBLIC OF CROATIA

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ABSTRACT

Two key processes are closely connected to highly educated population: continuous growth of their part in the population and the tendency of higher concentration in space. The concentration of human capital is emphasised in the cities which is partially the consequence of the fact that young urban people more frequently decide to take higher education than young people in rural areas. Moreover, people who come to the cities from rural areas for the purpose of further education very frequently become permanent residents (rural 'brain-drain'). The aim of the paper is to research spatial concentration of highly educated population in Croatia using the data from the 2021 Census. Herfindahl-Hirschman index and classical Gini coefficient were used as the measurements for concentration. Furthermore, the paper suggests the use of modified Gini coefficient which compares the spatial distribution of highly educated population with the distribution of total population. The analysis was conducted on the level of municipalities and cities. The results have confirmed the assumption that highly educated people show the higher spatial concentration level in comparison with the less educated population. The concentration level of people with science doctor's degree is especially high. The regional analysis detects the highest degree of concentration in the central part of Croatia (the capital city). Additional analysis according to age groups also shows the differences in the concentration of highly educated people according to age.

Keywords: spatial concentration, human capital, Gini coefficient, Herfindahl-Hirschman index, Croatia

INTRODUCTION

Population spatial deployment is a reflection of protracted economic and demographic processes. Croatia was caught in the global shift from rural-agrarian into urban-industrial concept after the Second World War which led to a disruption of an even distribution of population [20]. At that time, a strong development of urban concentrated secondary and tertiary activities had a migration of population from rural to urban areas as a consequence [25]. The migration which changed the population deployment in the sense of demographic polarization in Croatia culminated in the 1960s and 1970s. Migration currents sometimes sidestepped smaller and mid-sized towns, targeting directly bigger towns [20]. Throughout several decades, polarization processes generated a certain level of population concentration. It markedly concentrated in Zagreb and the surrounding area, as well as in coastal counties [14] which shaped two focal areas of urbanization in Croatia [21]. From the 1980s onwards, the growth of bigger towns has been slowing down due to

the strengthening of sub-urbanization processes marked by dispersion of population into town-surrounding areas [28], [14].

While the researches of population spatial deployment mainly focus on the entire population, in Croatian literature and wider, there is a lack of papers researching the processes of polarization and population deployment based on the level of education. In general, there are not enough papers dealing with the education structure of population in spatial context. Therefore, the aim of this paper is to research spatial concentration of highly educated population in Croatia. The starting assumption is that highly educated population is more distinctly concentrated in space than total population. The research goal is divided into the following tasks:

- establish the degree of spatial concentration of the population at the age of 15 and older, highly educated population and population with academic level of PhD,
- research whether there are differences in spatial concentration of highly educated population regarding age,
- research whether there are differences in spatial concentration of highly educated population among the five regions in Croatia (so-called planning areas),
- single out the towns and municipalities with the highest percentage of highly educated.

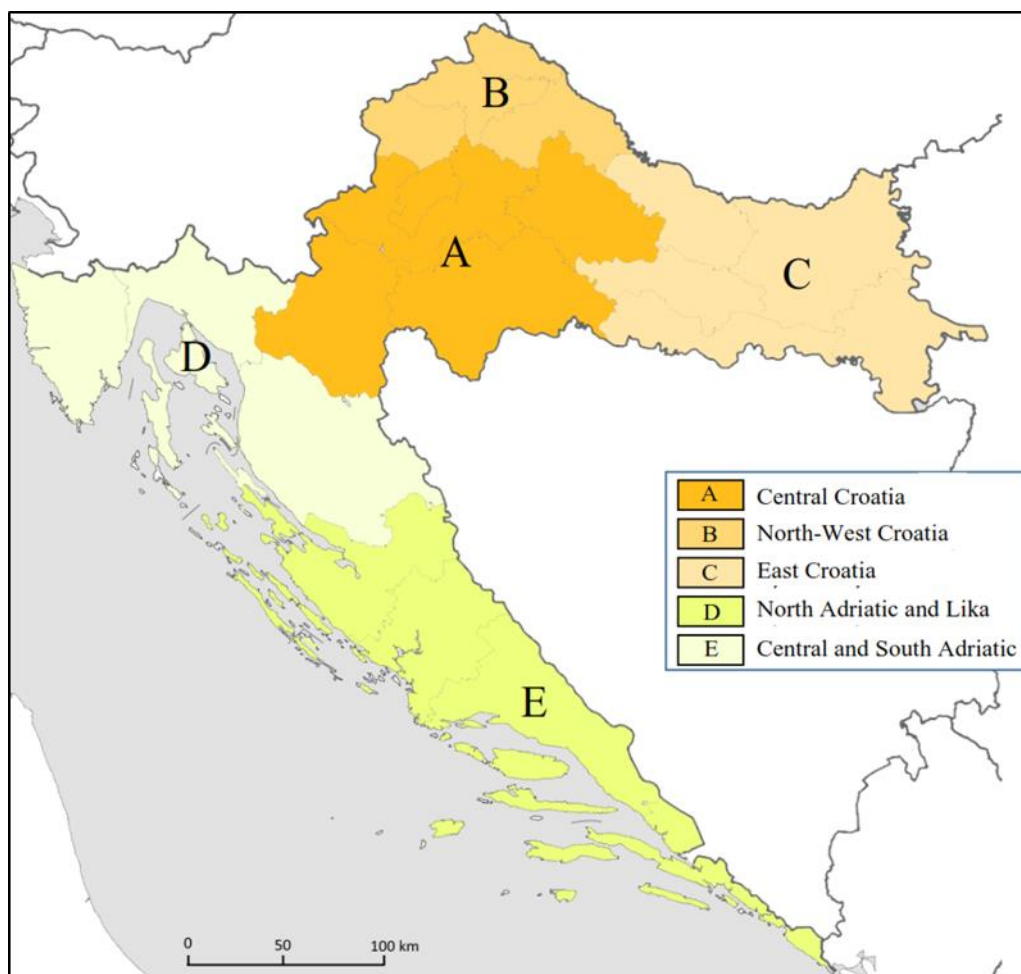


Figure 1. Conceptual division of Croatia in the so-called planning areas Source: [21]

THEORETICAL FRAMEWORK

Two important processes are tied to highly educated population: continuous growth of their participation in total population and a tendency of higher concentration in space. The expansion of the institutions of higher education accompanied by the growth of students in the last decades confirms that many European countries are moving towards the society of knowledge [29]. The number of inhabitants with higher education in Croatia is growing with every census, indicating that every next generation is more educated. For example, in 1971 only 3.6% of population at the age of 15 and more was highly educated (graduating from non-university college at least) [23]. Until 2001, that number grew to 11.9% and in 2001 there was 24.1% of population with higher education level living in Croatia [6], [7]. Despite the fact that the percentage of highly educated people has more than doubled in the last twenty years, Croatia is still below the average level in the European Union.

The other key process is the tendency of spatial concentration of highly educated population. People with a higher level of education are more prone to living in bigger towns [11], which is to say that there is a rather small number of highly educated in rural areas. In fact, there are two main reasons for the deficit of highly educated in the countryside: young people from rural areas decide on higher education at a smaller rate, and those who decide to go to university often continue living in the city after graduating [17]. There are several reasons as to why young people from rural areas decide on higher education compared to urban young people. Most universities and other higher education institutions are located in urban areas, which means that physical distance between the place of living and studying, emotional distance and higher expenses constrain young people from rural areas to enter universities. Furthermore, young rural people have less need for higher education because the local market is dominated by activities demanding less knowledge [29]. Social background plays another important role, e.g. a lot of rural young people do not have highly educated parents [17].

An additional problem for rural areas lies in the fact that those rural young people who decide to go to town for education, do not return to their region after graduating. Initially, young people temporarily migrate from their places of living to the places of studying, only to often make it a permanent place of living after graduating. One of the main reasons why young people do not return to the countryside after graduating from university is the problem of getting a job in their field of training [17]. Unfortunately, unlike students in towns, rural students often have to leave their communities if they want to upgrade their talents. Apart from modest career opportunities, negative perception of rural areas includes fewer possibilities of acquiring high income [26]. Poor infrastructure in such areas, including traffic and municipal infrastructure, also contribute to their negative perception. Certainly, some part of educated young population would continue living in the countryside if commuting to work was improved through better traffic connections [17].

Education and attending universities appear as population migration factors [9], firstly temporary, and later final migrations. As it can be seen, migrations do not influence only the spatial population deployment but can lead to changes in the population structure due to its selective character [24]. Migrations are selective considering the level of education, in which course more educated and more qualified people leave rural areas more often [22], [26]. The mobility of human resources leads to its agglomeration in big towns [8]. This means that at the same time rural 'brain-drain' results in creating agglomerations of

high capital in towns and its lack in rural areas. Rural ‘brain-drain’ represents a serious threat to social and economical vitality of rural areas [1]. Those with relatively lower education, skills and income remain in the countryside [26]. On the other hand, clustering of people with higher education increases the productivity of certain areas and towns, which creates potential for their economic growth [1].

METHODOLOGY

Spatial concentration researches are common in spatial economy and economic-geographical analysis. In order to establish the level of geographic concentration of economical activities (e.g. concentration of employed, companies etc.) different scales of concentration have been developed. Different varieties of the Gini coefficient, Herfindahl-Hirschman index and other scales have found a wide use in those scientific fields. Even though the issues of population concentration and spatial deployment are important in demographic research, studies which would deal with measuring the level of population concentration are rare. For example, some authors dealt with measuring territorial population concentration [3], [2], [10], [19]. For the needs of their research authors mainly ‘borrow’ scales developed in economic studies and modify and adjust them accordingly.

In order to establish the level of spatial concentration of highly educated population in Croatia, the following indicators were used in this paper: Herfindahl-Hirschman index (HHI), Gini coefficient (G) and locational Gini coefficient (G_l). The analysis are based on the results of Census in 2021 conducted by the Croatian Bureau of Statistics. Data on the number of highly educated people in towns and municipalities were used to calculate the indicators. The results of this research provide the answer to the question whether highly educated population is concentrated in a smaller number of towns and municipalities or it is more equally distributed on national territory.

Herfindahl-Hirschman index (HHI) is one of a very simple and frequently used scales of concentration. It is used in this paper in order to compare spatial distribution of highly educated people with the uniformed population distribution. Gini coefficient (G) represents the most widespread scale of spatial concentration [12]. This coefficient derives from Lorenz’s curve, which means it is defined by the space between the line of uniformed distribution and Lorenz’s curve (the line of real deployment) [13].¹³

Although often used, the drawback of these markers is that they do not take into consideration the differences among regions while measuring the concentration of population (e.g. municipalities differ in area and population) [12]. Therefore, locational Gini coefficient (G_l) was used additionally as a relative indicator which co-relates geographical deployment of highly educated population with the deployment of total population of Croatia. The indicator used in this paper is a modification of location Gini coefficient initially used by P. Krugman whilst working on economic-geographical research [16].

The locational Gini coefficient calculation is based on location quotients which, for the purpose of this article, were calculated as follows:

$$LQ = (P_{Hej} / P_{HeCro}) / (P_j / P_{Cro}) \quad (1)$$

¹³For the entire calculation procedure of the listed markers consult Braičić & Lončar (2018).

where P_{Hej} represents the number of highly educated in a municipality/town j , P_{HeCro} the number of highly educated in Croatia, P_j total number of inhabitants in a municipality/town j , P_{Cro} total number of population in Croatia. That way the portion of highly educated in a municipality/town is put into a relation with the portion of the municipality/town in total population of Croatia.

Locational Gini coefficient, modified for the purpose of this paper, was calculated according to this formula (adjusted according to [13], [8]):

$$G_l = 1 - \sum_{k=1}^n (x_k - x_{k-1})(y_k + y_{k-1}) \quad (2)$$

where k represents a municipality/town j ranked according to location quotient value, x_k cumulative portion of a municipality/town k in total population of Croatia, y_k cumulative portion of a municipality/town k in total number of highly educated inhabitants of Croatia. If highly educated population was distributed in space proportionally to total population, this index would be 0. This formula was also used to calculate Gini coefficient according to population age groups as well as for certain Croatian regions.

RESULTS AND DISCUSSION

Spatial concentration of highly educated population in the Republic of Croatia

Croatia is not an evenly populated state which is the consequence of geographical, social-economical, political, endogenous demographic factors and inherited settlement structure [20]. According to the last census in 2021, there were 3.3 million inhabitants aged 15 and more. Out of that number, 798,852 were highly educated, while only 16,879 inhabitants had a PhD.

A part of the first research task was to compare the level of population spatial concentration according to the level of education. Table 1 presents the results of the calculation of three relevant indicators of spatial concentration of total and highly educated population. Lower values of Herfindahl-Hirschman index represent more even distribution, while the values approach number one when highly educated population is concentrated in smaller number of towns and municipalities. The situation is similar with Gini coefficient. If the values are closer to zero, population is more evenly distributed in space. Values closer to one indicate more distinct concentration in space. From the results presented in the table it is clear that total population aged 15 and more is not evenly distributed in space and that highly educated population shows even higher level of spatial concentration. When spatial concentration of highly educated is analysed HHI is 0.1105 and Gini coefficient is 0.816. Population with academic PhD is a separate category which is even more concentrated in space - HHI was 0.3009 while Gini coefficient was very close to one (it was 0.9372).

Table 1. Scales of population spatial concentration in Croatia in 2021

Population group	Herfindahl-Hirschman index	Gini coefficient	Locational Gini coefficient
P ₁₅₊	0.0447	0.6727	-
P _{He}	0.1105	0.816	0.2482
P _{PhD}	0.3009	0.9372	0.5362

Note: P₁₅₊ – total population at the age of 15 and more; P_{He} – highly educated population; P_{PhD} - population with PhD Source: Authors' calculations based on data from CBS, 2021 [7]

Besides the two basic indicators, locational Gini coefficient was calculated, which compared spatial deployment of highly educated with spatial deployment of total population (aged 15 and more). If the value of locational Gini coefficient was 0, it would mean that highly educated population is distributed in space in the same way as total population. Values closer to one mean that spatial distribution of highly educated significantly deviates from the distribution of total population. Obtained values of this coefficient confirm that highly educated population is more concentrated in space (0.2482) than total population. Based on the results of all three indicators it can easily be claimed that more educated population is more concentrated in space than total population, and especially high level of spatial concentration is for the population with PhD. The rest of this research was looking for the answer whether there are differences in spatial concentration of highly educated population regarding age (Tab. 2, Fig. 2). Regardless of the used indicator, Herfindahl-Hirschman index or Gini coefficient, the same conclusions were drawn. Highly educated population, regardless of age, is spatially more concentrated than total population. While the differences in spatial concentration among age groups of total population are very small, they are significantly more distinct when only highly educated population is observed. The lowest values for the two indicators were determined for the youngest highly educated population (aged 20-24), which is also more equally deployed in Croatia. With the rise of age, spatial concentration of highly educated also rises and reaches its peak in the age groups between 40 and 54. Highly educated population of those age groups is the most spatially concentrated. After that age, the level of concentration is dropping so the population at the age from 55 to 74 is again more evenly distributed in Croatia. However, it is impossible not to notice that with the oldest age groups of highly educated (75+) there is another growth of spatial concentration.

Table 2. Spatial concentration of total and highly educated population in Croatia in 2021 by age groups

Age group	Herfindahl-Hirschman index		Gini coefficient		Locational Gini coefficient (P _{He})
	P	P _{He}	P	P _{He}	
20-24	0.0421	0.0565	0.6722	0.7297	0.1258
25-29	0.055	0.096	0.6928	0.775	0.1536
30-34	0.0576	0.1094	0.7013	0.8007	0.1790
35-39	0.0563	0.1172	0.7059	0.8243	0.2092
40-44	0.0558	0.1328	0.701	0.8526	0.2532
45-49	0.0504	0.1364	0.6959	0.8601	0.2896
50-54	0.0439	0.1339	0.6715	0.8512	0.3143
55-59	0.0366	0.1078	0.6508	0.8272	0.3006
60-64	0.0345	0.0932	0.6479	0.8172	0.2871
65-69	0.0364	0.0991	0.6544	0.8264	0.2916
70-74	0.0387	0.0949	0.666	0.8256	0.2681
75+	0.0435	0.1303	0.6641	0.8534	0.3174

Note: P – total population; P_{He} – highly educated population Source: Same as in Table 1.

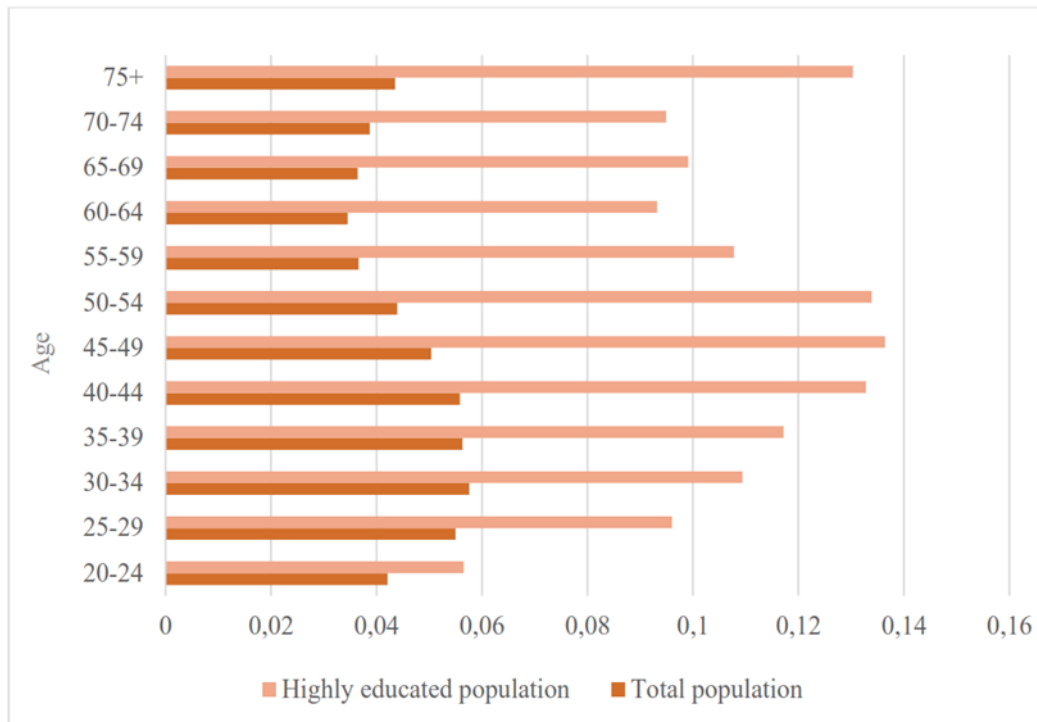


Figure 2. Herfindahl-Hirschman index of population spatial concentration in Croatia (2021) by age groups

Young people who have recently gained higher education are more evenly distributed in space for various reasons. Since they have only recently graduated, they still have not migrated towards larger urban centres. With time, in search for work and career many young people decide to move to larger urban centres. Due to selective migrations of highly educated people towards larger towns, their concentration in space grows with the age of population. Another reason for more even distribution of young highly educated is the fact that more and more rural young people, due to better accessibility of education, gain higher education. It is not only the privilege of urban young people.

The highest level of spatial concentration is with the highly educated population between the age of 40 and 54. Highly educated population at that age is the most work productive and mostly employed in markedly urban centralized activities. Spatial concentration of the population older than 55 lowers because the career pressures diminish [5], so a part of population returns to smaller communities. At the age of 75+, another growth of concentration can be noticed, which means that rural areas have significantly small number of highly educated in the oldest age groups. We are talking about the population mainly born in the 1930s and 1940s when a very small number of young people from rural areas entered universities. Higher education was elite, socially selective and linked to larger towns. Therefore, today's population at the age of 75 and more was extremely concentrated in towns even in their youth.

Locational Gini coefficient indicates the difference between the spatial concentration of highly educated by age groups and the concentration of total population (Fig. 3). At the younger age groups, highly educated population has a very similar spatial deployment to total population. With the rise of age, the differences become bigger, which means that highly educated become more spatially concentrated. At all age groups above 40, the value of locational Gini coefficient goes over 0.25, which indicates that the differences in

spatial concentration of total and highly educated population are more emphasized than with the younger age groups.

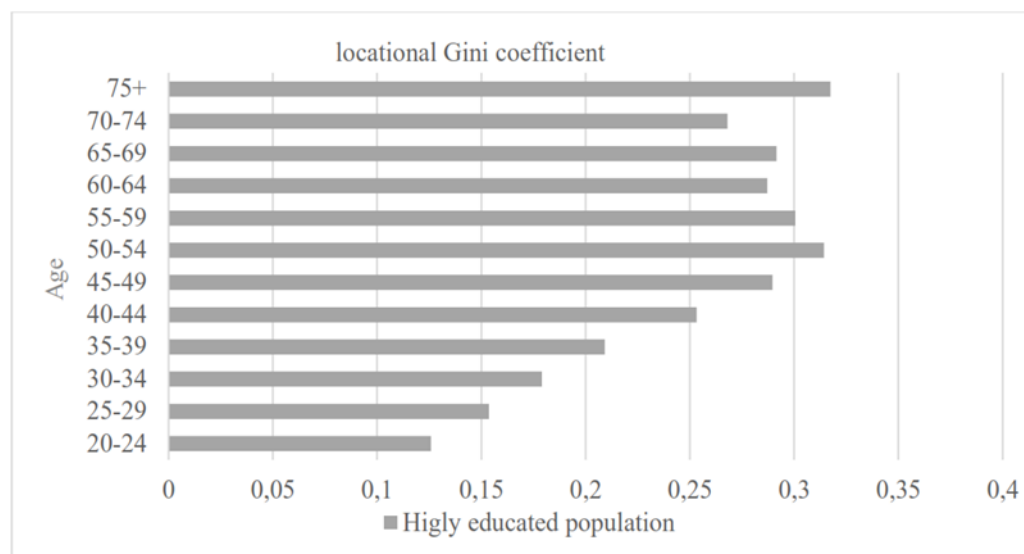


Figure 3. Locational Gini coefficient of spatial concentration of highly educated population in Croatia (2021) by the age groups (referential value = total population of a certain age group)

The research established the differences in spatial concentration of highly educated population among Croatian regions (Tab. 3). For the purpose of spatial analysis Croatia was divided into five so-called planning areas (regions): Central Croatia, East Croatia, North-West Croatia, North Adriatic and Lika and Central and South Adriatic [15]. In all regions highly educated population is more strongly concentrated than total population, and population with PhD even more than that.

The highest spatial concentration of total and highly educated population was established in Central Croatia, which is to be expected since the capital city Zagreb is situated in this area. There is a strong concentration of economic subjects and activity in general, especially tertiary sector [27] which mainly employs highly educated population. The most even population distribution of total and highly educated population is in the area of North-West Croatia. There is no larger macro-regional centre in that region so the population is less concentrated (Fig. 4).

In other plan regions there are larger macro-regional centres: Osijek in East Croatia, Rijeka in North Adriatic and Lika region and Split in Central and South Adriatic region. Even though the level of polarization of total and highly educated population in those regions is roughly equal there are certain differences. For example, total population is somewhat more evenly distributed in the area of East Croatia in regard to two coastal regions (North Adriatic and Lika, Central and South Adriatic). Lowland and agricultural character of East Croatia favours lower polarization of population, and Osijek is a traditionally weaker macro-regional centre than Split or Rijeka. On the other hand, population in coastal regions is mostly concentrated along the Adriatic coast, while the hinterland and islands are less populated [18]. When highly educated population is concerned, it is equally concentrated in those three regions. However, the exception are people with PhD who are more spatially concentrated in East Croatia. The network of higher education institutions is less developed on the territory of this region, and due to this fact almost 70% of all people with PhD in East Croatia live in Osijek, as a large university town. The biggest gap between spatial distribution of total population and

distribution of people with PhD was recorded in East Croatia, confirmed by locational Gini coefficient (0.2664 for highly educated; 0.6402 for PhD). In coastal macro-regional centres (Split, Rijeka) the concentration of people with PhD is not as noticeable as in East (and, of course, Central) Croatia.

Table 3. Spatial concentration of population in Croatia in 2021 in the so-called planning areas

Planning area	Herfindahl-Hirschman index			Gini coefficient			Locational Gini coefficient	
	P ₁₅₊	P _{He}	P _{PhD}	P ₁₅₊	P _{HE}	P _{PhD}	P _{He}	P _{PhD}
Central Croatia	0.2954	0.5161	0.7956	0.806	0.9115	0.9732	0.2040	0.3768
North-West Croatia	0.0243	0.0551	0.1137	0.4648	0.6301	0.7959	0.2384	0.4849
East Croatia	0.0381	0.0942	0.428	0.5587	0.7478	0.9241	0.2664	0.6402
North Adriatic and Lika	0.0678	0.1007	0.1941	0.6076	0.6916	0.8016	0.1382	0.3675
Central and South Adriatic	0.0622	0.1091	0.2588	0.6689	0.7657	0.8794	0.1851	0.4499
Republic of Croatia	0.0447	0.1105	0.3009	0.6727	0.816	0.9372	0.2482	0.5362

Note: P₁₅₊ – total population at the age of 15 and more; P_{He} – highly educated population; P_{PhD} – population with PhD Source: Same as in Table 1

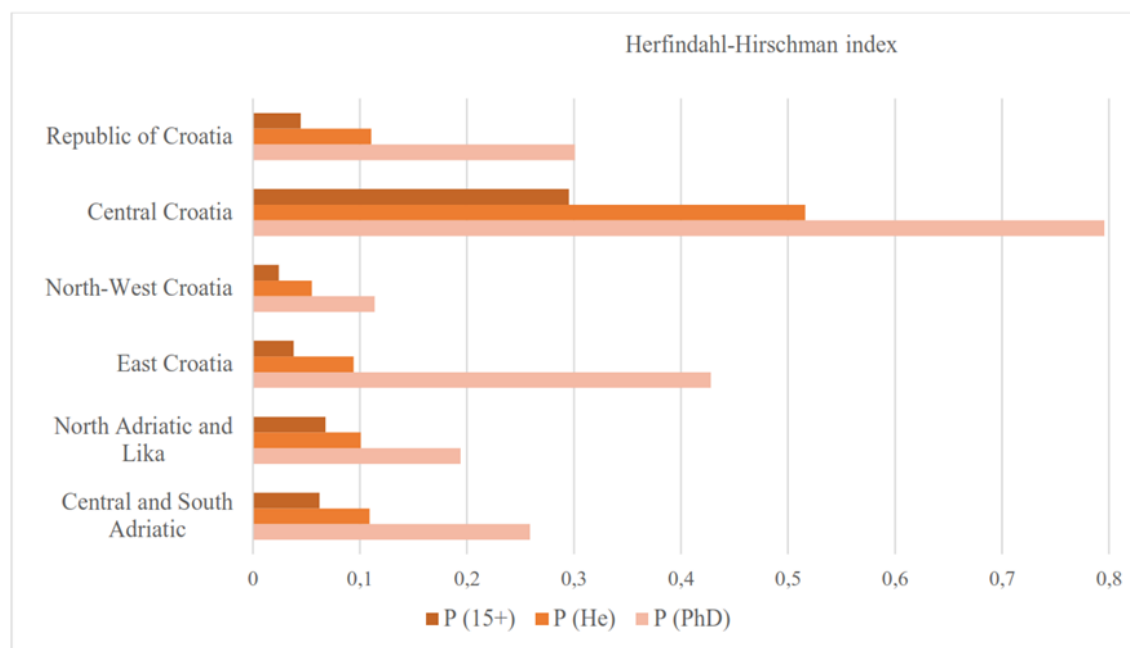


Figure 4. Herfindahl-Hirschman index of population spatial concentration (2021) in the so-called planning areas in Croatia

Patterns of spatial distribution of highly educated in Croatia

So far the analysis has pointed out the level of spatial concentration of highly educated but the used indicators do not reveal the patterns of their spatial distribution. Therefore, the rest of the paper will point out some patterns of distribution of highly educated in the Republic of Croatia.

The beginning of this paper pointed out the distinction between educational behaviour of young people in urban and rural areas. Since the analysis used statistical data at the level of administrative towns and municipalities, in the rest of the text the terms urban and rural will be used for the data which refer to towns and municipalities. The deficit of highly educated in rural areas in Croatia is visible from the information in table 4. Even though there are 28.3% of inhabitants aged 15 and more living in municipalities in the Republic of Croatia, there are only 16% of highly educated living there. Furthermore, there are significant differences among certain Croatian regions. The biggest disproportion between the portion of highly educated in administrative towns and municipalities is in Central Croatia - the region with the largest spatial concentration of highly educated. In Central Croatia 95.1% of highly educated live in towns, while the other 4.9% live in municipalities (rural areas). In most of the other regions - East Croatia, North Adriatic and Lika, Central and South Adriatic - a little over 75% of highly educated live in towns, and 20-25% in municipalities. The exception is North-West Croatia, the region with the most even population deployment, where the difference between the portion of highly educated in towns and municipalities is lower: 63.1% of highly educated in this plan region live in towns, and 36.9% in municipalities.

Table 4. Portions (%) of population aged 15 and more and highly educated population in towns and municipalities in planning areas in Croatia in 2021

Planning area	P ₁₅₊		P _{He}	
	Towns	Municipalities	Towns	Municipalities
Central Croatia	87.1	12.9	95.1	4.9
North-West Croatia	47.3	52.7	63.1	36.9
East Croatia	58.2	41.8	76.8	23.2
North Adriatic and Lika	70.6	29.4	75.4	24.6
Central and South Adriatic	71.1	28.9	78.8	21.2
Republic of Croatia	71.7	28.3	84.0	16.0

Source: Same as in Table 1

Below are the towns and municipalities with 25% or more of the population aged 15 and over with higher education. These are, in this order:

- in Central Croatia: Zagreb (39.1%), Zaprešić (27.9%) and Samobor (26.1%);
- in Easter Croatia: Osijek (30.2%);
- in North-West Croatia: Varaždin (32.1%), Koprivnica (26.2%) and Čakovec (25.7%);
- in North Adriatic and Lika: Kostrena (40.4%), Opatija (35.3%), Rijeka (32.8%), Kastav (32.7%), Medulin (32.3%), Omišalj (30.5%), Pula (28.6%), Fažana (27.4%), Punat (26.9%), Lovran (26.6%), Crikvenica (26.5%), Rovinj (26.5%), Malinska (26.1%), Kraljevica (26.0%), Viškovo (25.7%), Vrbnik (25.4%), Poreč (25.2%), Pazin (25.0%) and Matulji (25.0%);
- in Central and South Adriatic: Zadar (30.8), Šolta (30.2), Sutivan (28.4), Podstrana (28.3), Korčula (27.4), Bol (26.2), Jelsa (26.2), Janjina (26.1), Gradac (25.9), Vis (25.8), Šibenik (25.7), Makarska (25.7), Okrug (25.3), Orebić (25.2), Hvar (25.2), Župa Dubrovačka (25.1), Konavle (25.1) and Lastovo (25.0).

Space differences in the level of education are emphasized among continental and coastal regions in Croatia. Besides the city of Zagreb, and several other towns in continental part of Croatia, a significant accumulation of highly educated population can be noticed in coastal areas. For example, in Central and South Adriatic region there are more than 25% of highly educated in 21 towns or municipalities, and in East Croatia only in one local unit - the city of Osijek! Such spatial distribution pattern of highly educated is the result of different socio-economical characteristics of continental and coastal part of Croatia, for example the differences in the level of urbanization, differential economical models which do not have the same demand for highly educated and so on.

The concentration of the inhabitants with an academic PhD in urban areas is even more emphasized (Tab. 5). If we compare the towns and municipalities, it results with the fact that 92.6% of people with PhD in Croatia live in towns. That is especially emphasized in Central Croatia where 98.4% of people with PhD live in towns. In fact, more than a half of total number of people with PhD in Croatia is concentrated in the city of Zagreb.

Table 5. Portions (%) of population with academic PhD in towns and municipalities in planning areas in Croatia in 2021

Planning area	P _{PhD}	
	Towns	Municipalities
Central Croatia	98,4	1,6
North-West Croatia	73,3	26,7
East Croatia	90,0	10,0
North Adriatic and Lika	79,2	20,8
Central and South Adriatic	86,7	13,3
Republic of Croatia	92,6	7,4

Source: Same as in Table 1

CONCLUSION

The aim of this paper was to research spatial concentration of highly educated population in Croatia. With the continuous growth of highly educated, it was concluded that with every higher level of education the level of population spatial concentration grows as well. In the process, highly educated population shows significantly higher spatial concentration compared to total population, especially population with academic PhD. It is significantly the consequence of agglomeration of people with higher level of education in towns since they rarely find employment in their field of expertise in rural areas. Selective migrations according to the level of education are a threat to social and economic survival and improvement of rural areas.

The research has established the differences in spatial concentration of highly educated regarding age. The youngest highly educated population has a more even distribution in space since they still have not migrated towards larger urban centres. While looking for work many decide to move to larger towns. That results with the highest concentration of highly educated population in the area at the age of most work productivity - between the ages of 40 and 54.

The results of the research indicate that there are differences among Croatian regions in the level of spatial concentration of highly educated population, as well as in their spatial distribution in the state territory. The capital city is in Central Croatia so the highest level of the concentration of human resources was measured there, while in North-West Croatia, the region without larger urban centres, human resources are the least spatially concentrated. When the spatial distribution of human resources is concerned, the city of

Zagreb and its surroundings (and only a few other towns in continental part of Croatia) are standing out with high portions of highly educated in total population, as well as numerous towns and municipalities in the coastal area.

This research is based on the data from the Census in 2021. In order to provide the insight not only into the current state, but also into the direction and the dynamics of concentration processes, future research should include the previous census data as well. Furthermore, this paper emphasizes the measurements of the level of spatial concentration of highly educated population, while its spatial distribution is considered only marginally. Therefore, one of the future research should be directed at a more detailed research of the laws of spatial distribution of highly educated in Croatia.

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