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Regional differentiation of higher education in Russian regions in 2020

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ABSTRACT

The aim of this study was to evaluate the specific values of the indices that describe the spread of higher education institutions in all regions of Russia and the number of their students in the total working-age population living in these regions. The initial empirical data were the results of official statistical surveys conducted on information on the development of higher education, as well as the number of working-age population in eighty-two regions of the Russian Federation for 2020. In the course of the research, four mathematical models were developed. The study showed that on average, there are almost 14.8 higher education organizations per million working-age residents in the regions. It is proved that every twenty-fourth person of working age in 2020 studied under higher education programs. The conducted analysis showed the presence of a significant differentiation of the values of the considered indicators by region. The regions with the maximum and minimum values of the considered indicators were identified. It is shown that higher education has received significant development in Russia.

KEYWORDS: Higher education; university students; Russia; higher education institutions; working population.

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Diferenciación regional de la educación superior en las regiones de Rusia en 2020

RESUMEN

El objetivo de nuestro estudio fue evaluar los valores específicos de los indicadores que caracterizan la dispersión de las instituciones de educación superior en todas las regiones de Rusia, y el número de sus estudiantes en el número total de la población activa que vive en estas regiones. Los datos empíricos iniciales fueron los resultados de las encuestas y estadísticas oficiales realizadas sobre el desarrollo de la educación superior, así como el número de personas en edad de trabajar en ochenta y dos regiones de la Federación de Rusia para el año 2020. Durante el estudio, se desarrollaron cuatro modelos matemáticos. El estudio reveló que, en promedio, hay casi 14,8 organizaciones de educación superior por millón de habitantes en edad de trabajar en las regiones. Se ha demostrado que una de cada 24 personas en edad de trabajar en 2020 se inscribió en programas de educación superior. El análisis mostró una diferencia significativa entre los valores de los indicadores examinados por región. Se identificaron las regiones con valores máximos y mínimos de los indicadores considerados. Se muestra que la educación superior ha recibido un desarrollo significativo en Rusia.

PALABRAS CLAVE: Educación superior; estudiantes universitarios; Rusia; instituciones de educación superior; población activa.

Introduction

The role of the higher education system has significantly increased in recent years in developed and developing countries. According to many authors (for example, Pinheiro et al., 2015; Avdeeva et al., 2017) this is due to the fact that organizations specializing in teaching students in higher education programs provide significant economic growth and have a positive impact on the social climate in modern countries. Without specialists with higher education, both enterprises that produce various goods and specialized in providing various services cannot work in the twenty-first century. The introduction of technological and managerial innovations also requires highly qualified employees (Tamayo & Huergo, 2017; Schaarschmidt & Kilian, 2014). Therefore, conditions have been created in most states that provide access to higher education for the population (Guri-Rosenblit et al., 2007). As shown in the study (La mobilité internationale, 2019), in 2016, the number of students of

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higher education institutions in all countries increased by one and a half times compared to 2006 and reached 218 million people.

As indicated in scientific publications (Stiglitz, 2014; Douglas, 2011), one of the most urgent problems for modern national economies is the study of the achieved level of accessibility of education in higher education organizations. Our research is devoted to assessing the level of accessibility of higher education in the regions of Russia. Previous studies (for example, Abel & Deitz, 2011; Ciriaci, 2014) have proved the importance of developing the higher education system in the regions. This is especially true for countries with a large number of regions, where there is a need to consolidate young people in regional labor markets. The possibility of obtaining higher education in your region significantly improves the social climate and promotes higher education without moving to a new place of residence. In addition, the social status of the regions is increasing, and the prerequisites for their further economic growth are being created.

All this determines the increased interest in the study of regional aspects of the development of higher education. Calls for an in-depth study of the regional features of such education and the identification of differences between regions were expressed in the works (Cervantes, 2017; Unger & Polt, 2017).

In 2020, there were 1,259 institutes of higher education in Russia (Official statistical information on additional professional and higher education, 2021). Of these, 710 were independent organizations, in which 3550137 students studied. In addition, there were 549 separately located branches, which enrolled 499,196 students. Of the total number of students, 60% studied during the day with a break from work, 35% of students studied in the evening after finishing work. The remaining 5% of students received education by correspondence.

The purpose of our study was to evaluate the indicators describing the distribution of higher education organizations by regions of Russia, the share of students in the total population of working age in each of the regions, as well as the share of students admitted to study and graduated in 2020.

Our article makes a certain contribution to the knowledge about the regional features of the higher education system in Russia. The theoretical contribution is related to the methodology proposed by the authors, which allows us to estimate the distribution of

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the values of the indicators of the level of higher education by regions based on the development of mathematical models that represent the density functions of the normal distribution. Based on empirical data, in the course of the study, new knowledge was obtained about the number of higher education organizations per million working-age residents, the share of students receiving higher education in the working-age population by region, as well as the share of students admitted to higher education organizations in the working-age population and the share of students who received higher education. In addition, the regions with the maximum and minimum values of indicators characterizing the regional features of the higher education system are determined.

The structure of this work is as follows. The first section of the article presents a literary review devoted to scientific research on the problems of higher education in Russia. The second section demonstrates the methodological approach to the study of the problem under consideration, as well as the sources of empirical information used in the research process. The results of a computational experiment related to the development of normal distribution density functions are given in the third section. The fourth section contains a discussion of the results obtained, as well as a description of the regions with maximum and minimum values of indicators. The penultimate section is devoted to conclusions. The following is a list of the bibliography used.

1. Literature review

A brief analysis of scientific papers devoted to general issues of higher education in Russia and some of its regions is given in Table 1. The first column of the table shows the authors of scientific publications, the second column shows the main issues described in the publications and related to the assessment of the number of higher education institutions and the number of students studying in these organizations. The articles have been published in recent years.

As the data in Table 1 show, the problem of studying the indicators of the higher education system, and in particular the number of higher education institutions and the number of students studying in them, is relevant in Russia. Most of the scientific publications listed in Table 1 analyzed such indicators for Russia as a whole and its individual federal districts.

DOI: http://dx.doi.org/10.46925//rdluz.35.25

Table 1. Scientific publications on the volume of higher education development in Russia

Authors	Problems under study	Objects of study	Type of indicators
1	2	3	4
Bekmurzaev & Shamilev (2015)	Dynamics of the number of students in 2010-2014 studying at higher education institutions	Russian Federal districts	Comparative
Kashepov (2019)	The number of higher education organizations and students studying in them for the period from 2000 to 2018. Average duration of training	Russia	Factual
Krivich (2019)	The share of students who studied at state and non-state institutions of higher education in the total number of students for the period from 2013 to 2018	Russian Federal districts	Factual
Sudakova (2018)	Change in the number of universities and their students for the period from 2011 to 2016	Russia	Factual
Ushakova (2017)	Distribution by year from 2000 to 2016 of the number of students who studied under the master's, specialist's and bachelor's degree programs	Russia	Factual
Yudina (2019)	Analysis of the number of new students admitted to universities. The dynamics of changes in the indicator for 2001-2019 shows its decline for demographic reasons	Russia	Factual
Zborovsky (2018)	From 2013 to 2017, the number of independent higher education	Ural Federal district	Factual

	organizations decreased by 25% (from 71 to 53)		
Cherednichenko (2018)	Forms of study and the number of students enrolled in higher education organizations in 2000-2017	Russia	Factual
Bezhanova, Shkhagoshev, Shetov (2019)	Forecast of the dynamics of changes in the number of students at universities	Russia	Factual
Dorofeeva (2020)	Provision of educational services for the period 2007-2019	Russia	Factual
Belyaev (2021)	Comparative analysis of the change in the number of students in 2019 compared to 2015	Russia and federal districts	Factual
Kurbatova, Donova, Kranzeeva (2021)	Accessibility of higher education in mineral-rich regions	27 Russian regions	Comparative

Source: The table is compiled by the author on the basis of the information provided in the RSCI.

The issues of a comprehensive analysis of regional features of accessibility of higher education have been studied to a small extent in published works. Accordingly, there was no comparative analysis of the number of educational organizations in the regions of Russia, as well as the number of students in these organizations. Data in table 1 show that in the majority (83%) discussing publications we analyze factual values of indicators, that does not allow to make comparative analyze, since the regions differ from each other in the number of population, territorial features and economic development. Taking into account this conclusion, it is advisable to conduct a comparative analysis on the basis of comparative values of indicators, for example, taking into account the number of able-bodied population in the regions.

2. Methodology and design

Our paper examines information on all universities and other institutions of the higher education system that are located in each of the regions of Russia in 2020. As you

DOI: http://dx.doi.org/10.46925//rdluz.35.25

know, in Russia, students receiving higher education study for a different number of years. Thus, students study for four years in bachelor's degree programs, students belonging to the specialty degree study for five years, and students who additionally receive a master's degree study for two years. The number of students belonging to these three groups was considered in our study.

Our study consisted of four main stages. The first stage was associated with the definition of the initial empirical data, which for each of the 82 regions of Russia described such indicators as the number of public and private institutions of higher education, as well as the number of students who studied in them. At the same stage, data on the working-age population living in the regions in 2020 were determined. The second stage was devoted to the calculation of indicators that describe the number of higher education institutions per million residents of working age, as well as the share of the number of students in the total number of people of working age. The third stage was associated with the development of density functions for the normal distribution of indicators across the regions of Russia. The fourth stage was devoted to the discussion of the results obtained and the identification of regions with maximum and minimum values of indicators.

The study was based on data included in the official statistical report (Official statistical information on additional vocational and higher education, 2021). Data on the number of working-age population by region were taken on the basis of information from Rosstat (Official statistical information on the population of the Russian Federation by municipalities, 2021).

In our study, three hypotheses were tested:

- the first hypothesis is that higher education institutions operated in each of the regions of Russia in 2020;

- the second hypothesis is that there are significant differences in regional indicators that characterize the development of higher education;

- the third hypothesis is that the minimum and maximum values of the indicators were in the regions of Russia, which belong to different federal districts.

Mathematical modeling of the distribution of indicator values across the regions of Russia was based on the development of density functions of the normal distribution. The corresponding technique was demonstrated in the articles (Pinkovetskaya & Slepova, 2018;

DOI: http://dx.doi.org/10.46925//rdluz.35.25

Pinkovetskaya et al., 2021). Both the average values of the indicators and the average square deviations of the indicators for the totality of all regions are indicated directly in the functions.

The development of mathematical models describing the distribution of indicators using the density functions of the normal distribution is based on the construction of histograms. With a large amount of empirical input data (35 or more), we can group this information into intervals to make working with the data more comfortable. To do this, the source data is divided into a certain number of intervals.

The general form of the density function of the normal distribution is as follows:

$$y(x) = \frac{A}{\sigma \times \sqrt{2\pi}} \cdot e^{\frac{-(x-m)^2}{2\times\sigma\times\sigma}},$$

where:

x - the indicator whose distribution we are studying;

m - the average value of the indicator for all observed objects;

σ - the mean square (standard) deviation.

The obtained functions allow us to estimate the average values of each of the five indicators in the regions under consideration, as well as their variations typical for most regions. In addition, the study identifies regions where the indicators considered are above the maximum and below the minimum ranges. The limits of the indicator ranges for the majority (68%) of the regions are calculated based on the average values and the corresponding standard deviations. The lower bound of the range is equal to the difference between the mean and the standard deviation, and their sum corresponds to the upper bound of the range.

3. Modeling and results

The assessment of the distribution of indicators characterizing the activity of the higher education system in the regions of Russia was based on the development of mathematical models. Results of the development of models representing the density functions of the normal distribution (y_1 ; y_2 ; y_3 ; y_4) on such indicators (x_1 , %; x_2 , %; x_3 ; x_4) across all regions of Russia are specified further:

DOI: http://dx.doi.org/10.46925//rdluz.35.25

- the quantity of higher education institutions in calculation on million working-age people in the region

$$y_1(x_1) = \frac{398.29}{5.36 \times \sqrt{2\pi}} \cdot e^{-\frac{(x_1-14.79)^2}{2\times 5.36\times 5.36}}; \quad (1)$$

- the proportion of university students in the whole quantity working-age people in the region, %

$$y_2(x_2) = \frac{140.57}{1.72 \times \sqrt{2\pi}} \cdot e^{-\frac{(x_2-4.20)^2}{2\times 1.72\times 1.72}}; \quad (2)$$

- the proportion of students admitted in 2020 in universities in the whole quantity working-age people in the region, %

$$y_3(x_3) = \frac{44.51}{0.47 \times \sqrt{2\pi}} \cdot e^{-\frac{(x_3-1.07)^2}{2\times 0.47\times 0.47}}; \quad (3)$$

- the proportion of students finished universities in 2020 in the whole quantity working-age people in the region, %

$$y_4(x_4) = \frac{32.80}{0.38 \times \sqrt{2\pi}} \cdot e^{-\frac{(x_4-0.85)^2}{2\times 0.38\times 0.38}}. \quad (4)$$

The quality of functions (1)-(4) we tested using such criteria: by the Kolmogorov-Smirnov, the Pearson and the Shapiro-Wilk. Calculated values of criteria are given in Table 2.

The data shown in the second table shows that all four models well approximate the original empirical information. This conclusion is confirmed by comparing the calculated statistics and critical values. So, the calculated statistics on the Kolmogorov-Smirnov test in the second column of the table are in the range from 0.05 to 0.06, that is, less than the critical value equal to 0.174. Similarly, the calculated statistics on the Pearson test (the third column of table 2) are in the range from 2.35 to 4.49, that is, less than the critical value equal to 9.49. It is known that the critical value of the Shapiro-Fork test is 0.93, and the calculated statistics for this test are in the range from 0.95 to 0.98. Thus, the test showed that the requirements of all three criteria are met and the developed functions are of high quality.

DOI: http://dx.doi.org/10.46925//rdluz.35.25

Table 2. Calculated values of criteria

Indicators	Criteria		
	The Kolmogorov-Smirnov test	The Pearson test	The Shapiro-Wilk test
The quantity of higher education institutions in calculation on million working-age people in the region	0.06	4.48	0.95
The proportion of university students in the whole quantity working-age people in the region	0.06	4.13	0.96
The proportion of students admitted in 2020 in universities in the whole quantity working-age people in the region	0.06	4.49	0.95
The proportion of students finished universities in 2020 in the whole quantity working-age people in the region	0.05	2.35	0.98

Source: The data in the table are based on the results of calculated functions.

Based on the developed functions (1)-(4), an assessment of the average values of indicators, average square deviations and intervals in which the values of indicators characteristic of most regions of Russia are located, which are demonstrated in Table 3, was carried out.

4. Discussion

The analysis showed that in 2020 there were institutes of higher education in all 82 Russian regions. Therefore, the first hypothesis was confirmed. It should be noted that this fact seems to be fundamental, since it indicates the availability of higher education directly in the regions where adults live.

The information given in column 2 of Table 3 shows that for every million of the working-age population, on average, there are 14.8 institutes of higher education in Russia. The number of universities and their branches in most regions is in the range from 9.4 to 20.1 per million people of working age.

DOI: http://dx.doi.org/10.46925//rdluz.35.25

Table 3. The values of indicators describing the level of development of higher education in the regions of Russia in 2020

Indicator numbers	Average values	Standard deviation	Values for most regions
1	2	3	4
The quantity of higher education institutions in calculation on million working-age people in the region	14.79	5.36	9.43-20.15
The proportion of university students in the whole quantity working-age people in the region, %	4.2	1.72	2.48-5.92
The proportion of students admitted in 2020 in universities in the whole quantity working-age people in the region, %	1.07	0.47	0.6-1.54
The proportion of students finished universities in 2020 in the whole quantity working-age people in the region, %	0.85	0.38	0.47-1.23

Source: The calculations are carried out by the authors on the basis of functions (1)-(4).

The average share of university students is almost 4.2% of the total population of working age. Accordingly, out of twenty-four people of working age, one in 2020 was a student who studied at the institute of higher education. In most regions, the share of students in the working-age population was in the range from 2.5% to 5.9%.

In 2020, about 1.1% of all people of working age entered higher education institutions. For most regions, this indicator was in the range from 0.6% to 1.5%.

About 0.8% of the working-age population of Russia in 2020 successfully graduated from higher education institutions and became qualified specialists. For most regions, the

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values of this indicator were in the range from 0.5% to 1.2%. It should be noted that the number of students who successfully graduated from higher education institutions was less compared to those who entered the training. This seems logical, since not all those who have started their studies fully master the programs and become certified specialists.

Using the data in Table 3, the coefficients of variation for all four indicators were calculated. The coefficient of variation is the ratio between the mean square deviation and the average value of the indicator. The calculated coefficients of variation are given below:

- the first indicator is 36%;
- the second indicator is 41%;
- the third indicator is 44%;
- the fourth indicator is 45%.

The obtained coefficients of variation indicate that there was a significant (more than 33%) differentiation of the regional values of the considered indicators. Thus, the second hypothesis was confirmed.

The minimum and maximum values of the indicators were noted in the regions of Russia, the lists of which are shown in the fourth table. In the regions with the maximum values, the indicators exceeded the upper limits of the intervals indicated in the fourth column of the third table. Accordingly, in regions with minimal values, the indicators were less than the lower limit of these intervals. The fourth table for each of the regions shows not only the value of the indicator, but also the location of the region.

Table 4 provides information on the values of indicators for each of the regions (column 3), as well as their territorial location (column 4). The analysis of this information showed that there is no connection between the maximum and minimum values of the indicators and the territorial location of the regions. That is, the regions with high and low values of indicators are located in different federal districts. Thus, we can state the confirmation of hypothesis 3.

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Table 4. Characteristics of Russian regions with maximum and minimum indicator values

Indicators	Region	Value	Federal district
1	2	3	4
The quantity of higher education institutions in calculation on million working-age people in the region	With maximum values of indicators		
	Moscow city	20.54	Central
	Saint Petersburg city	21.87	North-West
	Yaroslavl region	21.89	Central
	Orel region	22.45	Central
	Astrakhan region	23.26	South
	Pskov region	23.60	North-West
	Sevastopol city	23.64	South
	Kamchatka territory	26.18	Far Eastern
	Sakha republic	26.34	Far Eastern
	Smolensk region	30.35	Central
	Chukotka autonomous district	31.53	Far Eastern
	With minimum values of indicators		
	Chechen republic	4.81	North Caucasian
	Tyumen region	4.90	Ural
	Kostroma region	5.87	Central
	Kabardino-Balkar republic	5.93	North Caucasian
	Novgorod region	6.31	Privolzhsky
	Ingushetia republic	6.68	North Caucasian
	Sakhalin region	7.13	Far Eastern
	Mari El republic	8.04	Privolzhsky
	Altai republic	8.41	Siberian
	Leningrad region	9.24	North-West
The proportion of university students in the whole quantity working-age people in the region	With maximum values of indicators		
	Kursk region	6.12%	Central
	Novosibirsk region	6.17%	Siberian
	Tatarstan republic	6.50%	Privolzhsky
	Voronezh region	6.55%	Central
	Orel region	6.85%	Central
	Omsk region	6.85%	Siberian
	Tomsk region	9.15%	Siberian
	Moscow city	9.89%	Central

	Saint Petersburg city	9.99%	North-West
	With minimum values of indicators		
	Chukotka autonomous district	0.44%	Far Eastern
	Leningrad region	0.58%	North-West
	Murmansk region	1.49%	North-West
	Moscow region	1.76%	Central
	Sakhalin region	1.96%	Far Eastern
	Jewish autonomous region	2.17%	Far Eastern
	Altai republic	2.23%	Siberian
	Tyumen region	2.24%	Ural
The proportion of students admitted in 2020 in universities in the whole quantity working-age people in the region	With maximum values of indicators		
	Sevastopol city	1.59%	South
	Oryol region	1.67%	Central
	Novosibirsk region	1.73%	Siberian
	Voronezh region	1.75%	Central
	Tatarstan republic	1.75%	Privolzhsky
	Omsk region	2.04%	Siberian
	Tomsk region	2.63%	Siberian
	Saint Petersburg city	2.98%	North-West
	Moscow city	3.01%	Central
	With minimum values of indicators		
	Chukotka autonomous district	0.08%	Far Eastern
	Leningrad region	0.09%	North-West
	Murmansk region	0.36%	North-West
	Jewish autonomous region	0.43%	Far Eastern
	Sakhalin region	0.43%	Far Eastern
	Moscow region	0.45%	Central
	Tyumen region	0.55%	Ural
	Magadan region	0.56%	Far Eastern
	Kamchatka territory	0.56%	Far Eastern
The proportion of students finished universities in 2020 in the whole quantity working-age people in the region	With maximum values of indicators		
	Kursk region	1.28%	Central
	Omsk region	1.38%	Siberian
	Tatarstan republic	1.41%	Privolzhsky
	Voronezh region	1.42%	Central
	Adygea republic	1.45%	North Caucasian
	Oryol region	1.50%	Central

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	Tomsk region	1.69%	Siberian
	Saint Petersburg city	2.04%	North-West
	Moscow city	2.26%	Central
	With minimum values of indicators		
	Chukotka autonomous district	0.05%	Far Eastern
	Leningrad region	0.09%	North-West
	Sakhalin region	0.31%	Far Eastern
	Murmansk region	0.31%	North-West
	Moscow region	0.35%	Central
	Magadan region	0.43%	Far Eastern
	Altai Republic	0.45%	Siberian
	Tyumen region	0.46%	Ural

Source: Developed by the authors on the basis of data from Table 3.

Conclusion

The research described in this article allowed us to gain new knowledge about the regional features of the development of the higher education system in Russia. The study contributed to the assessment of the accessibility of students' education in higher education institutions in regions where young people who want to study according to the relevant programs permanently live. In addition, a certain contribution was made to the study of the share of students in the working-age population of each of the 82 regions of Russia. The methodology proposed by the authors was based on the development of mathematical models describing the distribution of indicators by region. The purpose of our study was to evaluate the indicators describing the distribution of higher education organizations by regions of Russia, the share of students in the total population of working age in each of the regions, as well as the share of students admitted to study and graduated in 2020. The results of the study have a certain novelty and originality. Thus, based on empirical data, it was found that there are higher education organizations in each of the Russian regions. Consequently, people could receive higher education in the territory of the region in which they live. The study was based on the calculation of relative indicators that describe the relationship between the number of institutions of higher education and the number of university students and such a generalizing indicator as the number of able-bodied people. The study proved that the saturation of higher education institutions in

2020 was almost 14.8 institutes for every million people of working age on average in Russian regions. Calculations showed that out of twenty-four people of working age, one person studied at the Institute of higher education. In 2020, about 1.1% of people of working age started studying at higher educational institutions, and more than 0.8% of people of this age successfully completed their studies and became qualified specialists.

The results of the mathematical modeling of empirical data allowed us to conclude that there are significant differences in the values of each of the four indicators under consideration for different regions. A list of regions was compiled, which included regions in which the values of each of the four considered indicators were maximum and minimum.

The proposed author's methodology and the results of calculations are of interest to researchers, and can also be used in monitoring regional features of higher education in Russia and other countries. Especially those that have a significant number of territorial elements. In addition, the research results can be used in the practical activities of governments and public organizations directly related to the regulation and support of higher education institutions and the development of educational systems and technologies. The data directly related to the Russian regions can be used by applicants when choosing the direction and place of study.

The study used official statistical information on the quantity of institutions of higher education and the number of university students in all 82 regions of Russia, that is, there were no restrictions on empirical data in the study. Future research may be related to the assessment of the gender structure of university students in Russia.

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