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Clustering by the level of demographic potential of the regions of Kazakhstan based on SPSS

Abstract

Object: Based on a statistical analysis of the demographic development of the regions of Kazakhstan for the period from 1999 to 2020, to group the regions according to the main demographic indicators and conduct a comparative analysis and assessment.

Methods: Correlation-regression analysis, comparative analysis, multivariate statistical and mathematical method, special computer program SPSS.

Results: A comparative dynamic analysis of the regions of Kazakhstan between clusters for the period from 1999 to 2020 was carried out. As a result of the analysis, it was found that the main demographic indicators differ by clusters up to 2-3 times.

Conclusions: In general, the demographic development has been slow throughout the country over the years, and regions have been identified that are oriented towards a regressive way of development. First of all, it is proposed to solve the demographic problem of these regions in order to enter the way of progressive demographic development in the country as a whole.

Keywords: demographic situation, regions, trends, multifactor, grouping, cluster analysis rating.

Introduction

The demographic historical path of Kazakhstan has passed through various stages, and there is a large gap in the birth rate which is a key demographic factor. For example, in 1965, when the total fertility rate was about 35 units, there were 4.5 children per woman of childbearing age, and now this figure is 22 units and, accordingly, an average of 3 children. It corresponds to the cultural, educational, and rural population of the country at that time (66%) and is explained by the high demand for the birth of a child. The economic development of the country brings about changes in this indicator due to the desire of women of childbearing age to study and receive education, involvement in career activities, increasing interest in a residence in a city, increase in the average childbearing age of women, and deterioration in demand to have a child.

The main problem is that the population growth rate has stabilized at an average of 1.2% over the past 15 years, and the main demographic parameter – the total birth rate is limited to 22 units, and there has been a downward trend in recent years (Bureau of National Statistics, 2022).

If we considered this information at the global level, according to 2020 data, Kazakhstan ranks 81st out of 181 countries with a total fertility rate and 98th in terms of mortality rates, and Tajikistan (40; 175), Kyrgyzstan (61; 143), Uzbekistan (74; 145) are among countries with a higher demographic situation, respectively (Knoema, 2020).

Regional demographic development trends in the country especially in urban and rural populations have been identified along with the known data on the current demographic development trends. We also note that the average annual population growth of more than 1% does not indicate the stability of the demographic situation.

Literature Review

The demographic potential level of the regions has to be analyzed to determine their state of social and economic development. Dynamics in demographic processes influence all the directions of the economy: social, economic, and political (Gwiaździńska-Goraj, Pawlewicz, & Jezierska-Thöle, 2020).

Demographic potential identifies the region's attractiveness for citizens and investors, which in turn affect its social and economic development. It has been proven that regions with strong socio-economic devel-

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opment exhibit much more favorable demographic dynamics than weak regions (Porsche, L. Die Zukunft von Kleinstädten gestalten, 2015).

The scientists' opinions characterizing the historical path of demography development are different at the world level. Besides, the thesis about the nature of the multifactorial influence on fertility is the most common in modern demographic science, and the totality of these factors is interpreted by each demographer in different ways. For example, in the article "population" in the Encyclopedia Britannica, the factors influencing the birth rate decline in Europe over the past decade are industrialization, urbanization; raise in the education level of the population; dissemination of the concept of a small family, according to the conclusions of demographers (Teitelbaum, 2021).

As assumed by Lutz, Butz, and K.C. (2014) demographic study and forecasts appear to rely on two main issues: the speed of fertility decreases, and what takes place in the countries where fertility levels fall below a total fertility rate (TFR) (Morosanu, 2016).

As for the works of researchers in the history of economic demography, a close connection is found here between demographic processes and globalization in different historical epochs. It is noted that all globalization eras are associated with a demographic crisis, including in regions closely related to international trade, on the contrary, a decline was not observed in regions not included in the globalization process (Kuzovkov, 2013). The demographic process, accompanied by the process of globalization, provokes the population's migration movement. Coleman and Belanger noted the studies that examined immigration processes in the context of globalising world and its connection with ethno-cultural characteristics (Coleman, 2006; Belanger et al., 2019).

Thus, globalization and demographic cycles historically intersect. According to the World migration report for 2020, confirming the impact of the globalization process on the general demographic movement, including the immigration movement of the countries in the world, 3.6% of the total population are considered migrants (IOM UN Migration, 2021). In our studies, we also note that globalization had an impact on the historical process of demographic development in Kazakhstan.

Besides, world scientists in their studies associate the birth rate with the geographical place of residence and regions (Vasle, David, 2018; Bocquier, Bree, 2018).

They also note a high correlation between fertility and ethnic characteristics and traditions (Jianlin Niu & Yaqiang Qi, 2020).

Modern statisticians such as Myer & Well explain that right statistical tool is important to hypothesis testing, test statistics and research design. Statistical programs such as SYSTAT, SAS, SPSS, POWER, and UCLA are used for experimental research in the behavioral and social sciences. The result of the research will be offered as an option for other scientists to modify accordingly (Myer & Well, 2003). A repeated test of ANOVA is a suitable method for this analysis of socio-economic issues as we are comparing the means for related groups.

Problem statement

The demographic process in Kazakhstan as a whole has a positive trend; the population is growing every year though it has large differences in demographic parameters in the regions. Basically, there is a two-fold difference between the birth and death rates in the southern and northern regions. For example, in the Kostanay region, depopulation has been going on for twenty years which is a great problem.

Birth rates dropped sharply in the first years of independence (1991–2002), including in the northern regions. Subsequently, the improvement of the economic situation in the country increased the birth rate, and it remained at a low level and below the republican level in the northern regions. Compared to the national average of 17 regions, 9 regions have a lower total birth rate (TBR) and a higher total mortality rate (TMR).

The study found a correlation between the intensity of the total birth and death rates in the regions over the past 15 years ($R = -0.91$) which corresponds to a high birth rate and a decrease in the death rate in the regions. It is concluded that the regions, both with a good demographic situation and with a low one, are stably formed by these two main indicators.

Each country's region rating was determined with region classification by demographic indicators and situational analysis. Firstly, grouping according to the current actual demographic situation in the regions of the country and secondly, clustering of regions to determine the future demographic policy of the country was conducted.

Research method

A solution to grouping by complex parameters can be obtained by cluster analysis of multidimensional statistical and mathematical methods with special computer programs (Dubrov, Mkitaryan, & Trpshin, 2011; Rakhmetova & Dubrova, 2011).

The use of multidimensional data clustering methods is conditioned by the need to identify groups of Kazakhstan regions with a similar state of demographic development, to model the demographic space.

In our study, a large number of demographic parameters were summarized and divided into several groups regarding specifics to cover the general current situation based on cluster analysis in full. Coefficients were chosen as parameters to enable us to compare the regions. The data of these parameters for 2009–2020 were analyzed and used to obtain several options based on SPSS applications (Orlova, 2009; Nasledov, 2013) using the cluster analysis method for grouping (clustering) regions depending on the current demographic situation.

Group of parameters:

1. Birth rates:

- crude fertility rate, total fertility rate, fertility rate depending on the age groups of women, the proportion of persons having 3 children in turn, the proportion of persons having 5 children and more in turn;

2. Mortality rates:

- crude mortality rate, infant mortality rate;

3. Reproduction parameters:

- coefficients of natural increase, net reproduction rate;

4. Age structure of the population:

- proportion aged 0-14, proportion aged 15-64, proportion aged 65 and over, demographic burden.

A correlation analysis was performed under the terms of the cluster analysis method to exclude a high dependence between parameters, and parameters were selected to form the optimal number of features (Dubrov, Mkitaryan, & Trpshin, 2011). During the study, the influence of parameters on the prospects for the demographic development of the country and its specific values were taken into account in comparison with previous periods, national specifics (large families), and world countries that have the potential to grow or decrease (in particular, infant mortality is still high). The presence of a close correlation between some parameters prevented to obtain the required groups of parameters to obtain the expected options in the course of a comprehensive study.

As a result, clusterization was performed in six variants with averaged data for 2017–2020. This article provides an analysis of one variant, where clusterization was performed across the country by parameters (features): crude mortality rate (CMR), infant mortality rate (ASMR), demographic burden (DR), the proportion of 5 children born in turn (GFR:OS(5)) and more.

As a result of calculations, 17 regions of the country were divided into 3 clusters: high, medium, and low levels, which corresponded to the task.

It was assumed in the null hypothesis that the current demographic situation in the regions does not have any particular differences. The table results of the analysis of variance (ANOVA) showed that the sample groups and the p-value is small in comparison to the mean values. It follows that the null hypothesis is not fulfilled, justifying the existence of differences in the demographic parameters in the regions divided into three clusters (Table 1).

Table 1. Analysis of variance (ANOVA)

Variable	Analysis of Variance					
	Between SS	df	Within SS	df	F	siqnif. p
Zscore (CMR)	6,005	2	,230	13	26,102	,000
Zscore (ASMR)	2,950	2	,700	13	4,213	,039
Zscore (DR)	5,977	2	,234	13	25,501	,000
Zscore GFR:OS(5)	6,259	2	,191	13	32,794	,000
Note – Compiled by the authors						

Comparative analysis

The first cluster included 6 regions: Akmola, Karaganda, Kostanay, Pavlodar, Northern and Eastern Kazakhstan. The second cluster included 4 regions: Aktobe, Western Kazakhstan, Nur-Sultan and Almaty

city, and the third cluster included Almaty oblast, Atyrau, Zhambyl, Kyzylorda, Mangystau, Turkestan, Shymkent regions (Table 2).

Table 2. Average Values of Parameters by Clusters

No.	Regions	Parameters			
		CMR	ASMR	DR	GFR:OS(5)
1(6)	Akmola, Karaganda, Pavlodar, Kostanay, Northern and Eastern Kazakhstan	10.4	8.2	632	3.4
2(4)	Aktobe, Western Kazakhstan, Nur-Sultan, Almaty city	6.1	6.5	586	3.5
3(7)	Almaty oblast, Zhambyl, Kyzylorda, Mangistau, Atyrau, Turkistan, Shymkent	5.4	8.2	755	9.3
	Total Average	7.6	7.9	664	5.7
Note – Compiled by the authors					

The average value of the total mortality rate of the regions in the first cluster is twice as high as in the other two. Infant mortality is the same in the first and third clusters and lower in the second cluster. Comparison of the demographic burden through average values does not show the situation in full, since the demographic burden in the first cluster - 632 units is formed mainly by people over the age of 65 who make up 65% of the disabled population in the cluster. In the third cluster - 755 units is formed by children under 15 years old (75% in the average cluster), since the region has a high birth rate in the country.

Let us analyze the main parameters of the regions grouped by the demographic development state, for the trends in their change in the period from 2017 to 2020. In general, there has been a downward trend in mortality in the country over the past 20 years due to the current epidemic situation (COVID-19) in 2019-2020, and we included data for 2017 and 2020 in the analysis apart as mortality increased in 2017–2020.

In the regions of the first cluster, the mortality rate increased in 2017 compared to 2009 in four out of 6 regions by 2–11%, after this year there was a slight decrease in all regions, that is, by an average of 14%, while the mortality rate in this cluster is 33% higher than the national average one. Also, there was an increase of 17% in 2020 compared to 2017. In terms of the overall mortality rate in the regions of the first cluster, it is still higher (2017–44%, 2020–41%) (Table 3).

Table 3. Dynamics of Parameters in Clusters

Parameters	Years	Cluster			RK
		1	*2*	*3*	
Mortality growth rate, %	2017/2009	86	98	92	90
	2020/2017	117	133	131	125
TMR intensity, %	2009	133	89	81	100
	2017	144	88	80	100
	2020	141	89	83	100
TBR	1999	11.3	12.5	18.9	14.6
	2009	16.4	21	27.6	22.1
	2020	15.4	22.1	27.9	22.8
TFR	2009	2.3	2.5	12	7
	2020	5.1	6.8	22	13
Note – Compiled by the author					

Mortality rates in the second cluster are also lower than in the northern regions of the first group, but in 2020, one can see an increase in the number of deaths by 33% compared to 2017. The mortality rate in Nur-Sultan was 5 units in 2009 and 3.9 in 2017. It is explained by the fact that it is the city of youth and a high level of medical care, and in 2020 it rose by 1.4 units and amounted to 5.3 units. The two major cities have maintained levels lower than those of the Republic, averaging 20% lower between 2009 and 2020.

In the third cluster, the mortality rate in 6 regions decreased from 8.2 in 2009 to 5.7 in 2017, and it increased by 31% in 2020 compared to 2017. At the same time, the regions of this cluster are on average 20% lower than the republican level in the period from 2009 to 2020. If we compare the development

dynamics of these parameters in the regions included in the cluster with the level in the Republic, then we see the difference between the intensity.

Now we compare the total fertility rate in these clusters for 1999–2020, and in general the difference between the clusters is 5-6 units. Compared to 1999–2009, the dynamics of the total birth rate remained stable for the period 2009–2020. Scientists noted that this is one of the factors hindering the development of demographic processes in the country caused by the impact of the demographic crisis in 1991–2002. This parameter also shows that the first cluster is below the level in the Republic.

In total, there are about 3 children per woman of childbearing age in the country. However, it increases the total population by one or two percent. The proportion of three children per woman in 2019 compared to 2009 is growing in all clusters at a high rate, especially in the second cluster where it is doubled. This is not enough given our natural resources, especially land area. In general, a trend towards an increase in the share of large families has formed in the entire cluster, as evidenced, for example, by the trend of 2017–2020. When a detailed analysis of births of the number of children in turn is made, the tendency for the birth of the 1st and 2nd children in turn is decreased, this is due to a decrease in the number of women of childbearing age. The birth of 3 children in turn of mothers in some regions is also decreasing. Therefore, the main task of demographic policy is to increase the proportion of births of 5 or more children in turn, and this parameter is the main factor to solve the demographic problem. Due to the fact that 90% of the birth of the fifth child occurs in women aged 25-44, TFR, i.e. a special birth rate, for 1000 women aged 25-44 was calculated. When the data in Table 2 are analyzed for this parameter, we see a high difference between the clusters. There is a gap of almost 6 times between the first cluster and the third cluster. General demographic growth is possible only at the expense of a child from 4-5 and above.

For the rating assessment of this grouping of clusters, we calculate their rank total value using the following formulas (Kuvshinov, & Polovtsev, 2007)

$$K_j = \Sigma a_{ij} \tag{1}$$

$$\overline{K_j} = \frac{1}{n}\Sigma a_{ij},\ \mathrm{i} = 1, \dots, 4;\ \mathrm{j} = 1, \dots 17 \tag{2}$$

where K_j – the sum of the ranks of the i-th parameter of the j-th region;

a_{ij} – the rank of the i-th parameter of the j-th region;

n – the number of parameters;

j – region number;

$\overline{K_j}$ – the average sum over the cluster.

Here, the rank of the values for the parameters of regions in each cluster is determined and calculated by formula (1). Then the average value of the sum of ranks for clusters was calculated by formula (2). Here, the place of regions in the demographic situation is determined according to this option. The cluster with the lowest sum of ranks has a high ranking, high demographic state, and the cluster with the highest sum of ranks has a low demographic state. As a result, the rating of the 1st cluster was 46, the rating of the 2nd cluster was 34, and the rating of the 3rd cluster was 22 units.

Discussions

Analysis of the study results showed that a downward trend has formed in the demographic situation of 6 regions of the Northern and Central regions. In particular, the depopulation trend has continued in the first cluster in the Kostanay region over the past 10 years, and therefore it is required to take measures at the state level. The demographic situation in the city of Nur-Sultan in the second cluster maintains a stable situation associated with the internal city-village migration movement. The demographic parameter in the city of Almaty is latent, as it turned out because the birth rate is below the republican level, but Almaty with migration attractiveness gives an annual population growth that, one might say, has no demographic contribution to the country.

In addition to the prevailing demographic trends in the country, it became clear that there are differences in its regions, including in urban and rural areas. The average annual population growth of more than one percent does not indicate the stability of the demographic situation.

Conclusions

The regions of the country were grouped according to the distance of their quantitative values for 4 main demographic parameters using computer technology with multidimensional statistical methods. In the course of clustering, seventeen regions were divided into three clusters according to several features that

characterize the demographic situation of the regions in Kazakhstan. The state of demographic development of the regions in each cluster was assessed by the rating method, and the regions belonging to different three groups were identified: high (reproduction), medium (stationary), and low (regressive, variable) type. The following regions are in the process of constant growth: Almaty, Zhambyl, Kyzylorda, Mangystau, Atyrau, Shymkent, Turkestan regions. Demographically stable trends persisted in the Aktobe, Western Kazakhstan, Nur-Sultan and Almaty city. And the regressive or transitional trends include Akmola, Karaganda, Pavlodar, Kostanay, North Kazakhstan and East Kazakhstan regions.

The system of parameters affecting the demographic state of each region made it possible to identify the demographic potential in some regions, and the beginning of depopulation in other regions. Therefore, when fertility and mortality is predicted in the future, it is required to take into account the prospective features of each region (attractiveness, comfort of climatic conditions, infrastructure development, standard of living of the population, ethnic composition, etc.) and trends in the system of parameters characterizing the current demographic situation, determining the type of population reproduction in every region.

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SPSS базасында Қазақстан өңірлерінің демографиялық әлеуетін деңгейі бойынша кластерлеу

Аңдатпа

Мақсаты: 1999-2020 жылдар аралығындағы Қазақстан өңірлерінің демографиялық дамуына статистикалық талдау жүргізу негізінде өңірлерді негізгі демографиялық көрсеткіштер бойынша топтастыру және салыстырмалы талдау жасау және бағалау жүргізу.

Әдісі: Корреляциялық-регрессиялық талдау әдісін қолдана отырып, аймақтарды бірнеше демографиялық көрсеткіштер бойынша топтастыру үшін факторлар топтарын алдын-ала іріктеу жүргізілді және кластерлеудің нұсқалары анықталды. Мақалада SPSS арнайы компьютерлік бағдарламасы негізінде жүзеге асырылған көпөлшемді статистикалық-математикалық әдісті кластерлік талдауға арналған 4 фактор бойынша нұсқа ұсынылған.

Қорытынды: 1999-2020 жылдар аралығындағы кезеңде кластерлер арасында Қазақстан өңірлеріне салыстырмалы динамикалық талдау жүргізілді. Талдау нәтижесінде негізгі демографиялық көрсеткіштердің кластерлерде 2-3 есеге дейін айырмашылықтары бар екендігі анықталды.

Тұжырымдама: Тұтастай алғанда, бүкіл ел бойынша осы жылдар ішінде демографиялық дамудың баяулауы сақталды, сондай-ақ дамудың регрессивті жолына бағытталған аймақтар анықталды. Бірінші кезекте бүкіл ел бойынша прогрессивті демографиялық даму жолына шығу үшін осы өңірлердің демографиялық проблемасын шешу ұсынылады.

Кілт сөздер: демографиялық жағдай, өңірлер, үрдістер, көпфактор, топтама, кластерлік талдау, рейтинг.

Р. Рахметова, С. Калиева, Р. Андекина, А. Максютова

Кластеризация по уровню демографического потенциала регионов Казахстана на базе SPSS

Аннотация:

Цель: На основе проведения статистического анализа по демографическим развитиям регионов Казахстана за период с 1999 по 2020 гг. сгруппировать регионы по основным демографическим показателям и провести сравнительный анализ и оценку.

Методы: Используя метод корреляционно-регрессионного анализа, предварительно проведена выборка групп факторов для группировки регионов по нескольким демографическим показателям и определены варианты для кластеризации. В данной статье предложен вариант по 4 факторам для кластерного анализа многомерного статистико-математического метода, реализованный на базе специальной компьютерной программы SPSS.

Результаты: Проведен сравнительный динамический анализ регионов Казахстана между кластерами за период с 1999 по 2020 гг. В результате анализа установлено, что основные демографические показатели имеют различия по кластерам до 2–3 раз.

Выводы: В целом, по стране за эти годы сохранялось замедленное демографическое развитие, а также определены регионы, ориентированные на регрессивный путь развития. В первую очередь, предлагается решение демографической проблемы этих регионов для выхода на путь прогрессивного демографического развития, в целом, по стране.

Ключевые слова: демографическая ситуация, регионы, тенденции, многофактор, группировка, кластерный анализ, рейтинг.

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