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POPULATION DYNAMICS IN CENTRAL AND EASTERN EUROPE IN THE FIRST DECADE OF THE 21ST CENTURY

The aim of this paper is to explore the dynamics of population in Central and Eastern Europe. Based on the data from the online database Health Nutrition and Population Statistics of the World Bank, cluster analysis has been performed. It is established that during the first decade of the 21st century, the development of some demographic variables is not sufficient implying the necessity of measures to ensure a positive demographic trend, together with actions enhancing effective functioning of the economies in the region. Similar dynamics of some demographic variables, especially infant and child (under 5) mortality as well as life expectancy for both males and females was detected.

Keywords: *birth rate; Central and Eastern Europe; cluster analysis; life expectancy; mortality; population; demographic variable.*
JEL classification: C38; J11; J13.

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НАСЕЛЕННЯ ЦЕНТРАЛЬНОЇ ТА СХІДНОЇ ЄВРОПИ В ДИНАМІЦІ: ЗА ДАНИМИ ПЕРШОЇ ДЕКАДИ XXI СТОЛІТТЯ

У статті досліджено динамічні тренди населення Центральної та Східної Європи. Дані для аналізу взято з бази даних Світового Банку «Здорове харчування та статистика населення» та проаналізовано шляхом кластерного аналізу. Негативні тренди розвитку для декількох демографічних змінних протягом першої декади XXI ст. свідчать про необхідність вжиття заходів з одночасного покращення демографічної та загальноекономічної ситуації в регіоні. Також відмічено схожість динаміки розвитку деяких демографічних змінних за країнами регіону, зокрема, рівня смертності немовлят та дітей до 5 років, тривалість життя як для жінок, так і для чоловіків.

Ключові слова: *рівень народжуваності; Центральна та Східна Європа; кластерний аналіз; рівень тривалості життя; рівень смертності; населення; демографічна змінна.*
Рис. 8. Табл. 4. Літ. 18.

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НАСЕЛЕНИЕ ЦЕНТРАЛЬНОЙ И ВОСТОЧНОЙ ЕВРОПЫ В ДИНАМИКЕ: ПО ДАННЫМ ПЕРВОГО ДЕСЯТИЛЕТИЯ XXI ВЕКА

В статье исследованы динамические тренды населения Центральной и Восточной Европы. Данные для анализа взяты из базы данных Мирового Банка «Здоровое питание и статистика населения» и проанализированы посредством кластерного анализа. Негативные тренды развития по нескольким демографическим переменным в течение первого десятилетия XXI века свидетельствуют о необходимости принятия мер по одновременному улучшению демографической и общеэкономической ситуации в регионе. Также отмечена схожесть динамики развития некоторых демографических переменных по странам региона, в частности, относительно уровня смертности в младенчестве и до 5 лет, продолжительность жизни как женщин, так и мужчин.

Ключевые слова: *уровень рождаемости; Центральная и Восточная Европа; кластерный анализ; уровень продолжительности жизни; уровень смертности; население; демографическая переменная.*

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Introduction. In the second half of the 20th century, there has been a significant change in dynamics of the world's population. We are currently witnessing new demographic phenomena – the growth of population aging rate, decline in fertility rates in both developed and developing countries, a drop in the share of young population in the total population and productive population, longer life expectancy, reduced infant and child (under 5) mortality and total mortality as compared with previous periods etc. Further development of demographic characteristics in the global economy are elaborated in Gress (2006; 2008) and Chi and Ventura (2011). Dudas, Schonwiesner and Ulicna (2001) review basic demographic variables. Mladek and Kacerova (2008) dealt with the issues of population, especially aging population in Slovak Republic. Bleha (2006) draws attention to the necessity of using the results of population projections for the formation of state economic policy as well as other areas. Podolak (2002) elaborated on spatial aspects of fertility decline in Slovakia. All these authors, however, give some demographic aspects and their development only for Slovakia. In this article, we therefore decided to focus on the entire region of Central and Eastern Europe (CEE). This region witnessed a rather tumultuous development in the demographic, economic, political and social areas in the last two decades – the change of political regimes in individual states, fall of economies, worsening social indicators or significant change in certain demographic characteristics. We decided to focus on the development of demographic characteristics of the countries in the CEE region in the early 21st century.

In addition to basic demographic variables used in our analysis, other variables can have some effect on population dynamics. Belkin and Storozhenko (2010) analyzed the construction and housing and their impact on population dynamics, and concluded that the correlation between these characteristics is important in terms of changes in population dynamics, and construction expenditures in Russia generated 3 to 5 times more expenditures in other sectors (Belkin and Storozhenko, 2010: 78). An important issue is the study of "population momentum", which occurs in the third stage of demographic transition, where there is a significant population growth, and because of this momentum, the growth of population continues in the period when there is a decline in the fertility rate to replacement fertility rate (Blue and Espenshade, 2011: 721). Certain recommendations regarding the development of demographic variables at the beginning of the 21st century (which are also in line with the conclusions of this article) can be found in Demeny (2012: 693), who comes with controversial recommendations addressing demographic challenges, such as granting the right to vote to children (Demeny, 2012: 698–701). Urbaniak (2014) elaborations on economic impact of ageing population in Europe form the point of view of adopting new legislation towards the extension of working life in European countries. From the regional on population dynamics view, de Graaff, van Oort and Florax (2012) presented an important analysis of employment dynamics in different economic sectors. They attempted to compile a model for interaction between population and employment, and argued that population is an exogenous variable for employment and changes in population have the greatest impact on employment in the retail sector, education and health (de Graaff et al., 2012: 81). For national economy development, it is important to know the population dynamics and its characteristics for proper planning of economic policy. Trends in population development may impact on the environment, and in turn, changes in the environment may affect the eco-

nomic development of the state. Jiang and Hardee (2011) studied the impact of population on climate change. They state that changes in population trends have a major impact on greenhouse emissions. In future, the development of key demographic characteristics (those discussed in the article – age structure, distribution of population between urban and rural areas, but also, for example, structure and size of households) will play a vital role in the reduction of emissions and reducing climate changes (Jiang and Hardee, 2011: 307). In terms of the impact of population growth on economic growth, the work by Minh (2009) is significant. It is dedicated to the effects of age structure on economic growth in Vietnam, pointing to the fact that during the first decade of the 21st century, there was a significant change in demographic variables of Vietnam with the growth of workforce and reducing the dependency ratio. Minh notes that demographic change has contributed over the last 5 years by 15% to economic growth (Minh, 2009: 389). Senesi (2003) deals with the impact of the level of wealth and age structure on aggregate consumption. Based on the established model, he notes the impact of age structure and population dynamics on the life cycle, concluding that the propensity to save should fall in economies where there is aging population ceteris paribus (Senesi, 2003: 392).

The aim of this paper is to divide the CEE countries by their demographic characteristics to different groups with the most similar characteristics within groups and the most dissimilarities among groups and to identify population dynamics and its changes within these groups. In addition, we try to answer the question whether in these countries due to geographical and cultural proximity convergence or divergence occurred in population dynamics during the analyzed period.

Methodology and data. In determining the objects of the analysis (CEE countries), we used the definition of the region by (OECD, 2007). Except the list of the countries included in the OECD definition, we joined also the countries that form part of the mentioned region – namely Bosnia and Herzegovina, Macedonia FYR, Montenegro, and Serbia. As a basis for analysis, we used the variables obtained from the online database "Health, Nutrition and Population Statistics" of the World Bank (Health Nutrition and Population Statistics, 2014). All data for individual countries come from the database. As the base years for the analysis, we selected years 2001, 2006 and 2011. For these years, we were able to obtain complete data for all analyzed countries[4], which allowed for sufficient analysis of population dynamics in the countries of the region in the first decade of the 21st century. In the analysis of population dynamics in the countries of the CEE region, we applied cluster analysis. We chose cluster analysis based on its design to group observations or variables into clusters based upon similarities between them. The aim of the decomposition of the CEE countries was to create several rather homogenous groups (clusters). We concentrated on joining the statistical units (countries) in each cluster that were the most similar to each other. Units in different clusters were to be, however, the most dissimilar. Cluster analysis allowed creating several groups of the analyzed units. Individual groups contain units with the most similar demographic characteristics (in terms of selected variables). In the analysis, we used the Ward's clustering method. The distance between objects was expressed by the square Euclidean distance. Based on the

[4] The only exception is variable "Population growth" for 2011 for Croatia, where data were not available. Therefore, we decided to use the average annual population growth for years 2000–2010 for Croatia to fill in the missing data.

cluster analysis, we identified 6 main clusters of the observed CEE countries with similar characteristics within clusters and prevailing different characteristics among them. Tables 2 and 3 show these clusters. Appendix A presents the dendrogram for 2001 as the output of the performed cluster analysis.

Individual variables for analysis were divided into 6 basic groups as shown in Table 1. In the group "State of population", we analyze the basic demographic variables – total population and annual population growth. The group "Age structure" comprises 4 variables particularly important for national economy. The first two relate to the share of unproductive population in total population. The other two directly relate to the development of key macroeconomic indicators, particularly GDP formation, the level of household consumption and income and expenditure of national budget (the impact on direct and indirect taxes and transfer payments).

Table 1. **Summary of input variables,** *authors'*

Group	Variable	Unit	Label
State of population	Total population	mln	POP_t
	Population growth (annual)	%	POP_g
Age structure	Population aged 00–14 (% of total)	%	POP_y
	Population aged 65 and above (% of total)	%	POP_o
	Age dependency ratio, young	%	AGE_y
	Age dependency ratio, old	%	AGE_o
Fertility	Total fertility rate	Births per woman	FER_t
	Adolescent fertility rate	Births per 1,000 women ages 15–19	FER_a
Natality and mortality	Crude birth rate	Live births per 1,000 midyear population	CBR
	Crude death rate	Deaths per 1,000 midyear population	CDR
	Infant mortality rate	Infants dying before reaching one year of age per 1,000 live births	MR_i
	Under 5 mortality rate	Probability per 1,000 that a newborn baby will die before reaching age 5	MR_u5
Life expectancy	Life expectancy at birth, male	Years	LE_m
	Life expectancy at birth, female	Years	LE_f
Urban population	Urban population (% of total)	%	URB_%
	Urban population growth (annual)	%	URB_g

The third group is "Fertility", which tracks the total fertility of women of childbearing age (15–49 years) and adolescent fertility (15–19 years). Total fertility is particularly important for the maintenance of population, it should reach the theoretical minimum of 2.1 children per woman[5]. Adolescent fertility rate is important for national budget. On the revenue side, the country loses on direct taxes, because young mothers stay at home with children, on the expenditure side, there is upward pressure on expenditures related to the provision of basic needs for children. In the group "Natality and mortality", there are 4 variables. The first two – crude birth rate and crude death rate are important to natural increase or decrease of population. In the

[5] For more information on the minimum total fertility rate see (McFalls, 2007: 5).

analysis, we include the variables related to infant and child mortality, which may provide information on the state of health in the analyzed countries. The penultimate group "Life expectancy" comprises the variables on life expectancy of males and females. The development of these variables over time is important for economies to correctly setting the retirement age, which has impact on the expenditure side of the national budget in the absence of pension savings in the private sector. The last group is "Urban population", where we analyze the total urban population as a percentage of the total population and the growth rate of urban population.

In the second part of the article, we analyze the CEE countries grouped into clusters based on the variables in Table 1. In the analysis, we use the following algorithm steps: in the first step, we identify and analyze the composition of each cluster created based on the data from the base year 2001. In the second step, we identify the main differences between the clusters based on the variables included in the analysis. During the second step, we performed two partial analyses. The first analysis aims to identify differences between the clusters based on the variables in the selected years. The second partial analysis focuses on the dynamics of changes over the selected period (2001–2011), concentrating on the development of individual clusters over time. In the analysis, we gradually identify the variables' changes over time for all clusters, which allows for better comparison of variables' dynamics.

Output analysis. This section analyzes the composition and dissimilarities of clusters of the CEE countries grouped basing on the variables from Table 1. In the first step of output analysis, we identify and analyze the structure of individual clusters. In the second step of analysis, we identify the main differences between clusters based on input variables. For the identification of dissimilarities among clusters, we used the centroids of the variables for all the clusters in the selected years. Table 2 summarizes the basic information on individual clusters; Appendix B shows cartographic interpretation. Table 3 provides the summaries of the characteristics of each cluster based on the analyzed variables.

Table 2. **Summary of cluster characteristics,** *authors'*

Cluster	Members	Percent	Countries
1	1	6.25	Albania
2	5	31.25	Bosnia and Herzegovina, FYR Macedonia, Montenegro, Serbia, Slovakia
3	2	12.5	Bulgaria, Romania
4	3	18.75	Croatia, Czech Republic, Slovenia
5	4	25	Estonia, Hungary, Latvia, Lithuania
6	1	6.25	Poland
Total	*16*	*100*	

2001 served as the base year for cluster analysis. We assumed the individual clusters of the CEE countries to be rather homogenous, creating clusters of geographically neighboring countries. However, the results were not in accordance with our assumption. From the cartographical point of view (Appendix B, Table 2), one can see that only geographically homogenous clusters are clusters 1, 3, and 6. Clusters 1 and 6 comprise only one country from the CEE region – Albania (cluster 1) and Poland (cluster 6). Cluster 3 is composed of two neighboring countries – Bulgaria and Romania. Clusters 2, 4, and 5 are relatively geographically homogenous with one

country in each cluster that do not share common state border with other countries in these clusters. Cluster 2 consists of 5 countries, mostly from the South of the region with the exception of Slovak Republic. Cluster 4 comprises three countries with Czech Republic not sharing the borders with other two countries from this cluster – Croatia and Slovenia. Cluster 5 consists of 4 countries, 3 of them being the Baltic states (Estonia, Latvia, and Lithuania). Hungary is the only member of this cluster that does not share border with other members of this cluster. Based on the results of the cluster analysis we point to the fact that the countries of the CEE region draw their demographic characteristics not basing on purely geographical closeness, but also on other factors, therefore, clusters are not geographically homogenous.

Table 3 shows clusters characteristics based on centroids. We computed centroids of each characteristic for each cluster using the average values of available data for each demographic characteristic. In the next step of our analysis, we identify the key differences among clusters in each year.

Basing on the results in Table 3 we note significant differences among clusters for selected demographic variables. For the first group of factors (State of population), cluster 6 (Poland) with the total population of 38.25 mln exceeded the total population of all other clusters put together by more than 6 mln. However, it did not perform well in terms of population growth, which was positive only for clusters 2 (0.3%) and 4 (0.04). Cluster 3 witnessed the most negative population growth, -1.62%. Concerning the group "Age structure", cluster 1 is the cluster with the highest share of young population in the total population and the lowest share of old population. The situation changed considering the dependency ratio, where young population dependent on productive population was the lowest in cluster 4 and the highest in cluster 1. Concerning the dependency ratio of old population, cluster 1 recorded the lowest share and cluster 5 – the highest share. As mentioned earlier, group "Fertility", especially for adolescent fertility, is important from the point of view of national budget expenditures. We note that only cluster 1 had total fertility at the level sufficient to maintain population, even though the growth rate of population was negative. Total fertility for all other clusters was below the minimum replacement level with clusters 3 and 4 being the worst at 1.24. Adolescent fertility rate was the highest in cluster 3 (41.17) and the lowest in cluster 4 (12.27). Taking into account the group "Natality and mortality" with 4 different demographic variables, cluster 1 (Albania) performed the best in two of these variables – crude birth rate and crude death rate (16.1. for CBR; 5.94 for CDR). However, for infant and child mortality the results were the worst (22.2 for MR_i; 25 for MR_u5). On the other hand, clusters 3 and 5 recorded the lowest birth rates and the highest death rates (CDR in cluster 5 was 2.2 times higher than in cluster 1). Life expectancy for males was the highest in cluster 1 (71.7) and lowest in cluster 5 (66) with a difference of almost 6 years. On the other hand, considering the life expectancy of females, cluster 6 recorded the highest value of 78.4 and cluster 3 – the lowest at 75.05, which makes a difference of approx. 3.5 years. Concerning the last group of variables – "Urban population" – the lowest share of population living in cities was in cluster 1, where less than half of the total population lives in rural areas (42.75%). All other clusters recorded more than half of the total population living in urban areas; cluster 5 had the highest average urban population, 67.33%. Even though the clusters 1 and 5 performed the worst and the best

respectively, the situation was quite different in urban population growth rate, where cluster 1 ranked first with the annual rate of 1.82% and cluster 5 got the rate of -0.37%. Cluster 3 witnessed the most negative rate at -1.48%.

Table 3. **Cluster characteristics based on input variables,** *authors' own calculations*

	2001							
Cluster	**POP_t**	**POP_g**	**POP_y**	**POP_o**	**AGE_y**	**AGE_o**	**FER_t**	**FER_a**
1	3.286	-0.57	29.70	7.12	47.00	11.27	2.14	16.25
2	3.888	0.30	20.33	11.57	29.86	17.00	1.51	23.00
3	15.076	-1.62	16.64	15.23	24.42	22.35	1.24	41.17
4	5.556	0.04	16.15	14.75	23.39	21.37	1.24	12.27
5	4.347	-0.48	17.61	15.09	26.18	22.42	1.29	21.20
6	38.248	-0.54	18.68	12.51	27.15	18.18	1.31	16.02
Cluster	**CBR**	**CDR**	**MR_i**	**MR_u5**	**LE_m**	**LE_f**	**URB_%**	**URB_g**
1	16.10	5.94	22.20	25.00	71.71	77.89	42.75	1.82
2	11.03	9.62	10.64	12.10	70.71	76.53	53.35	0.61
3	9.25	12.85	19.65	22.80	68.05	75.05	61.06	-1.48
4	8.97	10.33	5.53	6.50	71.74	78.72	60.13	0.08
5	9.05	13.05	9.83	11.95	66.00	76.73	67.33	-0.37
6	9.60	9.50	7.80	9.00	70.20	78.40	61.66	-0.62
	2006							
Cluster	**POP_t**	**POP_g**	**POP_y**	**POP_o**	**AGE_y**	**AGE_o**	**FER_t**	**FER_a**
1	3.179	-0.52	25.75	8.88	39.40	13.59	1.69	17.76
2	3.878	-0.02	18.40	12.71	26.76	18.48	1.42	19.95
3	14.643	-0.37	14.32	16.22	20.60	23.36	1.35	37.91
4	5.572	0.20	14.80	15.74	21.35	22.72	1.34	10.16
5	4.274	-0.37	15.26	16.42	22.33	24.05	1.39	19.31
6	38.141	-0.06	15.99	13.31	22.62	18.83	1.27	14.81
Cluster	**CBR**	**CDR**	**MR_i**	**MR_u5**	**LE_m**	**LE_f**	**URB_%**	**URB_g**
1	13.28	5.86	16.70	18.70	73.22	79.56	47.91	1.81
2	10.36	10.36	8.62	9.80	71.38	76.97	53.83	0.02
3	9.90	13.35	14.85	17.10	68.90	76.05	61.71	-0.03
4	9.68	10.21	4.30	5.13	73.52	80.28	60.22	0.24
5	9.98	13.43	7.23	8.70	66.79	77.33	67.74	-0.17
6	9.80	9.70	6.20	7.20	70.90	79.60	61.35	-0.23
	2011							
Cluster	**POP_t**	**POP_g**	**POP_y**	**POP_o**	**AGE_y**	**AGE_o**	**FER_t**	**FER_a**
1	3.154	-0.96	22.08	10.35	32.67	15.31	1.52	15.50
2	3.839	-0.13	17.00	13.20	24.40	18.96	1.44	17.04
3	14.367	-0.57	14.22	16.75	20.58	24.30	1.38	33.48
4	5.610	0.05	14.52	16.79	21.15	24.47	1.48	9.02
5	4.100	-1.17	14.90	17.14	21.94	25.24	1.46	15.79
6	38.534	0.91	14.93	13.75	20.93	19.28	1.30	12.72
Cluster	**CBR**	**CDR**	**MR_i**	**MR_u5**	**LE_m**	**LE_f**	**URB_%**	**URB_g**
1	12.75	6.24	12.80	14.30	74.01	80.22	53.38	2.13
2	10.36	10.67	6.48	7.40	72.54	77.96	53.91	-0.20
3	9.40	13.25	10.70	12.30	70.85	78.00	62.95	-0.96
4	10.17	10.30	3.23	3.93	75.17	81.47	60.40	-0.92
5	10.05	12.93	5.00	6.00	69.78	79.53	68.45	-3.98
6	10.10	9.70	4.90	5.80	72.60	81.10	60.89	0.83

In the span of 5 years (2001 to 2006) there were no significant changes in the analyzed demographic variables dynamics among the clusters. The most important changes include the change in population growth rate, when, in 2006, only cluster 4 recorded population growth, and all other clusters recorded population decline. Concerning total fertility, cluster 1 recorded the decline below the replacement level from 2.14 in 2001 to 1.69 in 2006, which was still the highest total fertility of all the clusters. We identified the last change between 2001 and 2006 in urban growth rates, where there was a change in the highest decline from cluster 3 in 2001 to cluster 6 in 2006.

Concerning the last year of our analysis – 2011 – the greatest changes in dynamics of demographic variables, compared to the previous years, were identified in population growth rate and urban growth rate. For population growth rate, there was a change in cluster 6, which recorded the positive rate at 0.91% in 2011, while cluster 5 recorded the lowest negative rate at -1.17%. For urban growth rate, there was a significant change in cluster 5, the most negative rate being at -3.98% in 2011 (after -0.17% in 2006 and -0.37% in 2001).

In the last step of the analysis, we focus on dynamics and changes in the selected individual demographic variables in each cluster during the selected period. In order to provide lucid figures, we normalized the values for each variable based on unity-based normalization. All data values take the value from 0 to 1, with the lowest data value being 0 and the highest being 1.

Cluster 1. Population dynamics in cluster 1 (Figure 1) shows both positive and negative progress for the analyzed demographic variables. Based on Figure 1 we note, that negative dynamics in population growth led to total population decrease over the years 2001–2011. In addition, age dependency ratio of young population fell, while age dependency ratio of the old population increased. This fact may lead to future population aging, which is already a problem in the old EU member states and may pose a threat for the national budget of Albania from the point of view of increased expenditures on healthcare. Another problem with deteriorating variable is a decline in the total fertility rate. In 2001, Albania was the country with the highest total fertility rate, which was even above the replacement level at 2.14. However, during the first decade of the 21st century total fertility rate declined to only 1.52, which, even being the highest of all the observed clusters, is still below the replacement level. Crude birth rate decreased, which was in line with the changes in the total fertility rate and crude death rate slightly increased. Despite negative dynamics in total fertility rate, other variables improved, especially infant and under-5 mortality rate, which declined; life expectancy at birth for both males and females, which increased over the analyzed years; and urban population as a share of total population together with urban population growth.

Cluster 2. Dynamics of demographic variables in cluster 2 demonstrates similar evolution of these variables as seen in cluster 1. Population growth declined in cluster 2 leading to a decline in total population. There was also a decrease of young population and increase of old population in total population, which leads to the same conclusion as in cluster 1 – age dependency of young population declined over the analyzed decade and age dependency of old population increased. As in all other clusters, total fertility rate declined, however, it did not reach at least the replacement

level in any of the analyzed years. The dynamics of this variable suggests there will be further decline in total population with increasing share of old population in both total population and productive population. Cluster 2 witnessed the same changes in both crude birth rate and crude death rate as cluster 1. There was a rapid improvement in decrease of infant and child under 5 mortality rates, which were reduced almost by 50%. Life expectancy of males and females and the share of urban population in total population also witnessed positive dynamics, even though the female life expectancy was the lowest among all clusters, at 77.96 years in 2011.

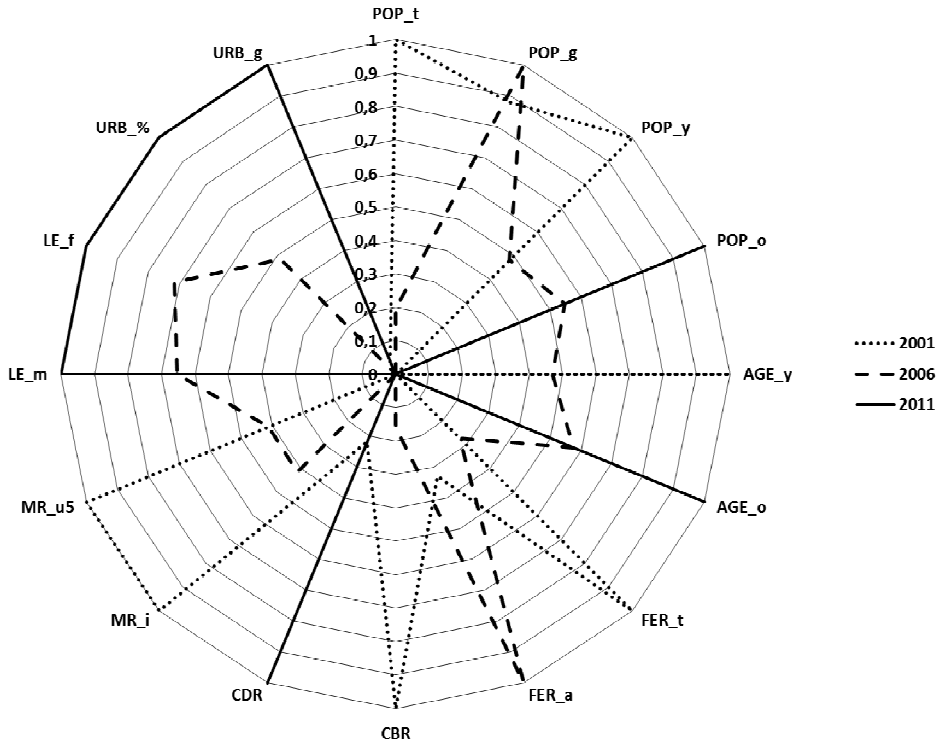

Figure 1. **Population dynamics in cluster 1,** *authors'*

Cluster 3 recorded different changes in demographic variables than the previous two clusters. Even though there was a decline in total population of this cluster, population growth improved. In 2001 population growth was the lowest among the clusters, at -1.62%, however, it improved to -0.57% in 2011 (2006 saw the best performance of this variable – -0.37%). Concerning the share of young and old populations in both total population and productive population, there is a similar pattern as in clusters 1 and 2. The share of young population declined and the share of old population increased. There was a positive change in total fertility rate as opposed to clusters 1 and 2. Even though total fertility increased, it did not reach the replacement level (increase from 1.24 in 2001 to 1.38 in 2011 is still far below the replacement level at 2.1). Changes similar to clusters 1 and 2 included the positive evolution of infant and under-5 mortality rate, which decreased, and males and females life expectancy, which increased.

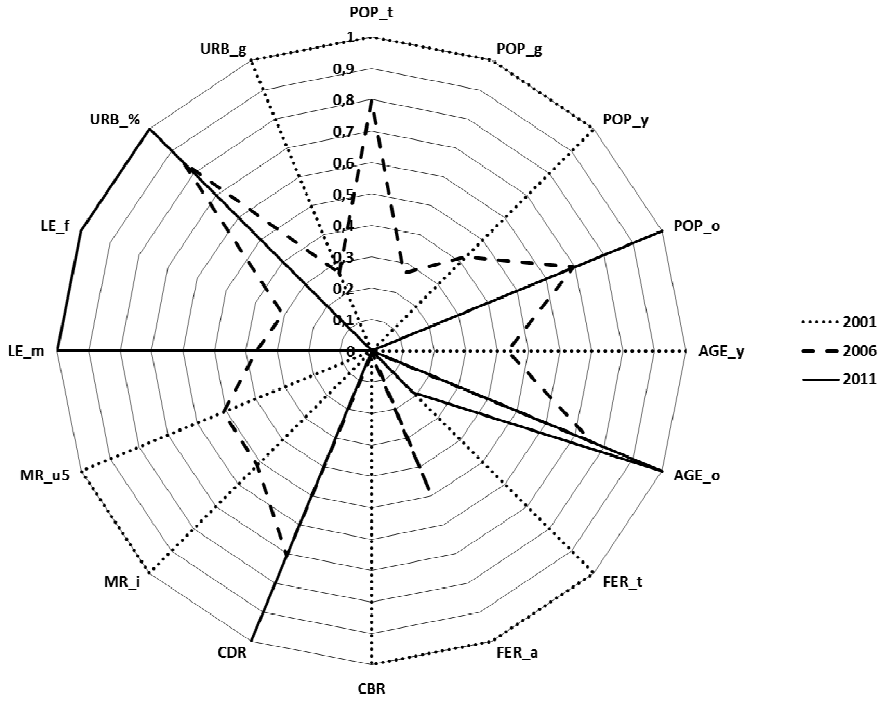

Figure 2. **Population dynamics in cluster 2,** *authors'*

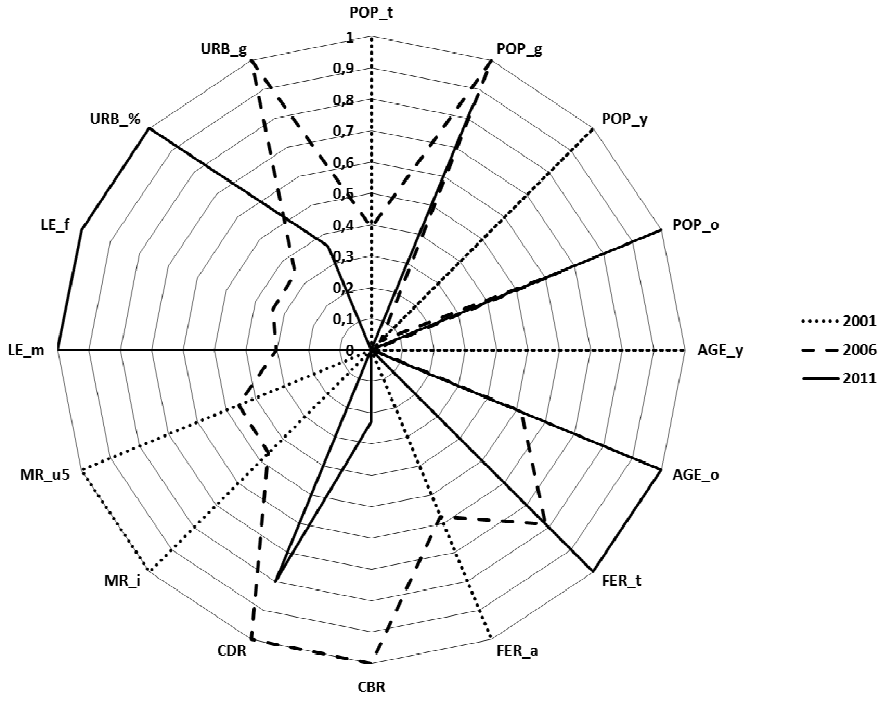

Figure 3. **Population dynamics in cluster 3,** *authors'*

Cluster 4 together with cluster 6 witnessed the growth in total population despite the negative dynamics of population growth. On the other hand, only cluster 4 recorded population growth over the analyzed decade (from 0.04% in 2001 through 0.2% in 2006 to 0.05% in 2011). Changes in the share of young and old population in both total and productive population are similar to all other clusters. However, changes in total fertility rate are similar to clusters 3 and 5 with a positive dynamics. The only negative aspect of this dynamics is, as noted for cluster 3, the increase below the replacement level (1.48 in 2011). Dynamics in crude birth rate and in crude death rate is different from the previous clusters. While there was an increase in the crude birth rate, crude death rate declined. We note the same dynamics in infant and under-5 mortality rates, males and females life expectancy, and urban population as in previous clusters. Cluster 4 performed best in mortality rates among all the clusters. Infant mortality reached 3.23 and under-5 mortality reached 3.93 in 2011. Concerning male and female life expectancy, in 2011 cluster 4 reached the highest numbers for both variables, 75.17 and 81.47 years respectively.

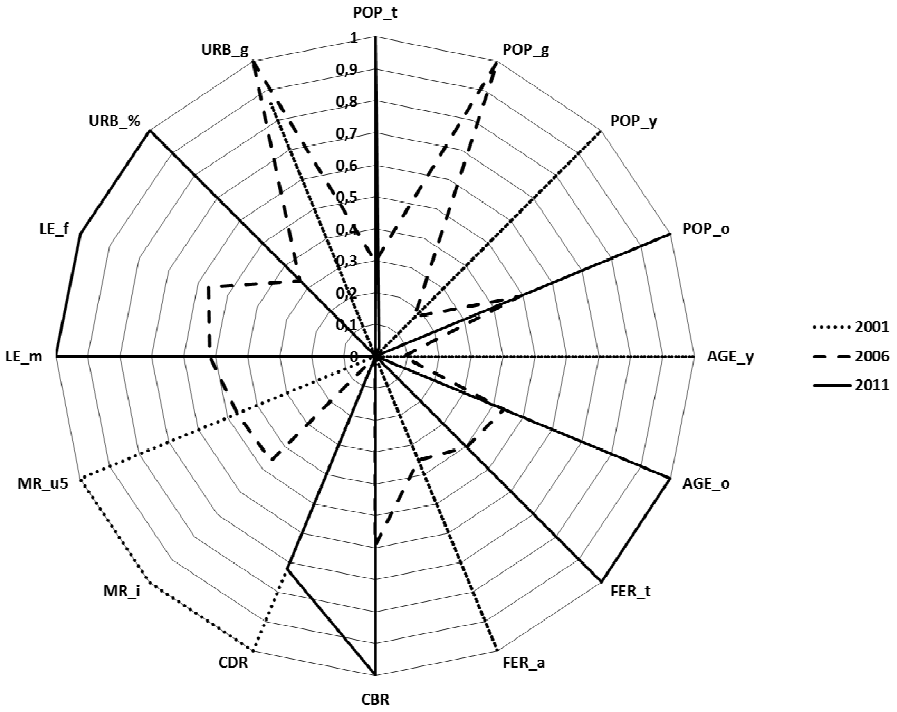

Figure 4. **Population dynamics in cluster 4,** *authors'*

Cluster 5. Developments in cluster 5 were in line with the developments of previous clusters with some slight changes. Concerning the total population, unlike in cluster 4, there was a decline as in clusters 1–3. We note the same development in the share of young and old population in total and productive population. Total fertility follows the same pattern as in cluster 4, however lags behind the replacement level (1.46 in 2011). We note improvements in both crude birth rate and crude death rate followed with the decline in infant and under-5 mortality rate. There was also positive develop-

ment in life expectancy for both males and females. Cluster 5 reached the highest share of urban population in total population in all analyzed years with 68.45% in 2011.

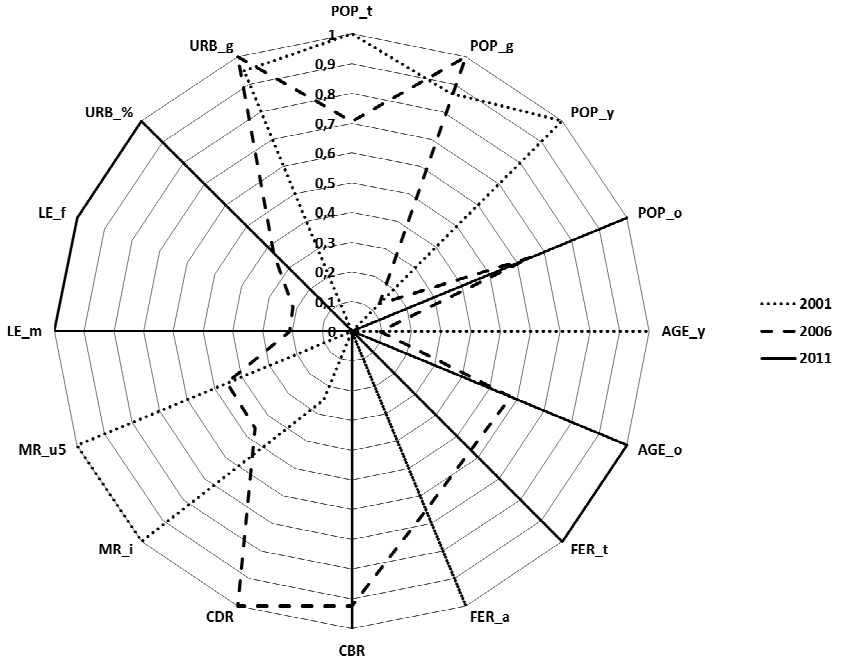

Figure 5. **Population dynamics in cluster 5,** *authors'*

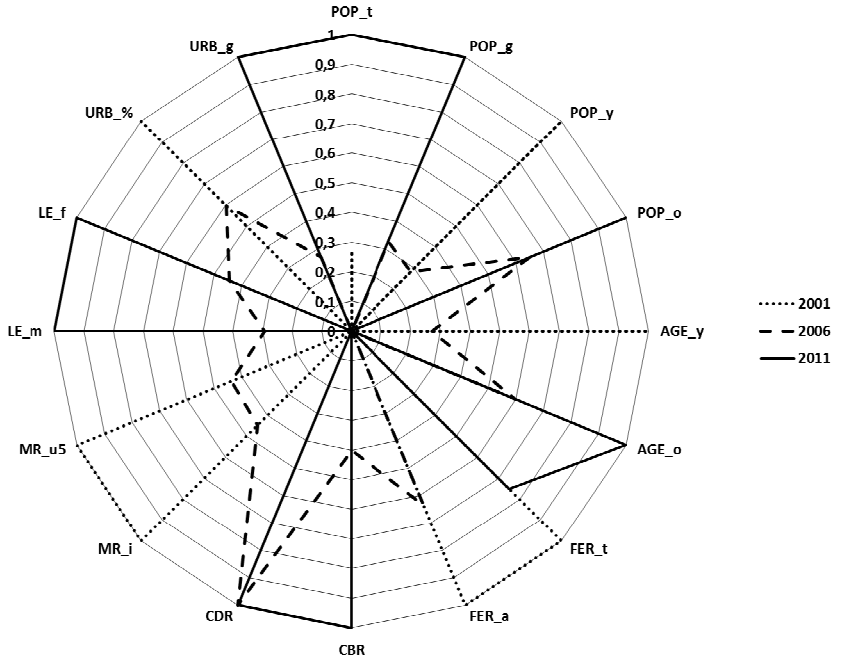

Figure 6. **Population dynamics in cluster 6,** *authors'*

Cluster 6 (Poland) differs from other clusters in the development of some demographic variables. Firstly, it is the cluster with the highest population of 38.53 mln in 2011, which is 6 mln more than the combined population of all other clusters. Secondly, cluster 6 reached the highest population growth in 2011 at 0.91% (as compared to population decline at -0.06% in 2006) and recorded population growth (together with cluster 4). Thirdly, this cluster witnessed total fertility decline (similar to clusters 1 and 2) recording the lowest fertility rate in 2006 and 2011, 1.27 and 1.30 respectively. Fourthly, cluster 6 was the only cluster to record the decline in the share of urban population in total population (from 61.66% in 2001 to 60.89% in 2011). In other variables, Poland showed similar dynamics to other clusters. Infant mortality and child under 5 mortality declined while life expectancy for both males and females and urban growth increased.

Discussion and conclusion. Table 4 summarizes the positive and negative dynamics in the evolution of the analyzed variables for all 6 clusters. Based on the results shown in Table 4 we note that all countries of the CEE region follow the same pattern as the old EU members. There was a growing share of old population in both total population and productive population in the analyzed countries. We assume similar developments in these variables in the future, which will lead to aging population in the CEE and to growing pressure on national budgets in these countries in order to satisfy the needs of the growing old population. Concerning the state of population, only clusters 4 and 6 recorded positive development in terms of total population, which increased in both. However, we observed population growth also in cluster 3, which recorded a decrease in total population that might have been due to emigration. Age structure (share of young and old population in both total and productive population) witnessed negative development in all clusters with a decreasing share of young population and an increasing share of old population. Even though there was a positive development in total fertility in clusters 3, 4, and 5 (i.e. an increase in the indicator over the years 2001–2011), we note that the level of this indicator in all 6 clusters was below the replacement level, which will negatively affect the population of the CEE in future. Concerning crude birth and crude death rates, the evolution of these two variables was rather ambiguous. While clusters 1 and 2 witnessed negative development in both variables (i.e. decrease in crude birth rate and increase in crude death rate), clusters 4 and 5 recorded positive development (increase in birth rate and decrease in death rate). Cluster 3 recorded positive development in crude death rate, but negative development in crude birth rate, while cluster 6 vice versa – positive development in crude birth rate and negative development in crude death rate. Despite the ambiguous development of crude birth and death rates, there was a positive development of infant and child mortality in all clusters with cluster 4 with the lowest values of these variables (3.23 for infant mortality and 3.93 for child mortality in 2011) and cluster 1 with the highest values (12.8 for infant mortality and 14.3 for child mortality in 2011). These two clusters performed best/worst in these two variables throughout the analyzed period. We note positive development of males and females life expectancy in all 6 clusters over the analyzed years with cluster 4 having the highest average life expectancy for men (75.17 years) and for women (81.47) in 2011. There was an increase in the share of urban population in total population, except cluster 6. However, the urban growth rate decreased during the selected period with the exemption of clusters 1 and 6.

Table 4. **Variable dynamics comparison for clusters, 2001–2011,** *authors'*

	POP_t	POP_g	POP_y	POP_o	AGE_y	AGE_o	FER_t	FER_a
Cluster 1	-	-	-	-	-	-	-	+
Cluster 2	-	-	-	-	-	-	-	+
Cluster 3	-	+	-	-	-	-	+	-
Cluster 4	+	+	-	-	-	-	+	+
Cluster 5	-	-	-	-	-	-	+	+
Cluster 6	+	+	-	-	-	-	-	+
	CBR	**CDR**	**MR_i**	**MR_u5**	**LE_m**	**LE_f**	**URB_%**	**URB_g**
Cluster 1	-	-	+	+	+	+	+	+
Cluster 2	-	-	+	+	+	+	+	-
Cluster 3	-	+	+	+	+	+	+	-
Cluster 4	+	+	+	+	+	+	+	-
Cluster 5	+	+	+	+	+	+	+	-
Cluster 6	+	-	+	+	+	+	-	+

Note: + positive development; - negative development.

As shown in Table 4, dynamics and changes in demographic variables are rather slow during a span of one decade. Therefore, further research will be needed in order to:

- Fully assess the dynamics of demographic variables in the CEE region and conclude whether trends in their evolution are of permanent or interim character.
- Assess the relations and interdependence of demographic and economic variables in the analyzed countries in order to formulate such recommendations regarding economic policy which will lead to improvements in demographic trends and individual economies, improving living standards for all citizens in these countries.

We believe that our research in population dynamics in the CEE countries may serve as a base for further studies in other world regions. Population dynamics strongly influences the economies all over the world. Therefore, further research of this phenomenon is required in order to appropriately address its changes and impacts on both individual economies and on the world economy as a whole.

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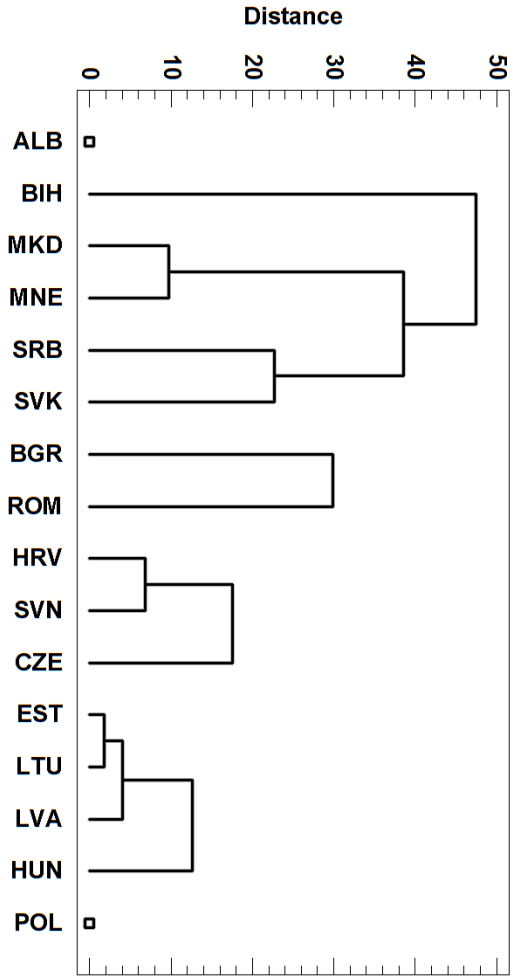
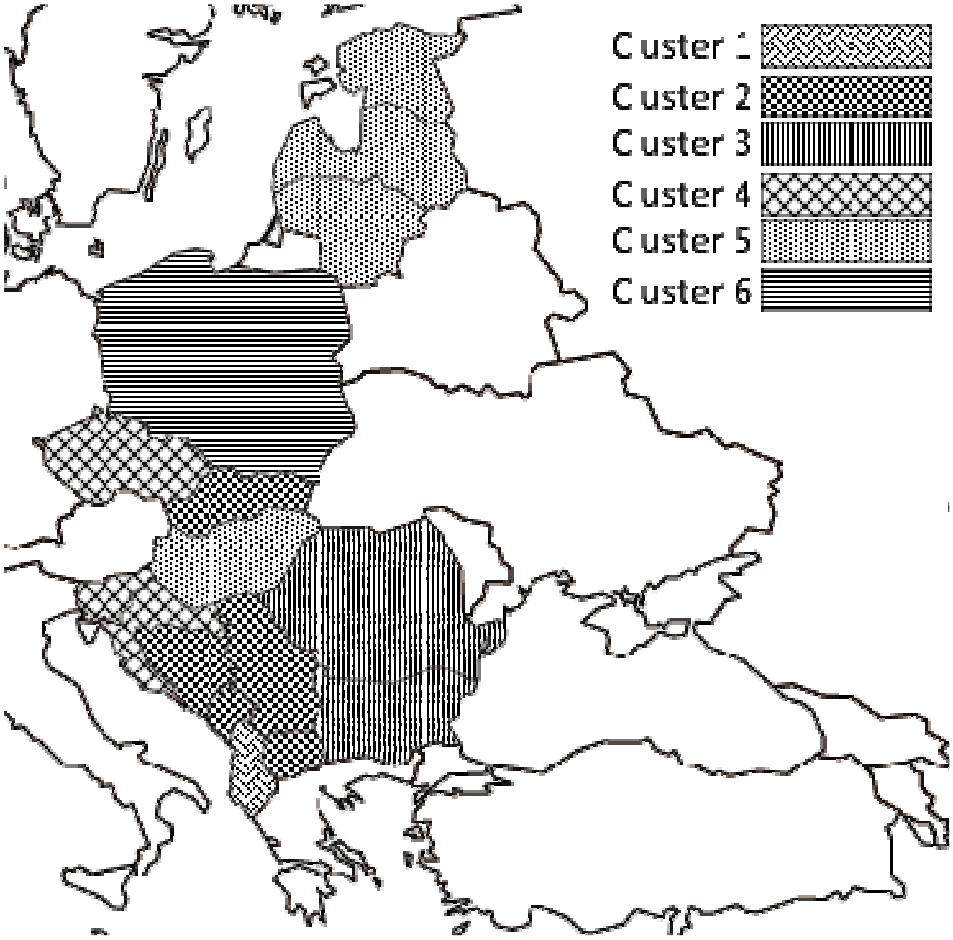
Appendix A. **Dendrogram for 2001,** *authors'*



Appendix B. **Spatial distribution of clusters,** *authors'*



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