European Research Studies Journal
Volume XXV, Issue 3, 2022

pp. 3-21

The Process of Depopulation in Central and Eastern Europe – Determinants and Causes of Population Change between 2008 and 2019

Submitted 12/08/22, 1st revision 11/09/22, 2nd revision 22/09/22, accepted 15/10/22

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Abstract:

Purpose: *The countries from Central and Eastern Europe will be one of the fastest depopulating areas of the world in the next few decades. In general, population growth or decline is the result of natural events (births and deaths) and permanent migration (foreign and internal). Hence, the purpose of this article is to analyze demographic data affecting population change in Central and Eastern Europe.*
Design/Methodology/Approach: *The authors have adopted the hypothesis according to which natural processes are the main cause of population change in the regions of Central and Eastern Europe while migration contributes less and less to the population decline in the regions under the study. The methodology is based on the indicator analysis and soft model. The source of statistical data is Eurostat and statistical offices of individual countries.*
Findings: *The hypothesis of the article was verified positively. Firstly, vast majority of Central and Eastern European regions experienced a decline in population in the period 2008 - 2019. Secondly, the estimation of the soft model allows to conclude that natural changes (parameter 0.5314) are far more responsible for the change in population in the studied regions than migration (parameter 0.2465).*
Practical Implications: *The study's results draw the attention to the fact that migration is contributing less and less to the population decline in the regions in the studied area. Moreover, the analysis of the statistical data allows to assume that in the future, without increased intensity of immigration (especially external), the regions of Central and Eastern Europe will experience inevitable depopulation.*
Originality/value: *The originality and value of the study are given by the fact that it examines one of the most crucial factors influencing development in the modern economy, i.e. demographic factors. Additionally, the analysis is conducted for Central and Eastern European countries for which depopulation is an extremely urgent problem.*

Keywords: *Demography, depopulation, natural increase, migration, Central and Eastern Europe.*
JEL classification: *J11, R10.*
Paper Type: *Research article.*

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1. Introduction

Population size of a given country or region is affected by many causes. Mostly, it is formed directly by natural factors such as births and deaths as well as net migration rate (Poston and Bouvier, 2010, p. 382; Lundquist *et al.*, 2015, p. 9). Additionally, demographic phenomena and processes occur in a specific macroeconomic environment; hence population size is also affected by economic, social or political circumstances. It should be noticed that the relations between demographic and socioeconomic development are of a two-way nature since demographic changes are not only determined by the socioeconomic development, but they themselves are a crucial factor of this development (Reher, 2011, p. 11-12).

However, it is difficult to associate directly specific demographic processes and phenomena with economic and social factors for several reasons. First, demographic phenomena are mostly the effect of autonomous decisions made by people based on their choices, personal or professional aims or health conditions. Second, it is difficult to define explicitly the directions and intensity of the relations between demographic and socioeconomic factors. This is most clearly seen in the outcomes of demographic policy of many countries, which are generally far from the assumed objectives. This shows how difficult it is to exert influence on demography by the use of economic or social measures. Third, the attempt at linking demographic and socioeconomic indicators is fraught with a high risk with regard to the selection of variables and, in principle, it will never be comprehensive.

It is true that there has been scientific research explaining mutual determinants of economic and demographic development, but it has concerned selected aspects, for instance the impact of human capital on the development. However, a comprehensive economic theory that would make spatial differentiation of economic structures dependent on spatial differentiation of demographic structures has not yet been formulated (Wiśniewski *et al.*, 2020, p. 10).

Further, linking socioeconomic and demographic processes is problematic not only with regard to a posteriori analysis. It should be emphasized that forecasting demographic processes poses many problems. In fact, only short-term forecasts can be considered fully credible, and the longer the prediction period, the lower the accuracy, which in the case of demography is confirmed by the facts. Long-term forecasts (over 25 years) usually have the character of study projections and determine possible development trends in the future (Stokowski, 2019, p. 136).

This does not change the fact that demographic forecasts should be the foundation of socioeconomic activity development. In recent decades, demographic forecasts have projected a steady increase in the world population, but an important change must be noted therein. According to researchers at the University of Washington, the global population is expected to peak in 2064 and then decline (Vollset *et al.*, 2020).

From the perspective of Central and Eastern Europe, another hypothesis contained in the article is particularly disturbing. The countries from just this part of Europe will be one of the fastest depopulating areas of the world. In other words, the regions and countries of Central and Eastern Europe are in danger of depopulation.

In general, it can be said that population growth or decline is the result of natural events (births and deaths) and permanent migration (foreign and internal). Hence, the purpose of this article is to analyze demographic data affecting population change. An important informative value is provided by determination which group of factors is decisive for population size. Consequently, the research problem depicted in the article is determination of the impact of natural causes and migration on population change in Central and Eastern Europe[3]. The analysis will be carried out at the regional level. The research has embraced 59 regions located in Central and Eastern Europe and belonging to the European Union (Table 1).

Table 1. *Regions in Central and Eastern Europe according to NUTS 2*

	Severozapaden		Budapest		Lubelskie
	Severen tsentralen		Pest		Podkarpackie
	Severoiztochen		Közép-Dunántúl		Podlaskie
	Yugoiztochen		Nyugat-Dunántúl		Warszawski stołeczny
	Yugozapaden		Dél-Dunántúl		Mazowiecki regionalny
	Yuzhen tsentralen		Észak-Magyarország		Nord-Vest
	Praha		Észak-Alföld		Centru
	Střední Čechy		Dél-Alföld		Nord-Est
	Jihozápad		Małopolskie		Sud-Est
	Severozápad		Śląskie		Sud - Muntenia
	Severovýchod		Wielkopolskie		Bucuresti - Ilfov
	Jihovýchod		Zachodnio-pomorskie		Sud-Vest Oltenia
	Střední Morava		Lubuskie		Vest
	Moravskoslezsko		Dolnośląskie		Vzhodna Slovenija
	Eesti		Opolskie		Zahodna Slovenija
	Jadranska Hrvatska		Kujawsko-Pomorskie		Bratislavský kraj
	Kontinentalna Hrvatska		Warmińsko-Mazurskie		Západné Slovensko

[3]*The name is of a geographical and political character and covers 19 countries including 8 that do not belong to the EU. It should be emphasized that delimitation of Central and Eastern Europe is not unambiguously determined.*

	Latvija		Pomorskie		Stredné Slovensko
	Sostines regionas		Łódzkie		Východné Slovensko
	Vidurio ir vakaru Lietuvos regionas		Świętokrzyskie		

***Source**: Authors' own study.*

The key to the selection of the regions were similarities related to socioeconomic processes occurring there, which were significantly influenced by the accession to the Community[4]. In result, the regions[5] from 11 countries have been analyzed and the data referring to them for the year 2008 and 2019 have been presented. It has been assumed that countries with similar recent history and at a similar level of socioeconomic development create similar conditions for demographic development, including causes affecting the population size.

The authors have adopted the hypothesis according to which natural processes are the main cause of population change in the regions of Central and Eastern Europe while migration contributes less and less to the population decline in the regions under the study. The objective of the study is achieved with the use of the indicator analysis and soft model. The first method is used to analyze the source data which serve as the basis for developing the soft model. In result of the estimation, the impact of natural causes and migration on population change is determined. The source of statistical data is Eurostat and statistical offices of individual countries.

2. Current Demographic Changes within the Context of Central and Eastern Europe

Currently, aging societies and population growth slowdown or decline may be regarded as major demographic changes. Both challenges have a common source such as, among others, lower birth rates (Linz and Stula, 2010, p. 2). Consequently, population is expected to peak in the current century, both globally and in individual continents. However, different parts of the world differ as far as the predicted moment of reaching this threshold is concerned. While the world's population should start to decline in the 2060s-70s, continents and regions such as North America or

[4]*Czech Republic, Estonia, Lithuania, Latvia, Poland, Slovakia, Slovenia, and Hungary joined the EU in 2004, Bulgaria and Romania in 2007, and Croatia in 2013.*

[5]*The research has incorporated the division according to the so-called statistical regions at the NUTS 2 level according to the Eurostat nomenclature. In most cases they correspond to local government units at the level of voivodeships in Poland, but it is not a rule, e.g. Estonia and Latvia are treated as one NUTS 2 region. What is more, compared to 2008, NUTS 2 division has changed in Lithuania (two units have been distinguished from one unit encompassing the entire country), Hungary (division of Közép-Magyarország into Budapest and Pest), and Poland (division of Masovian Voivodeship into Warsaw Metropolitan Area and Masovian Regional Area). Therefore, data for 2008 in these regions are estimates (if data in accordance with the current NUTS 2 division have not been presented).*

Sub-Saharan Africa will reach their population peak in 2093 and 2097, respectively (Scherbov and Lutz, 2011, p. 575).

However, it should be noted that in some parts of the world the population has already been declining for several decades. Eastern Europe, in particular, has been experiencing population decline since the 1990s, and the rest of Europe has seen population growth slowdown. If we assumed that present trends would persist, in the future all regions of Europe except the Northern regions would experience population decline (England and Azzopardi-Muscat, 2017, p. 10).

Significant demographic processes can also be observed among EU Member States. In general, it can be said that the main demographic trends in the EU include, among others, depopulation of some regions, especially those located in the Eastern and Southern parts of the Community, a shrinking share in the world population, a declining rate of population growth (decline is predicted after 2044), and lower fertility rates (Kiss *et al.*, 2021, pp. 1-10). The latter trend, combined with increasing life expectancy, is leading to significant changes in the age structure, i.e., an increase in the share of the elderly (65 years old and older) in the population and, consequently, the "aging" population (Haupt and Kane, 2000, p. 52; Hosper and Reverda, 2015, pp. 7-17).

In the subject literature, population aging is presented as a challenge in macroeconomic terms in the context of the pension system solvency and the burden on health care (Lutz and Gailey, 2020, p. 17), changes in the production factors' prices (capital, labor, land) and the limits of economies of scale (Dalen and Henkens, 2011, p. 444-447). The above-mentioned threats arise from the occurrence of the so-called "demographic payoff"[6], i.e., the entry into the labor market of only few generations of children at the time when numerous cohorts of their parents are reaching retirement age (Fihel and Okólski, 2018, p. 50).

However, there are growing opinions that perceiving only negative consequences of population aging can be misleading. This results from the assumption that the costs associated with the aging process can be foreseen and borne. On the other hand, there are economic, social and, above all, environmental benefits. In other words, population aging is a natural consequence of the expected population decline, which provides an opportunity to achieve sustainable development goals (Götmark *et al.*, 2018; Jarzebski *et al.*, 2021), reduce negative external effects (Dalen and Henkens, 2011, pp. 447-448) or reduce the pressure on non-renewable resources, and stop the decline in the quality of life (Poston and Bouvier, 2010, p. 285).

[6] *It occurs 30-40 years after the so-called demographic bonus, i.e. there is population growth with the simultaneous occurrence of decline in population and number of deaths. Multiple generations with fewer children dependents enter the labor market, there are fewer elders and life expectancy is increasing, health is improving and labor force participation is increased.*

Changes in the population age structure are not always synonymous with population decline. Negative demographic processes, such as lower fertility rates, can be compensated by increasing intensity of immigration. In fact, the example of European regions shows that the cause of population decline in EU countries and regions are primarily natural changes (the difference between births and deaths), while population growth is primarily the result of immigration (Demifier, 2010).

However, in most regions and countries in the Eastern part of the EU, negative natural changes prevail and lead to population decline. The situation in Southeastern Europe is particularly alarming as these regions are experiencing a negative trend of population decline, e.g., Bulgaria has lost 21% of its population since 1990, while the total population decline in the period 1990-2050 is projected to be 39% (Judah, 2021). However, similar processes are being experienced not only by Bulgaria, but also by other countries in the Eastern part of the EU, including Lithuania and Romania (Daugirdas and Pociute-Sereikiene, 2018; Koyama 2018; Otovescu and Otovescu, 2019). In other words, many countries and regions in the Eastern and Southeastern parts of the EU are experiencing depopulation today.

Depopulation should be understood as the process of a demographic and territorial nature. Its essence is a declining population of a given territory compared to previous periods, while the cause thereof is negative population growth, negative migration balance or both factors concurrently. Population decline has negative consequences for the region's development, which creates a vicious cycle for the regions experiencing depopulation (Merino and Prats, 2020).

In the case of migration, it is important to emphasize two levels of impact on depopulation, i.e., direct and indirect impact because those who emigrate are primarily "young adults" (Johnson and Winkler, 2015, p. 1066), i.e., people in reproductive age. It should be noted that while academic research does not show a correlation between the country's population and economic growth or life satisfaction (Florczak and Przybylinski, 2016, p. 419), population decline can have significant socioeconomic implications at the level of individual regions. In particular, for most countries, the problem of depopulation relates primarily to rural regions with low levels of infrastructure development (Johnson and Lichter, 2019; Alamá-Sabater, 2021)[7].

In every case, however, adapting to demographic changes such as aging and population decline requires some accommodative measures. Consequently, it is necessary to find demographic policy tools that would be both effective and socially acceptable. The use of tools that affect only the fertility rate seems to have limited effect. Taking into account interconnections between socioeconomic development

[7]*The research shows that at the lower level of development, investment improving the quality of life can effectively counteract depopulation. Over time, however, economic causes become more important (Merino and Prats, 2020).*

and demographic processes, it is therefore necessary to depart from considering demographic issues in quantitative terms, and focus on human capital development instead. In other words, demographic policy should take the form of "public human resource management," in which population size and its growth rate, fertility rate or age structure are neither strictly defined nor treated as goals themselves, but they should be considered in the context of strengthening human capital (Lutz, 2014).

Summing up, the population size of a country is not a "problem per se" (Florczak and Przybylinski, 2016, p. 419), but the direction and dynamics of population change, combined with the transformation of the age structure of the population (an increase in the share of non-productive age groups), is a determinant of socioeconomic development. However, despite the increased importance of the qualitative aspect of population (human capital), its quantitative quantifiers cannot be ignored, especially with regard to the considerable dynamics of population decline that can be observed in some regions of Central and Eastern Europe.

3. Characteristics of the Population Size in the Studied Regions in 2008 and 2019

In 2019, the regions under the study had a total population of 102,456,000 people, compared to 105,995,000 in 2008, which means that the population decreased by 3.3% in the 2008-2019 period. Only 16 out of 59 regions saw population growth, and these were the regions with national capitals in particular (e.g., Bratislavský kraj, Praha, and Warsaw Metropolitan Area). It should be noted that with regard to Croatia, Lithuania, Latvia, Estonia and Bulgaria, population decline was recorded in all the regions.

In particular, the most dynamic population decline occurred in the regions in Bulgaria and Romania (except Bucuresti - Ilfov). In Bulgaria, the regions lost from 1.2% of their population in Yugozapaden to 17.4% in Severozapaden, while Romania lost from 6.3% in Nord-Vest to 15.2% in Sud-Est. The list of the regions with the largest population and the largest dynamics of population growth and decline in the period 2008 - 2019 is provided in Table 2.

***Table 2**. Characteristics of the population size in the studied regions in 2008 and 2019*

Regions with the largest population				
		2019	2008	2019/2008
1	Śląskie	4 488 998	4 654 115	-3,5%
2	Wielkopolskie	3 473 172	3 386 882	2,5%
3	Małopolskie	3 360 545	3 279 036	2,5%
4	Nord-Est	3 198 564	3 722 553	-14,1%
5	Warszawski stołeczny	3 053 104	2 847 264	7,2%

Regions with the largest dynamics of population growth				
		2019	2008	2019/2008
1	Střední Cechy	1 369 332	1 201 524	14,0%
2	Praha	1 308 632	1 195 521	9,5%
3	Warszawski stołeczny	3 053 104	2 847 264	7,2%
4	Zahodna Slovenija	986 473	920 512	7,2%
5	Pest	1 278 874	1 195 020	7,0%
Regions with the largest dynamics of population decline				
		2019	2008	2019/2008
1	Severozapaden	742 304	898 371	-17,4%
2	Vidurio ir vakaru Lietuvos regionas	1 983 646	2 386 299	-16,9%
3	Sud-Est	2 396 171	2 825 756	-15,2%
4	Sud-Vest Oltenia	1 926 860	2 270 776	-15,1%
5	Nord-Est	3 198 564	3 722 553	-14,1%

***Source**: Authors' own study based on Eurostat.*

One of the main causes of depopulation is a declining number of births, which amounted to 1,014,000 in 2019, compared to 1,126,000 in 2008 (a 10% decline). It should be noted that only in five studied regions the level of births in 2019 was higher than in 2008 (Bratislavský kraj, Bucuresti - Ilfov, Warsaw Metropolitan Area, Małopolskie Voivodeship, and Praha). In the remaining regions, a decreasing number of births was recorded, ranging from 21% to 29%, with the largest decrease in the regions located in Bulgaria (Severozapaden, Severen tsentralen, Severoiztochen, and Yugoiztochen) (Table 3).

***Table 3.** Characteristics of births in the studied regions in 2008 and 2019*

Regions with the largest level of births				
		2019	2008	2019/2008
1	Śląskie	40 508	46 994	-13,8%
2	Nord-Est	38 508	42 752	-9,9%
3	Wielkopolskie	37 459	40 925	-8,5%
4	Małopolskie	36 946	36 852	0,3%
5	Warszawski stołeczny	35 752	31 915	12,0%
Regions with the largest dynamics of births growth				
		2019	2008	2019/2008
1	Bratislavský kraj	8 170	6 840	19,4%
2	Warszawski stołeczny	35 752	31 915	12,0%
3	Bucuresti - Ilfov	26 568	24 301	9,3%

4	Praha	14 933	14 339	4,1%
5	Małopolskie	36 946	36 852	0,3%
Regions with the largest dynamics of births decline				
		2019	2008	2019/2008
1	Severen tsentralen	5 774	8 171	-29,3%
2	Severoiztochen	7 956	11 133	-28,5%
3	Severozapaden	5 803	8 034	-27,8%
4	Latvija	18 786	24 397	-23,0%
5	Yugoiztochen	9 949	12 634	-21,3%

***Source**: Authors' own study based on Eurostat.*

A different trend occurred with regard to deaths (Table 4). Between 2008 and 2019, deaths number increased by 2.9% in the studied regions, i.e., it rose from 1,192,000 deaths in 2008 to 1,226,000 deaths in 2019. However, it should be noted that 18 regions experienced a decrease in the number of deaths, with the highest dynamics of decline (from 11% to 13%) recorded in Lithuania and Latvia (Latvija, Sostines regionas, Vidurio ir vakaru Lietuvos regionas). On the other hand, three regions (Zahodna Slovenija, Warmińsko-Mazurskie, and Lubuskie) had the highest dynamics of deaths growth (about 16%). In general, it can be said that the dynamics of deaths growth (2.9%) in the period 2008 - 2019 was significantly lower than the dynamics of births decline (10%).

***Table 4.** Characteristics of deaths in the studied regions in 2008 and 2019*

Regions with the largest number of deaths				
		2019	2008	2019/2008
1	Śląskie	51766	48016	7,8%
2	Nord-Est	43914	40843	7,5%
3	Sud-Muntenia	43444	42917	1,2%
4	Sud-Est	35414	32805	8,0%
5	Kontinentalna Hrvatska	35136	36383	-3,4%
Regions with the largest dynamics of deaths growth				
		2019	2008	2019/2008
1	Warmińsko-mazurskie	14894	12811	16,3%
2	Zahodna Slovenija	8876	7673	15,7%
3	Lubuskie	11070	9572	15,6%
4	Pomorskie	22450	19574	14,7%
5	Zachodniopomorskie	18470	16321	13,2%
Regions with the largest dynamics of deaths decline				
		2019	2008	2019/2008

1	Vidurio ir vakaru Lietuvos regionas	28877	33175	-13,0%
2	Sostines regionas	9404	10657	-11,8%
3	Severozapaden	15107	17042	-11,4%
4	Latvija	27719	31006	-10,6%
5	Eesti	15401	16675	-7,6%

Source: *Authors' own study based on Eurostat.*

Both the number of births and deaths are reflected in the value of the crude natural increase rate. In 2019, the rate was positive in only 12 regions, while in 2008 there were twice as many such regions, i.e. 24. In other words, in 2019, for only 20% of the studied regions the level of births was higher than the level of deaths, which should be considered an extremely unfavorable situation for the population size of the studied area. The regions in Bulgaria draw attention, where the crude natural increase rate ranged from (-)4.3 to (-)12.7, and as many as four out of six studied regions from that country were among the five regions with the lowest rate (Table 5).

Table 5. *Crude natural increase rate in 2008 and 2019.*

Regions with the highest rate				Regions with the lowest rate			
		2019	2008			2019	2008
1	Bratislavský kraj	3,2	1,8	1	Severozapaden	-12,7	-10,1
2	Východné Slovensko	2,6	3,3	2	Severen tsentralen	-10,2	-7,1
3	Praha	2,1	1,7	3	Yuzhen tsentralen	-6,3	-3,9
4	Pomorskie	1,6	3,5	4	Severoiztochen	-6	-2,5
5	Warszawski stołeczny	1,4	1,1	5	Sud - Muntenia	-5,9	-3,4

Source: *Authors' own study based on Eurostat.*

Apart from natural causes, population size is also influenced by migration. However, the level of analysis at the level of the regions must take into account both permanent internal and foreign migrations (Table 6).

Table 6. *Characteristics of permanent migration (internal and foreign) in 2008 and 2019*

Regions with the largest number of permanent migrants (internal and foreign) - inflow				
		2019	2008	2019/2008
1	Pest	85688	76318	12,3%
2	Warszawski stołeczny	57675	43927	31,3%
3	Wielkopolskie	48996	42747	14,6%

4	Śląskie	46650	44187	5,6%
5	Dolnośląskie	43173	35236	22,5%
Regions with the largest number of permanent migrants (internal and foreign) - outflow				
		2019	2008	2019/2008
1	Śląskie	51367	51344	0,0%
2	Wielkopolskie	47536	41619	14,2%
3	Észak-Alföld	41687	36282	14,9%
4	Pest	41303	32287	27,9%
5	Észak-Magyarország	38934	34288	13,5%

Source: *Authors' own study based on statistical offices of individual countries.*

It is necessary to emphasize methodological difficulties in unambiguous determination of the number of permanent migrants at the level of regions, which has also been noticed by Eurostat[8]. The analysis of the number of migrants allows to claim that both in terms of inflow and outflow Polish and Hungarian regions dominate, which, however, is determined by the size of the regions' population. The importance of migration for the population size of the regions can be expressed by the reference of the volume of migration to the population size of the regions. For this purpose, the crude migration rate is used (Table 7), which is calculated by Eurostat according to the rule saying that migration balance is treated as a part of the population growth that cannot be attributed to births and deaths. In 2019, the Pest region had the highest rate value (15.5), while Severozapaden had the lowest (-6.6).

Table 7. *Crude migration rate in 2008 and 2019*

Regions with the largest rate				Regions with the lowest rate			
		2019	2008			2019	2008
1	Pest	15,5	11,3	1	Severozapaden	-6,6	-8,8
2	Sostines regionas	12,7	-5,1	2	Sud - Muntenia	-3,8	-0,3
3	Bratislavský kraj	11,9	1,8	3	Severen tsentralen	-3,6	-6,6
4	Střední Cechy	10,5	21,3	4	Észak-Alföld	-3	-5,2
5	Praha	9,8	13,9	5	Sud-Vest Oltenia	-2,9	-1,5

Source: *Authors' own study based on Eurostat.*

[8]*The article attempts to estimate the size of permanent internal and foreign migrations based on statistical offices of individual countries. However, a certain margin of error should be assumed as to the data credibility. It should be noticed that Eurostat does not provide information about the level of migration for regions while the net crude migration rate is calculated according to the rule saying that migration balance is treated as a part of the population growth which cannot be assigned to births and deaths. This results from the fact that migration flows at the level of regions are either inaccessible or figures are not credible; compare https://ec.europa.eu/eurostat/cache/metadata/en/demo_r_gind3_esms.htm*

It seems interesting that, in contrast to the crude birth rate, the crude migration rate in 2019 was greater than zero in most studied regions (33). This means that in 55% of the regions, migration had a positive impact on the population size. Compared to 2008 (43%), this is an increase by 12 pp. As a result, based on the analysis of the statistical data, it can already be concluded that natural causes are mainly responsible for the population change in the studied regions. However, it will be possible to determine the exact impact of natural causes and migration after soft modeling, in which weights determining the intensity and direction of impact will be assigned to individual elements within the two groups.

4. Methodology of the Soft Model and Research Outcomes

The structure of the soft model includes two parts, i.e., the internal model and the external model. In the first model it is possible to describe the relations occurring between latent variables. In the second model, the relations between latent variables and indicators are presented. In other words, the external model describes how the hidden variables are observed. In both cases, the assumption is made that the relations are linear. In the soft model, we can distinguish relations between the latent variable and its indicators based on two definitions, i.e., when the value of the indicator is derived from the value of the latent variable (reflective indicator) or when the value of the indicator creates the latent variable (formative indicator).

In either case, it is necessary to maintain the condition that the indicators of a given latent variable must be highly correlated since they reflect a change in the value of the same variable. The selection of indicators can reflect the accepted economic theory or subjective opinion resulting from the research experience, acquired knowledge or intuition. The soft model takes the form of a multivariate model. In the case of non-delayed endogenous unobservable variables, they have the form: f1,...,fn, while endogenous unobservable variables are predetermined: fn+1,...,fk (k>n). The notation of the internal relations of the soft model is depicted by the function (Rogowski, 1990, p. 36):

$$f_{ti} = \sum_{j=1}^{k} \beta_{ij} f_{tj} + \beta_{i,k+1} + \xi_{ti}$$

where:
f_{ti} – observation of the i-th variable, where i+1,…,n
β_{ij} - j-th structural parameter of the i-th equation of the model (j= 1,...,k+1; $j \neq i$),
ξ_{ti} – random component of the i-th equation (expected value = 0).

With regard to the external relations, they refer to the weight relations that determine the values of the latent variables. This is a measurement model that represents latent variables as linear combinations of indicators (so-called weight relations):

$$f_{it} = \sum_{j=1}^{k_j} w_{ij} X_{tij}$$

where:
w_{ij} – weight connected with the indicator X_{ij} (i=1,…,k; j=1,…,k_i; k – a number of variables, k_i – a number of indicators), X_{ij} – j-th indicator of the i-th latent variable f_i.

The external model also determines the strength of reflection by the latent variable of its indicators:

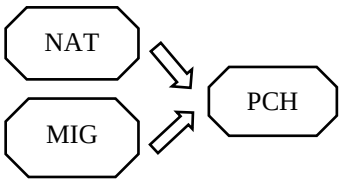
$$x_{tij} = p_{ij} f_{ti} + q_{i,j+1} + e_{tij}$$

where:
p_{ij} – factor charge which binds the latent variable f_i with the indicator X_{ij} (determines the strength of "refection" of the latent variable by the indicator),
$q_{i, j+1}$ – free expression of the relation,
e_{tij} – random component (expected value =0); uncorrelated over time (autocorrelation), between the equations as well as unobservable variables.

The soft model is estimated using the PLS (partial least squares) method. In accordance with the adopted method, we distinguish three stages of the model estimation, i.e., iterative estimation of weights, estimation of internal and external model parameters, and estimation of free expressions (Perło 2014, p. 91). The model should undergo substantive verification, i.e., the compatibility of the parameters of the internal and external model with the adopted theoretical model should be assessed. The test of consistency is carried out using classical measures of econometrics, for instance the squares multiple correlation coefficients (R^2). This should be followed by statistical verification using Tukey's Jackknifing and the S - G test.

The purpose of the soft model is to study the impact of two groups, i.e. natural causes and migration, on population change. Specifically, the soft model is to assess which of the two groups is more responsible for population change and what is the intensity of this impact. A diagram of the model is depicted in Figure 1.

Figure 1. *A diagram of the soft model of the impact of natural causes and migration on population change*



Source: *Authors' own study.*

The internal model is linear with three latent variables, i.e., population change (PCH), natural causes (NAT) and migration (MIG). The explanatory variables are natural causes (NAT) and migration (MIG). The evaluation of latent variables was carried out based on a set of ratios that form the indicators in the soft model. The indicators are the relations of the studied quantities observed in 2019 with reference to 2008. The rationale for selecting the years of observation is included in the introduction. The list of the indicators assigned to the latent variables is depicted in Table 8.

Table 8. *Latent variables and their indicators*

Latent variable	Indicators	Name of the indicator
PCH	PCH	The relation between the number of residents in 2019 and in 2008
NAT	BRT	The relation between the number of births in 2019 and in 2008
	DTH	The relation between the number of deaths in 2019 and in 2008
	RTN	The change of the crude natural increase rate in 2019 compared to the crude natural increase rate in 2008
MIG	IMM	The relation between the number of migrants for permanent residence (internal and foreign) in 2019 and the number of immigrants for permanent residence in 2008 - inflow
	EMI	The relation between the volume of migrants for permanent residence (internal and foreign) in 2019 and the volume of emigration for permanent residence in 2008 - outflow
	RTM	The change of the crude migration rate in 2019 compared to the crude migration rate in 2008

Source: *Authors' own study.*

Modeling was carried out using the MM program - soft modeling created by D. Karaś. In result of the estimation, the following parameters of internal relations and estimation errors determined by the Tukey's Jackknifing method were obtained:

$$PCH = \underset{(0{,}0910)}{0{,}5314\ NAT} + \underset{(0{,}0897)}{0{,}2465\ MIG} + \underset{(0{,}0102)}{0{,}0410} \qquad R2 = 0{,}5859$$

The model has been positively verified in terms of content and statistics, which allows to interpret the results. According to the equation, the change in population in the studied regions is more influenced by natural movement (parameter 0.5314) than migration (parameter 0.2465). Factor loadings (correlation coefficients between the unobservable variable and indicators) and standard deviations (estimation errors) are depicted in Table 9.

The factor loadings of the latent variable NAT (natural causes) inform that this variable is reflected to the greatest extent by the relation of births (0.9257). To a lesser extent, the latent variable is reflected by the relation of the natural increase

rate (0.7631). On the other hand, the relation of deaths has a negative impact on the change in population resulting from natural processes (-0.7589).

***Table 9**. Estimation of the external model parameters*

Latent variable	Indicators	Weights	Factor loadings	Determination factor
		error	*error*	
PCH	PCH	1,000	1,000	1,000
		0,000	0,000	
NAT	BRT	0,5395	0,9257	0,857
		0,169	*0,0045*	
	DTH	-0,3255	-0,7589	0,5759
		0,015	*0,0095*	
	RTN	0,3322	0,7631	0,5823
		0,0236	*0,0135*	
MIG	IMM	0,4739	0,9292	0,8635
		0,0133	*0,0035*	
	EMI	-0,081	-0,094	0,0088
		0,0152	*0,0151*	
	RTM	0,5807	0,9505	0,9035
		0,0125	*0,0024*	

***Source:** Authors' own study.*

Thus, in general, it can be claimed that the change in population in the studied regions resulting from natural processes is most influenced by the relation of births. In the case of the latent variable MIG (migration), it is strongly reflected by both the indicator referring to the relation of immigration (factor load of 0.9292) and the relation of the crude migration rate (factor load is 0.9595).

Emigration processes have a negative impact on population change, which is reflected by the negative value of the factor load (-0.094). However, its low value allows to claim that it reflects the latent variable to a small extent.

Summing up, on the basis of the parameters of internal relations, it should be noted that in the studied regions natural processes, among which the level of births played a key role, had the greatest impact on the population change. Migration impacted the population in the studied regions to a considerably smaller extent while, at present, emigration in particular only slightly affects the population decline in Central and Eastern Europe.

5. Summary

In result of the analysis of demographic data, it can be concluded that the studied regions of Central and Eastern Europe lost a total of more than 3% of their population between 2008 and 2019. The process of population decline affects vast majority of regions (73%), with the exception of the regions with national capitals primarily. The regions in Bulgaria, Romania and Lithuania are characterized by the highest intensity of decline. In addition, it should be noted that the population decline affects all regions in these countries (with the exception of Bucuresti - Ilfov in Romania).

Similarly, in Latvia, Lithuania and Croatia, all regions have experienced population loss, however, the dynamics of decline is slightly smaller. Given the small size of the population of these countries, the direction and intensity of population change can be a significant challenge. On the other hand, it should be noted that in the Czech Republic, most regions (5 out of 8) experienced population growth between 2008 and 2019, with only three regions experiencing a positive natural increase rate in 2019, and all (except Moravskoslezsko) experiencing a positive migration balance. In Poland, four regions had a larger population in 2019 than in 2008; at the same time, they were the only regions with a positive natural increase rate nationally.

In general, it can be said that the results of the analysis of the source data and the soft model correspond with the thesis included in the subject literature that in the EU regions, immigration processes are responsible for the population growth while natural changes are responsible for the decline (Demifier, 2010). Firstly, vast majority of Central and Eastern European regions experienced a decline in population in the period 2008 - 2019. Secondly, the estimation of the soft model allows to conclude that natural changes (parameter 0.5314) are far more responsible for the change in population in the studied regions than migration (parameter 0.2465), which provides the answer to the research problem defined in the introduction.

Among the first group, attention should be paid to the high dynamics of the decline in births in the period 2008 - 2019 (by over 100,000, i.e., 10%). This is reflected in the negative natural increase rate in most regions (47 out of 59 the studied regions). It should be emphasized that with regard to this rate, the trend is expressly downward as in 2008, a positive value of the rate was recorded in twice as many regions. On the other hand, with regard to the migration rate, more than half of the regions (55%) recorded a positive value in 2019 (in 2008 only 43%), which suggests that migration not only does not negatively affect the population size, but it can mitigate the declining number of births. This allows to positively verify the hypothesis that natural processes are the main cause of population change in the Central and Eastern European regions, and that migration is contributing less and less to the population decline in the regions in the studied area.

The analysis of the statistical data allows to assume that in the future, without increased intensity of immigration (especially external), the regions of Central and Eastern Europe will experience inevitable depopulation, but obviously this thesis would require additional predictive research. It should be noted, indeed, that the impact on birth rate generates a limited effect. The practice of many countries may suggest that the use of population policy measures in the form of incentives (financial and/or in kind) or structural changes does not bring the assumed results, and it involves support in the process of raising children rather than effective formation of procreative attitudes.

In addition, it should be noticed that the declining trend in the number of births in the countries such as Bulgaria and Latvia (down by 20% - 30%) is difficult, if not impossible, to reverse without immigration support. It should not be overlooked that today the regions of Central and Eastern Europe are receiving war refugees from Ukraine, which, assuming a change to permanent residence for some of them, will have an impact on population numbers, particularly in the countries such as Poland, Slovakia or Romania.

Summing up, although the dynamics of a 3% decline in the population of the entire Central and Eastern European macro-region is not high, the analysis carried out at the regional level allows to conclude that some regions are currently experiencing intense depopulation caused by natural causes, i.e. falling numbers of births. In other words, depopulation has a particularly negative impact at regional and local levels.

Insofar as in the case of the countries such as the Czech Republic and Slovenia, depopulation affects a minority of the regions, in the case of Romania, Bulgaria, Croatia, Lithuania, Latvia and Estonia, and partly Poland, the intensity and pervasiveness of depopulation processes on a regional basis will have a key impact not only in the context of demographic policy, but also generally in a socioeconomic or political sense.

References:

Alamá-Sabater, L., Budí, V., Roig-Tierno, N., García-Álvarez-Coque, J.M. 2021. Drivers of depopulation and spatial interdependence in a regional context. Cities, Vol. 114. https://doi.org/10.1016/j.cities.2021.103217.

Croatian Bureau of Statistics. Population, Migration statistics. Retrived from (28..12.2021): https://www.dzs.hr/PXWeb/Menu.aspx?px_db=Stanovni%u0161tvo&px_language=en&rxid=98d3a45d-c0df-428d-8dbf-dcae7c2b0f26.

Czech Statistical Office. Population, Preliminary data, Immigrants, Emigrants. Retrived from https://vdb.czso.cz/vdbvo2/faces/en/index.jsf?page=statistiky#katalog=33115.

van Dalen, H.P., Henkens, K. 2011. Who fears and who welcomes population decline? Demographic Research, Vol. 25, p. 437-464. DOI: 10.4054/DemRes.2011.25.13.

Daugirdas, V., Pociute-Sereikiene, G. 2018. Depopulation tendencies and territorial development in Lithuania. Regional Statistics, Vol. 8, Issue 2, 46-68. DOI10.15196/RS080203.

Demifier. 2010. Demographic and Migratory Flows affecting European Regions and Cities. Luxembourg: ESPON.

England, K., Azzopardi-Muscat, N. 2017. Demographic trends and public health in Europe. European Journal of Public Health, Vol. 27, Supplement 4, 9-13.

Eurostat. Database, Database by themes, General and regional statistics, Regional statistics by NUTS classification, Regional demographic statistics. Retrived from: https://ec.europa.eu/eurostat/web/main/data/database.

Fihel, A., Okólski, M. 2018. Przemiany cywilizacyjne, ludnościowe i starzenie się społeczeństwa. In: Wyzwania starzejącego się społeczeństwa. Polska dziś i jutro. M. Okólski (ed.). Warsaw: Wydawnictwa Uniwersytetu Warszawskiego.

Florczak, W., Przybyliński, M. 2016. Zmiany w liczebności i strukturze populacji a rozwój społeczno-ekonomiczny. Economic Studies, NR 3 (XC).

Götmark, F., Cafaro, P., O'Sullivan, J. 2018. Aging human populations: good for us, good for the earth. Trends Ecol. Evol. 33, 851-862. DOI: 10.1016/j.tree.2018.08.015.

Haupt, A., Kane, T.T. 2000. Population Handbook, 4th International Edition. Washington, DC: Population Reference Bureau.

Hospers, G.J., Reverda, N. 2015. Demographic Changes. In: Managing Population Decline in Europe's Urban and Rural Areas. SpringerBriefs in Population Studies. Springer, Cham. DOI: 10.1007/978-3-319-12412-4_2.

Hungarian Statistical Office. Population and vital events, Migration. Retrived from: https://www.ksh.hu/population-and-vital-events.

Jarzebski, M.P., Elmqvist, T., Gasparatos, A. et al. 2021. Ageing and population shrinking: implications for sustainability in the urban century. npj Urban Sustain 1, 17. DOI: 10.1038/s42949-021-00023-z.

Johnson, K.M., Lichter, D.T. 2019. Rural Depopulation: Growth and Decline Processes over the Past Century. Rural Sociology, 84, 3-27. DOI: 10.1111/ruso.12266.

Johnson, K.M., Winkler, R.L. 2015. Migration Signatures across the Decades: Net Migration by Age in U.S. Counties, 1950-2010. Demographic Research. 22(38), 1065-1080. DOI: 10.4054/DemRes.2015.32.38.

Judah, T. 2021. Southeast Europe's Looming Demographic Crisis, Helvetas Mosaic. Retrived from: https://www.helvetas.org/en/eastern-europe/about-us/follow-us/helvetas-mosaic/article/March2021/demographic-decline-southeast-europe.

Kiss, M., Lecerf, M., Atanassov, N., Margaras, V., Zamfir, I. 2021. Demographic Outlook for the European Union 2021. European Parliament: European Parliamentary Research Service.

Koyama, Y. 2018. Migration from Bulgaria and Its Depopulation, 829- 836. In: Proceedings of the 4th International Conferenceon European Integration, Ostrava.

Linz, K., Stula, S. 2010. Demographic change in Europe - An Overview. Working paper no. 4 of the Observatory for Sociopolitical Developments in Europe. Frankfurt a. M.: Institute for Social Work and Social Education (ISS).

Lundquist, J.H., Anderton, D.L., Yaukey, D. 2015. Demography, The Study of Human Population, Fourth Edition. Long Grove, Illinois: Waveland Press.

Lutz, W. 2014. A Population Policy Rationale for the Twenty-First Century. Population and Development Review, 40(3), 527-544. Retrived from: http://www.jstor.org/stable/24027903.

Lutz, Wz., Gailey, N. 2020. Depopulation as a Policy Challenge in the Context of Global Demographic Trends. UNDP Serbia: Human Development Series.

Merino, F., Prats, M.A. 2020. Why do some areas depopulate? The role of economic factors and local governments. Cities, Vol. 97. DOI: 10.1016/j.cities.2019.102506.

National Institute of Statistics (Romania). Tempo-online database, Social statistics, internal and international migration. Retrived from: http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table.

Otovescu, C, Otovescu, A. 2019. The Depopulation of Romania–Is It an Irreversible Process? Revista de Cercetare si Interventie Sociala, 65, 370-388.

Perło, D. 2014. Modelowanie zrównoważonego rozwoju regionów. Bialystok: Wydawnictwo Uniwersyteckie Trans Humana.

Poston, D.L, Bouvier, L.F. 2010. Population and society: an introduction to demography. New York: Cambridge University Press.

Rogowski, J. 1990. Modele miękkie: teoria i zastosowanie w badaniach ekonomicznych. Bialystok: Dział Wydawnictw Filli UW.

Reher, D.D. 2011. Economic and social implications of the demographic transition. In: Demographic Transition and Its Consequences, R. Lee, D.S. Reher (eds.), A supplement to vol. 37 of Population and Development Review, 11-33. New York: The Population Council.

Scherbov, S., Lutz, W., Sanderson, W.C. 2011. The Uncertain Timing of Reaching 8 Billion, Peak World Population, and Other Demographic Milestones. Population and Development Review, 37(3), 571-578. http://www.jstor.org/stable/23036056.

Statistical Office Republic of Slovenia. SiStat Database, Population, Migrations. Retrived from: https://pxweb.stat.si/sistat/en/Podrocja/Index/100/population.

Statistics Lithuania. Population and Social statistics, Migration. Retrived from: https://osp.stat.gov.lt/gyventoju-migracija.

Statistics Poland. Local Data Bank, Category: Population, Group: International and foreign migration. Retrived from: https://bdl.stat.gov.pl/bdl/dane/podgrup/wymiary.

Statistics Slovakia. DATAcube, Demographic and social statistics, Population and migration, Population processes, Migration. Retrived from: http://datacube.statistics.sk/#!/lang/en/?utm_source=susr_portalHP&utm_medium=page_database&utm_campaign=DATAcube_portalHP.

Stokowski, F. 2019. Demografia. Warsaw: PWN.

Vollset, S.E., Goren, E., Yuan, C.W et al. 2020. Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: a forecasting analysis for the Global Burden of Disease Study. Lancet, 1285-1306. DOI: 10.1016/S0140-6736(20)30677-2.

Wiśniewski, R., Mazur, M., Śleszyński, P., Szejgiec-Kolenda, B. 2020. Impact of Demographic Changes in Poland on Local Development. Prace Geograficzne 274. Warsaw: Institute of Geography and Spatial Organization, Polish Academy of Sciences.