



CONTRIBUTION OF DEMOGRAPHIC FACTOR TO ECONOMIC GROWTH IN CEE COUNTRIES

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Abstract: In this paper, a growth model based on the Cobb–Douglas production function is adapted to include demographic aspects of the labour factor. The model is applied to 16 Central and Eastern Europe economies, where the contribution of individual variables to economic growth in the period 1993–2019 is calculated. As expected, some of the key findings are that tangible capital, human capital, and technology have been the main drivers of the growth of these economies to date, while population change generally has a slight negative impact. The research highlights the current importance of demographic factors and points to the risk that, if current unfavourable demographic trends — such as population decline and changes in the age structure in favour of an older population — continue, these factors could become a significant determinant of economic growth slowdown in Central and Eastern European countries in the upcoming period.

Keywords: economic growth, population, demographic change, Cobb–Douglas production function, contribution to growth, Central and Eastern Europe

JEL classification: J110, I250, O490

1. Introduction

The subject of this paper is the impact of the described demographic parameters on economic growth, i.e. growth of total real GDP, in 16 countries of Central and

Eastern Europe (CEE)¹. For the observed region, we selected, based on previous literature, relevant variables. These are the age dependency ratio, level of education, employment, population size, and material capital stock.

The initial hypothesis of the research assumes that demographic trends had a negative impact on the growth of CEE economies in the period 1993–2019. The aim of the analysis is to estimate the impact of individual demographic and economic variables on economic growth in these countries. Observing a period of slightly more than a quarter of a century, using a well-known economic growth model (based on the Cobb-Douglas production function), modified to include the described indicators, the contribution of each of these indicators to economic growth is estimated in each CEE country individually. This paper will evaluate the impact of these variables on growth, and the results obtained will indicate problems that are currently present, as well as those that may arise in the future.

Although demographic patterns vary significantly around the world, and even within individual regions, we can say that the CEE countries are characterized by very similar trends in terms of population change. The above-mentioned countries are facing a decline or, in the case of a smaller part of them, stagnation in number of their inhabitants, which represents a significantly different trend compared to most of the world (outside Europe), where the population is increasing. At the same time, there is a change in the age structure of the population towards a larger share of the population outside working age. In all CEE countries, a change in the direction of the dependency ratio was recorded over the observed 26 year period, from decreasing to increasing. Also, the countries in this region do not differ significantly from each other in terms of the level of education, i.e. the educational structure of the population.

Based on the methodological settings from the study by Zhao & Zhu (2016), the paper uses a modified version of the Cobb-Douglas production function, which, in addition to standard factors, contains separate demographic factors. Based on this defined function, the growth rates of 16 CEE countries in the period 1993–2019 were analyzed, and the contribution of each individual component to economic growth in this period was estimated.

The paper focuses on demographic factors of growth, their past trends and impact on GDP growth, as well as the implications of their current trends on future economic growth. The analysis will show that, in the context of the contribution of factors to GDP growth, some patterns are characteristic of all observed countries, while in some cases, huge differences exist among the CEE countries.

¹ This group of countries includes Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, Estonia, Latvia, Lithuania, Hungary, Montenegro, North Macedonia, Poland, Romania, Serbia, Slovakia, and Slovenia.

2. Literature review

Authors often resort to regression or panel analysis in an attempt to quantify the effect of population change on economic growth. The main explanatory variable in these studies is usually the age dependency ratio. Lee & Shin (2019), based on a panel study of 142 countries from 1960 to 2014, reveal the effects of population aging on economic growth. According to the results of this analysis, population aging (measured by the share of the elderly, i.e. the old-age dependency ratio) negatively affects economic growth only when it reaches a certain high level, and these negative effects are increasingly stronger as the population aging process deepens. Population aging has particularly limited economic growth in recent times, and more so in countries with an older population on average, which are generally more developed countries. The share of the working-age population growth is positively related to economic growth. According to the results of Cruz & Ahmed (2018), in which as many as 180 countries has been observed between 1950 and 2010, an increase in the working-age population share, on average, leads to higher per capita income growth rates and poverty reduction, with the results largely due to a decline in the child dependency ratio.

There are also single-country studies, that analysed demographic change in the context of a certain country's economic growth. Fang & Wang (2005) estimated that an increase in the dependency ratio by 1 pp. causes a decrease in economic growth by 0.115 pp. and showed that China benefited significantly from the age structure change in the period 1982–2000, when dependency ratio dropped significantly. Of China's 8.6% average growth rate in that period, 2.3 percentage points, or one quarter of the growth, was due to the improvement in the age structure. Maestas et al. (2023) found that population aging is slowing growth in the United States of America. According to their study, a 10% increase in the share of people older than 60 leads to a 5.5% decrease in GDP per capita, meaning that population aging reduced GDP per capita by 0.3 percentage points on average per year between 1980 and 2010. At the same time, two-thirds of the decrease comes from slower labour productivity growth, and one-third from slower employment growth.

The authors of some studies have noticed a different direction of certain demographic factors' influence on driving economic growth. For example, Pasichnyi & Nepytyaliuk (2021) on 45 countries set in the period 1990–2018, estimated with panel analysis that the growth rate of the working-age population negatively affects economic growth.

The literature dealing with the connection between these variables at the level of CEE region economies is not so extensive, but works that have confirmed the existence of statistically significant impact of demographic trends on the rate of economic growth can be found. Iftimi & Panaite (2021), on a sample of ten CEE countries in the period 1990–2019, conclude that a 10% increase in the share of

people aged 60 years or more leads to a decrease in the GDP growth rate per capita by 7.2%, and the impact of demographic change on productivity growth is even more negative. Khachatryan et al. (2023) observed 13 countries, including Moldova, Ukraine, and the 11 countries that are also the subject of this study. Using an ordinary least squares panel analysis, they estimated that a 10% increase in the dependency ratio between 2000 and 2021 was associated with a 3.12% decline in GDP per capita. Also, Liu (2024), using the set of 11 CEE economies from 1995 to 2020, based on the results of regression analysis, suggests that aging represents an obstacle to achieving higher growth rates in these countries.

In the methodological context, a study that differs from most other on this topic is Zhao & Zhu (2016). These authors used the Cobb–Douglas production function and modified it to a form that shows relationship between several demographic variables and economic growth. Using the data of 12 economies of the world, they found the contributions of each of the included factors to GDP growth by country. A similar approach will be applied in this analysis to a CEE countries sample.

3. Economic growth model and mechanism of action

Although not as frequently used in the context of demographic influence on growth, one of the most widely used groups of economic growth models is based on the Cobb–Douglas production function. Based on this function, over the course of several decades, economic theory has developed versions of economic growth models that included various factors in order to more adequately capture the drivers of economic growth or to help determine the effects that individual variables have on growth. The basic model based on the Cobb–Douglas function includes capital and labour as factors in the creation of output, or, in the context of macroeconomics, gross domestic product.

Starting from Robert Solow's exogenous growth model (Solow, 1956), based on a Cobb–Douglas type production function (Cobb & Douglas, 1928), The goal is to get a value-expressed impact of demographic factors on economic growth. The standard Cobb–Douglas production function starts from production factors of capital and labour, which affect economic growth to an extent that depends on the elasticity of production in relation to them, as well as on technological progress towards a more efficient use of these factors. The new, demographic element included in the production function implies decomposition of labour factor into demographic factors, such as the total population, the working-age population, and the dependency ratio, and "connecting" economic factors, such as the labour force participation rate and the employment rate.

The initial equality is written as follows:

$$(1) Y = AK^\alpha(LH)^{1-\alpha}e^\gamma,$$

where Y is national income, K is tangible (material) capital stock, L is the volume of employment, H is the indicator of human capital. Y is, therefore, gross national product (GDP), K is the material capital factor (capital stock), L is the labour factor (number of workers), and H represents the human capital component. In this case, human capital is measured by the average number of years of schooling, i.e. the average number of years during which workers acquire skills to perform work. A is a constant and is a measure of the efficiency in converting factors of production into output. Finally, γ (gamma) is a parameter of total factor productivity and includes all unspecified factors, such as advances in technology and the institutional framework. As can be seen in the equation, the exponents α and $1-\alpha$ add up to 1, which means that returns to scale are constant. If both the (material) capital factor and the labour factor increase n times, total national income will also increase n times, other things being equal.

This production function model is set up and will be further developed following the approach presented in the Zhao & Zhu (2016) paper. An alternative approach is the one that Hippe (2014) states, where total factor productivity is linked to labour, and human capital is separated from labour. In such a setting, there would be three measures of output elasticity with respect to factors of production (α , β , and $1-\alpha$), which would make the analysis more complex to some extent.

Therefore, for the purposes of our research, we apply a model similar to that one proposed by Zhao & Zhu (2016). The initial form of the production function represented by equation (1) can be modified by including demographic elements, so we obtain the following form:

$$(2) Y = AK^\alpha \left(\frac{P*UZ}{1+OZ} * H \right)^{1-\alpha} e^\gamma$$

where P is number of inhabitants (total population), UZ share of employed people in total population, and OZ dependency ratio. After mathematical operations, that is transformed into

$$(3) \text{gr}Y = \alpha * \text{gr}K + (1-\alpha) * \text{gr}P + (1-\alpha) * \text{gr}H + (1-\alpha) * \text{gr}\left(\frac{1}{1+OZ}\right) + (1-\alpha) * \text{gr}UZ + \gamma$$

where GDP growth rate is equal to sum of all factors' growth rates weighted by their exponent from equation (2), adding total factor productivity growth.

Equation (3) will be used to determine the value of the contribution of each observed factor to economic growth. In this way, it comes to the basic quantities that will be used in the analysis. These are GDP (Y), population (P), population outside working age (needed to calculate OZ), working age population (needed to calculate OZ and UZ), number of employed people (needed to calculate SZ), material capital stock (K), average number of years of education of workers (H), elasticity of output with respect to capital (α) and with respect to labour ($1-\alpha$). Based on this equation and the data that is going to be included in the calculation,

we will determine how many percentage points each factor contributed to GDP growth in the CEE countries during the observed period. Demographic data (total population, both working and non-working age) are taken from the United Nations' "World Population Prospects 2024" (United Nations, 2024), labour market data (population in the labour force, participation rate, employment) from the World Bank's "World Development Indicators" data². The source of data for the average number of years of schooling is the UNDP HDI data³, and for GDP and capital stock⁴ the International Monetary Fund database (IMF, 2021). Data on the labour share of GDP are taken from the United Nations website.⁵

It is noticeable that we arrived at the final form, represented by equation (3), by decomposing the factor L into several demographic indicators, through the equality

$$(4) L = \frac{P \cdot SZ \cdot SURS}{1 + OZ} = \frac{P \cdot UZ}{1 + OZ}$$

where SZ represents the employment rate, and SURS is the labor force participation rate. The product those two is the variable UZ, the share of employed people in the total population.⁶ The employment rate and the labor force participation rate jointly affect the size of the labor force, positively influencing its volume. These two indicators are combined within the share of employed people in the total population.

The values of the parameters α and $1-\alpha$ were assumed based on data on the labour share in national product, taking into account available data.⁷ According to these data, the constant for labour, $1-\alpha$, was taken to be 0.45 for Bulgaria and Romania, 0.6 for Slovenia and Croatia, and 0.5 for Albania, Bosnia and Herzegovina, Hungary, Estonia, Latvia, Lithuania, Poland, North Macedonia, Slovakia, Serbia, Montenegro and Czechia. Based on this, the capital constant, α , is obtained simply and is 0.55 for Bulgaria and Romania, 0.4 for Croatia and Slovenia, and 0.5 for the remaining CEE countries. Using the constants α and $1-\alpha$ and the growth of the corresponding factor in the observed period, the contribution of that factor to economic growth is obtained.

² World Bank (2025)

³ UNDP (2025)

⁴ Component K represents the tangible capital stock, so the change in K reflects the net change in the stock, taking into account both gross investment and depreciation.

⁵ UNStats (2025)

⁶ The following applies to the demographic factors used here: $OZ = (\text{number of individuals outside working age})/(\text{number of working age individuals})$, $SURS = (\text{number of people in the labour force})/(\text{number of working age individuals})$, $SZ = (\text{number of employees})/(\text{number of people in the labour force})$

⁷ UNStats (2025); Data on indicator 10.4.1. (Labour share in GDP) are available for twelve observed countries, with the exception of Hungary, Estonia, Montenegro and North Macedonia, for the period 2004–2021.

Table 1. Share of labour in GDP (%)

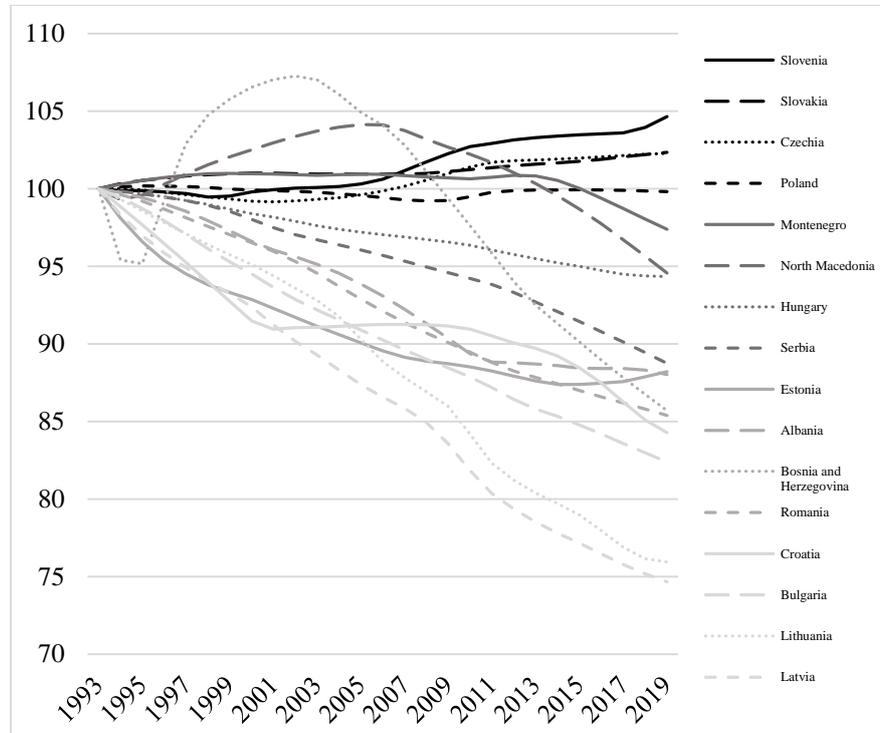
Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Selected constants: $1-\alpha=0.45$, $\alpha=0.55$																		
Bulgaria	41	41	39	38	40	42	44	43	46	49	50	51	51	53	53	53	53	51
Romania	45	48	46	40	42	41	44	40	40	39	40	40	44	43	44	45	47	41
Selected constants: $1-\alpha=0.5$, $\alpha=0.5$																		
Albania	47	47	47	47	46	48	48	48	48	48	48	48	48	47	47	48	49	48
Bosnia H.	51	52	51	52	55	57	56	56	58	56	55	55	54	52	52	53	55	52
Latvia	43	45	47	49	54	53	49	46	46	48	49	52	53	54	55	56	59	57
Lithuania	45	45	48	47	49	50	46	44	43	45	44	48	48	50	51	53	54	53
Poland	49	48	48	48	50	48	49	48	48	48	48	47	50	49	50	50	50	47
Slovakia	45	46	45	44	46	48	46	46	45	48	48	48	50	51	51	52	54	53
Serbia	61	59	57	57	55	53	49	46	47	48	49	49	49	48	48	52	57	52
Czechia	52	52	52	52	53	53	54	53	55	54	53	52	53	55	56	57	58	56
Selected constants: $1-\alpha=0.6$, $\alpha=0.4$																		
Slovenia	57	57	57	56	56	60	61	58	59	58	60	58	58	57	57	59	61	60
Croatia	63	63	60	59	59	61	60	59	58	56	56	57	55	55	57	56	62	56

Source: UNStats

4. Variables and empirical analysis

One of the key demographic and economic challenges for most CEE countries is the population decline since the 1990s. In the period from 1993 to 2019, the CEE countries with the largest demographic decline were Latvia (average -11.2% per year), Lithuania (-10.5%) and Bulgaria (-7.4%). The most favourable population trends were recorded in Slovenia (1.8%), Slovakia (0.9%) and the Czech Republic (0.9%).

In addition to the aforementioned Latvia, Lithuania and Bulgaria, as Figure 1 shows, several other CEE countries have been experiencing a constant, strong decline for more than twenty years. These are Romania, Serbia and – to a somewhat lesser extent – Hungary. Bosnia and Herzegovina has been experiencing a very high population decline since 2003, while Croatia, after an initial decline and several years of stagnation (2001–2011), has once again found itself on a declining trajectory.

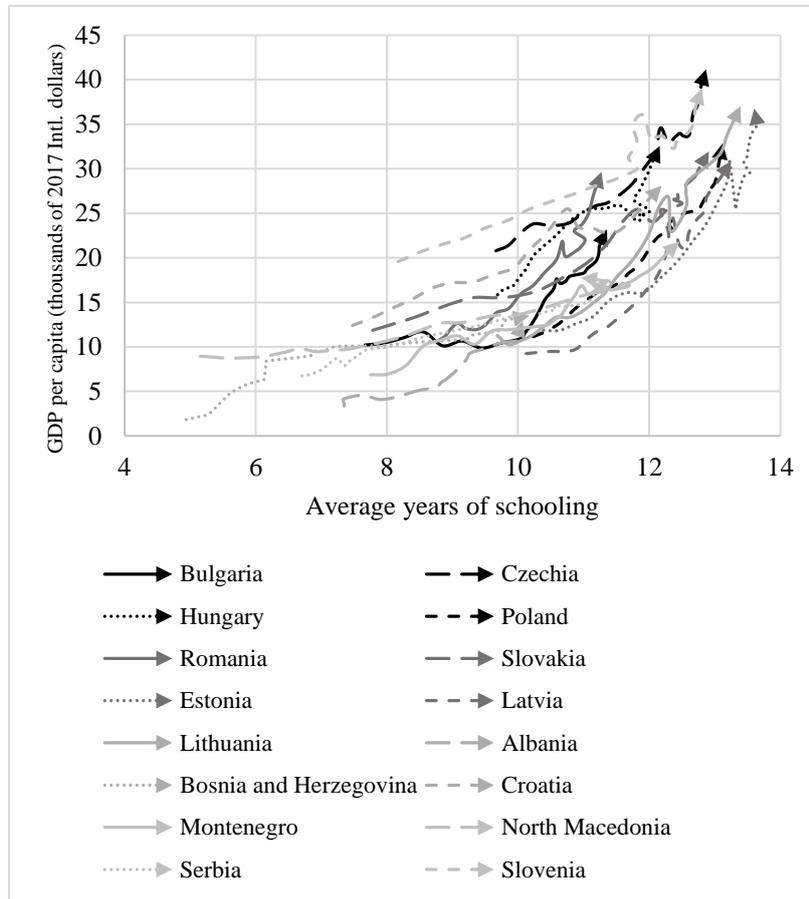
Figure 1. Population, base indices (1993=100)

Source: Author based on WPP2024

CEE countries, in a period of extremely unfavorable birth and migration trends, are increasingly dependent on enhancement of the human capital of their population. The average number of years of schooling has been steadily increasing in all countries covered since 1993. In 1993, it was 8.2 on average, and in 2019, it was 12.1. The largest increase in the average number of years of schooling in the 26 years observed was recorded in North Macedonia (an increase of 5.8 years).

An undoubtedly strong positive correlation between human capital and GDP per capita in CEE countries can be observed based on the presentation in Chart 2. It is also noticeable that the positive correlation between GDP per capita and human capital exists both when we look at different observation units (countries) in the same unit of time (year), but also when we look at one observation unit over a longer period of time. Based on this, the results were expected to show that the contribution of increasing the number of years of schooling to economic growth in the observed period was not negligible, but rather mostly very significant.

Figure 2. Human capital and GDP per capita from 1993 to 2019



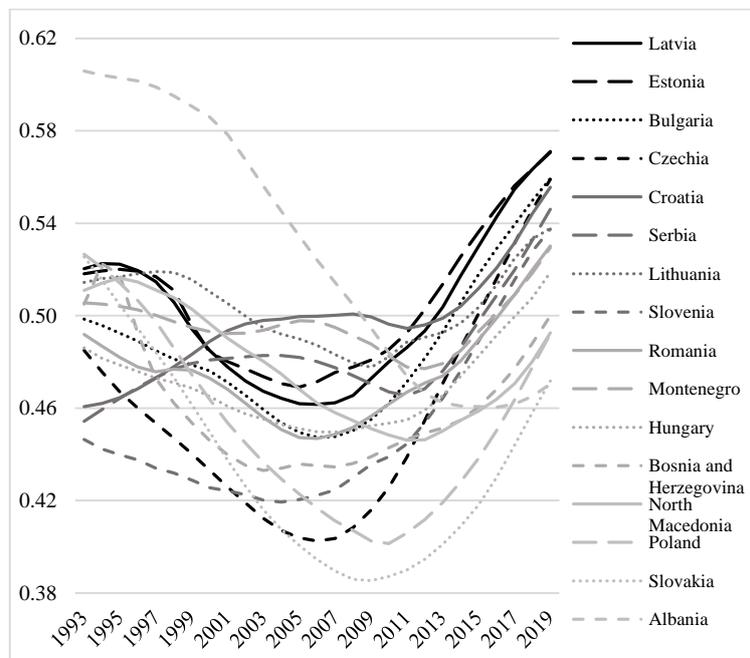
Source: Author's calculation based on IMF, WPP 2024 and UNDP

The next variable we observe – the age dependency ratio – in the CEE countries oscillated during the period covered, and for each country there were years in which it increased and years in which it decreased. In general, the increasing age dependency ratio at the beginning of this period, which was the case until the middle or towards the end of the first decade of the 21st century, is primarily the result of declining birth rates. Namely, in those years, CEE countries were mostly faced with an increase in the number of people aged 65 or more, but the decline in the contingent of residents under 15 was stronger than that growth, so that the population outside the working age (the sum of those under 15 and those over 65) was decreasing its share in the total population. However, in all CEE countries, a turning point occurred, so that the dependency ratio began to increase at some point. For this reason, this research also requires an analysis by subperiods, depending on the direction of movement of the age dependency ratio in each country.

In 1993, the CEE countries had a dependency ratio of 0.50 on average. The lowest value for this group of countries was achieved in 2008–2009, when the dependency ratio fell to 0.45. Then, an accelerated process of increasingly poor age structure followed, so this indicator in 2019 averaged 0.53.

By far the strongest increases in the age dependency ratio occurred in Serbia, where the ratio was 0.45 in 1993 and 0.55 in 2019, and in Croatia, where it increased from 0.46 to 0.56 from the beginning to the end of that period. The most prominent age structure change in the other direction is related to Albania, where the dependency ratio fell from 0.61 (1993) to 0.46 (2016), due to a significant decrease in fertility during that period, but then this country's dependency ratio also took on an increasing trend.

Figure 3. Old-age dependency ratio



Source: Author based on WPP2024

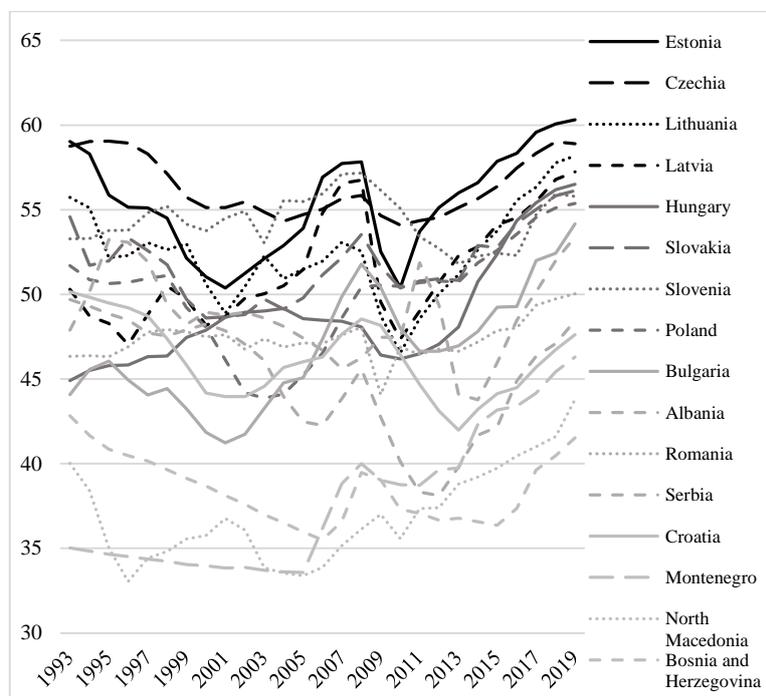
The period from 1993 to 2008 was marked first by a decline, and then by an increase, in the share of employed people in the CEE countries. During that period, this indicator⁸ has cumulatively increased by only 1% on average across the countries observed. From 2008 to 2010, due to the World Economic Crisis, employment fell in 14 countries, with the exception of Albania and Poland. The improvement in the labor market indicators is a feature of all CEE countries in the

⁸ Share of employed people in the population aged 15+

period after the World Economic Crisis, after 2010, when the factor of the share of employed people is increasing. It is worth noting that the ranking of these 16 countries according to the aforementioned indicator does not differ much in 2019 compared to the ranking in 1993.

The Baltic republics of the former USSR and Czechia have the highest values, followed by a subgroup of countries from Central Europe, and the former republics of the SFR Yugoslavia are at the bottom. Croatia and Serbia have made the least progress in relative employment improvement when observing the entire period.

Figure 4. Share of employed people in the population aged 15+



Source: Author based on *World Bank*

5. Results of the contribution of individual variables to economic growth: Overall and subperiod analysis

Economic growth in CEE countries between 1993 and 2019 averaged 3.6% per year⁹, with that number ranging from 2.4% in Bulgaria, whose economy grew the

⁹ This value, as well as all other average values for countries in the CEE region in this text, is an unweighted average. Economic growth is calculated according to GDP at constant prices, measured in 2017 international dollars.

slowest, to 7.3% in Bosnia and Herzegovina, which achieved the fastest average annual growth, which is largely due to the low initial level and the state of war at the beginning of the observed period. In addition to Bulgaria, Croatia, North Macedonia and Hungary also had slower growth rates over the past 26 years, while, along with Bosnia and Herzegovina, Albania, Montenegro and Poland grew the fastest. By decomposing growth into the previously mentioned factors, we have obtained indicators of the impact and contribution of these factors to economic growth over a period of slightly more than a quarter of a century.

Table 2. Growth and contribution to growth (in p.p. of GDP, annual average) 1993–2019

Country	Growth	Contribution to growth (in pp.)					
		Mater. capital	Popula-tion	Share of empl. in total pop.	Human capital	Depen-dency ratio	Total factor prod.
		K	P	UZ	H	$1/(1+OZ)$	γ
Bulgaria	2.4%	3.2	-0.3	0.4	0.7	-0.1	-1.4
Czechia	2.8%	1.3	0.0	0.0	0.6	-0.1	1.0
Hungary	2.6%	1.5	-0.1	0.4	0.4	0.0	0.3
Poland	4.2%	1.9	0.0	0.1	0.5	0.0	1.7
Romania	3.3%	2.5	-0.3	0.1	0.4	0.0	0.6
Slovakia	4.0%	1.3	0.0	0.1	1.0	0.1	1.5
Estonia	3.9%	2.5	-0.2	0.0	0.5	-0.1	1.2
Latvia	3.6%	2.7	-0.6	0.2	0.5	-0.1	0.7
Lithuania	3.6%	2.3	-0.5	0.1	0.6	0.0	1.1
Albania	4.8%	2.5	-0.2	0.2	0.6	0.2	1.6
Bosnia and Herzegovina	7.3%	3.6	-0.3	-0.1	1.4	0.0	2.7
Croatia	2.5%	1.3	-0.4	-0.1	1.1	-0.1	0.8
Montenegro	4.4%	1.7	-0.1	0.5	0.9	0.0	1.3
North Macedonia	2.5%	1.0	-0.1	0.2	1.5	0.0	-0.1
Serbia	3.3%	1.1	-0.2	0.0	1.0	-0.1	1.6
Slovenia	2.9%	1.0	0.1	0.1	1.0	-0.1	0.7
Average	3.6%	2.0	-0.2	0.1	0.8	0.0	1.0

Source: Author

The change in the number of inhabitants was negative in most countries (see the previous part), i.e. the population was decreasing, which reflected a slowdown in the growth rate and led to growth below the potential rate, which would have been in effect if the population had remained at the same number during these

years. In four countries, namely those that make up the Visegrad Group, the population stagnated or increased slightly from 1993 to 2019, but not enough to significantly boost GDP growth. In only one country, Slovenia, did population dynamics have any noticeable impact on GDP, increasing it by an average of 0.1 percentage point (p.p.) per year. In the Czech Republic and Slovakia, this impact is 0.04, and in Poland 0.0. Thus, in three quarters of the CEE countries, the contribution to growth from the population factor was negative. The strongest slowdown in growth due to the population chasm is observed in Latvia (−0.6), Lithuania (−0.5) and Croatia (−0.4), where, in relative terms, the population decline reduced potential GDP growth by about a seventh. Although these numbers do not seem large on an annual basis, over the entire period, low fertility and population emigration created major barriers to economic growth, and in these three countries, GDP from the most recent year covered is at a level of 86% (Latvia), 87% (Lithuania) and 90% (Croatia) of the GDP that would be achieved with neutral population change. The corresponding figure is 92% for Bulgaria, 93% for Bosnia and Herzegovina and Romania, and 94% of potential GDP for Albania, Estonia and Serbia. On average, the contribution of the population component to economic growth in these sixteen countries was −0.2 pp per year.

The capital stock grew in all CEE countries, albeit at an uneven pace and with different average shares in GDP creation, and therefore with different contributions to economic growth in the period 1993–2019. The contribution to economic growth from the growth of the tangible capital stock ranged from 1.0 in North Macedonia and Slovenia to 3.6 in Bosnia and Herzegovina, again with a stress on a low base. It should also be emphasized that the five CEE countries that had the highest level of capital per capita at the beginning of the observed period – the Czech Republic, Slovenia, Slovakia, Hungary and Croatia – as expected, recorded weaker growth in the capital stock, and a smaller contribution of capital to growth, than CEE countries' average. Along with them, the smallest increase in the capital was recorded in North Macedonia and Serbia, despite the fact that they were not abundant in technology and equipment even at the beginning of the period. Bulgaria, which we previously determined to be characterized by a higher share of capital in the generation of national product than most other CEE countries, increased material capital stock to a large relative extent, and this factor contributed to GDP growth by 3.2 p.p. on average yearly. Capital's contribution to growth in Serbia is among the weakest in CEE, at 1.1 pp. on average per year. Investments in this period, generally speaking, were not high. In fact, from 1993 to 2004, there was even a cumulative decline in the stock of material capital, as in most years investments were not sufficient to overcome depreciation. Only after that point did investment gradually accelerate, although not enough to attribute more than one-third of Serbia's economic growth in the 26-year time to the capital factor. It can be concluded that physical capital contributed to the growth of CEE countries by more than 50% yearly average per country (2.0 pp out of 3.6%).

Throughout the observed period 1993–2019, the analysis also included labour market developments, manifested in ratio of employed individuals and working age total population. In majority of CEE economies this factor made a slight positive contribution to economic growth, of 0.1 pp of GDP on average per year. Changes in the labour market (in the direction of employment) contributed most to the growth of Montenegro, the country with the smallest population in the observed group. This country experienced the largest relative increase in employment, which caused GDP growth of 0.5 pp. on average per year. In this segment, Bulgaria and Hungary each achieved 0.4 percentage points and, among the observed CEE countries from the European Union, their economies benefited the most (in terms of growth level) from additional employment relative to the total population. Generally speaking, for the entire CEE region, due to the low average of 0.1, we can conclude that these countries did not rely to a large extent on employment growth as a driver of economic growth in the period from 1993 to 2019. In Bosnia and Herzegovina and Croatia, the decline in the share of employed people had a negative impact of -0.1 pp each on GDP.

Human capital has proven to be an important factor in stimulating growth in CEE countries. The fact that the average contribution of this factor to growth was 0.8 pp of GDP per year suggests that the impact of improvements in the quality of labour, measured by the average number of years of schooling, on GDP was significant, and significantly greater than the contribution made by changes in the quantity of labour, measured by the ratio of employees to the total population. It is noted that in this indicator, the former Yugoslav republics performed better than the CEE average. Specifically, the parameter values are 1.5 for North Macedonia, 1.4 for Bosnia and Herzegovina, 1.1 for Croatia, 1.0 for Serbia and Slovenia, and 0.9 for Montenegro. These data are not surprising, given that at the beginning of the period, there were relatively few highly educated people in the mentioned countries, and that the average number of years of schooling in the first observed year (1993) was 6.7, with Bosnia and Herzegovina and North Macedonia having a particularly low level, while in the remaining ten CEE countries the average number of years of schooling was 9.1. In 2019, the former SFRY republics, with their average in the field of education (11.7 years), almost caught up with the rest of the CEE region (12.4 years). In the analysed period, North Macedonia generated as much as 60% of its growth from human capital, and Serbia almost a third. However, the problem for most Balkan countries remains the departure of numerous highly educated people outside the borders of their home countries toward more developed countries.

The age dependency ratio factor was on average 0.0 pp of GDP at the CEE level, which means that the change in the ratio of the working-age population to the non-working-age population did not have a significant impact on economic growth, not even by individual country (the highest value is 0.2 in Albania, and the lowest is -0.1 in several countries). However, it should be borne in mind that the

dependency ratio is characterized by movement in one direction over a long period of time, and that in all countries, throughout the entire period 1993–2019, there were sub-periods when this ratio declined and when it grew, so on average it had a negative impact on economic growth. At times when countries experienced a decline in the dependency ratio, the average contribution to economic growth was 0.15 pp of GDP, and at times when it increased, the contribution was -0.18 . Today, however, in all CEE countries, the dependency ratio is increasing, so it has and will have a negative contribution to GDP growth in the coming period, which is very important to emphasize.

In 14 out of 16 observed countries, total factor productivity, i.e. technological development, institutions and other aspects not included, recorded a positive contribution to GDP growth. At the level of all CEE countries, this contribution averaged 1.0 pp. per year, i.e. slightly more than a quarter of economic growth.

The opposite tendency is observed in Bulgaria. The significant negative contribution to total factor productivity, with an appreciable increase in the capital stock in Bulgaria, indicates that it was driving its growth through the capital factor, but, in that process, it was relying solely on increasing the level of investment and using existing, outdated equipment, rather than on improving technology and factor productivity. In North Macedonia, the contribution of total factor productivity is almost neutral (-0.1).

The results of the analysis by sub-periods, formed on the basis of the direction of the age dependency ratio movement, are given in Table 3. In the period 1993–2019, all countries experienced a change in this demographic indicator, mainly in the way that it declined in the initial years, and at a certain point during the 21st century began to increase, reflecting unfavourable population trends. When the age dependency ratio declines, it opens up the possibility for an increase in the relative size of the most productive part of the population, and the impact on economic growth is positive. When this ratio increases, the share of the working-age population decreases, which puts pressure on the labour contingent, i.e. the labour force factor, and this has adverse effects on economic growth. Exceptions to the usual trends are Serbia and Croatia, where the dependency ratio grew until 2003 and 2008, respectively, then declined for several years, only to return to an upward trajectory in both countries in 2011. It is also symptomatic for Serbia in first sub-period (1993–2003) that it experienced a decline in the stock of tangible capital, while all other CEE countries increased their capital stock. Thus, in 14 out of 16 CEE countries, in the initial period (lasting 10 or more years), the stock of tangible capital has been increasing and the dependency ratio has been decreasing simultaneously, and they found drivers of economic growth in both aspects. In Serbia, both indicators went in an unfavourable direction and represented two brakes on economic growth. Considering that both the total population and the share of employed people were declining, the sources of Serbia's economic growth were then reduced exclusively to increasing human capital and total factor productivity.

Table 3. Growth and contribution to growth (in pp. of GDP, annual average) by subperiods

Country	Sub-period	OZ	Growth	Contribution to growth (in pp.)						
				Mat. capital	Population	Share of empl.	Human capital	Dependency ratio		Total factor productivity
				K	P	UZ	H	1/(1+OZ)		γ
							when OZ does not grow	when OZ grows		
Bulgaria	1993-2006	decr.	2.4%	3.1	-0.4	0.2	1.1	0.1		-1.8
	2006-2019	incr.	2.5%	3.3	-0.3	0.5	0.3		-0.3	-1.0
Czechia	1993-2006	decr.	3.4%	1.5	0.0	-0.3	0.9	0.2		1.1
	2006-2019	incr.	2.1%	1.1	0.1	0.3	0.2		-0.4	0.8
Hungary	1993-2007	decr.	3.2%	1.9	-0.1	0.3	0.6	0.1		0.5
	2007-2019	incr.	1.8%	1.1	-0.1	0.6	0.3		-0.2	0.1
Poland	1993-2010	decr.	4.6%	1.9	0.0	-0.1	0.5	0.3		1.9
	2010-2019	incr.	3.6%	1.9	0.0	0.5	0.4		-0.3	1.2
Romania	1993-2006	decr.	3.5%	1.9	-0.3	0.1	0.6	0.1		1.1
	2006-2019	incr.	3.2%	3.0	-0.3	0.2	0.3		-0.2	0.1
Slovakia	1993-2009	decr.	4.6%	1.5	0.0	-0.2	1.4	0.3		1.5
	2009-2019	incr.	3.0%	1.1	0.1	0.4	0.3		-0.3	1.4
Estonia	1993-2005	decr.	5.8%	2.6	-0.4	-0.4	1.0	0.1		3.0
	2005-2019	incr.	2.3%	2.5	-0.1	0.4	0.2		-0.2	-0.4
Latvia	1993-2006	decr.	6.0%	3.1	-0.6	0.3	0.8	0.2		2.2
	2006-2019	incr.	1.2%	2.3	-0.6	0.2	0.3		-0.3	-0.7
Lithuania	1993-2009	decr.	3.6%	2.7	-0.5	-0.4	0.8	0.1		0.9
	2009-2019	incr.	3.6%	1.6	-0.6	0.9	0.4		-0.2	1.4
Albania	1993-2016	decr.	5.0%	2.6	-0.3	0.0	0.7	0.2		1.7
	2016-2019	incr.	3.4%	1.4	-0.1	1.6	0.1		-0.1	0.4
Bosnia and Herz.	1993-2003	decr.	15.1%	4.8	0.3	-0.7	1.1	0.2		9.4
	2003-2007	stagnate	5.4%	4.1	-0.5	-0.1	1.3	0.0		0.6
	2007-2019	incr.	1.9%	2.5	-0.8	0.5	1.7		-0.2	-1.9
Croatia	1993-2008	incr.	4.3%	1.6	-0.4	-0.1	1.5		-0.1	1.8
	2008-2011	decr.	-3.1%	1.7	-0.2	-1.6	0.7	0.1		-3.7
	2011-2019	incr.	1.5%	0.5	-0.5	0.5	0.7		-0.3	0.6
Monten.	1993-2012	decr.	4.7%	1.4	0.0	0.3	1.0	0.1		1.9
	2012-2019	incr.	3.6%	2.6	-0.3	1.1	0.6		-0.2	-0.2
North Maced.	1993-2011	decr.	2.4%	0.7	0.0	-0.2	1.8	0.1		0.0
	2011-2019	incr.	2.5%	1.7	-0.5	1.0	0.8		-0.2	-0.3
Serbia	1993-2003	incr.	3.8%	-0.2	-0.2	-0.4	1.0		-0.1	3.7
	2003-2011	decr.	3.9%	2.2	-0.2	-1.1	1.7	0.1		1.3
	2011-2019	incr.	2.1%	1.5	-0.3	1.5	0.5		-0.3	-0.7
Slovenia	1993-2004	decr.	4.0%	1.5	0.0	0.2	2.1	0.1		0.1
	2004-2019	incr.	2.0%	0.7	0.2	0.0	0.3		-0.3	1.1

Source: Author

In the following sub-period (2003–2011), when the old-age dependency ratio began to improve, it contributed to Serbia's growth by 0.1 pp on average per year, but at that time there was also an increase in investments, which created conditions for more conventional growth incentives. In Croatia, in the second sub-period (2008–2011), the growth of the capital stock remained at approximately the same level as in the first sub-period, but the impact of the global financial crisis, largely through a decline in employment (contribution of -1.6), led to a significant decline in GDP at that time.

The second decade of the 21st century is characterized by the fact that all observed countries recorded an increase in the share of the population outside the working age, which led to a negative contribution to economic growth, ranging from -0.4 to -0.1 pp. on average per year across countries. The current impact of changes in the age dependency ratio on the growth of CEE economies is around 0.3 percentage points (negatively) annually and this should not be ignored. When we add to this the factor of declining population, we conclude that in some CEE countries demographic trends reduce GDP by close to 1 pp per year.

The interconnection between trends in the employed population share and the age dependency ratio is interesting. In all observed countries, with the exception of a minor deviation in Latvia and Slovenia, it is observed that the contribution of increasing the employment factor is smaller when the dependency ratio decreases, and conversely, has a greater value when the dependency ratio increases. In other words, during periods of improving demographics, CEE countries relied on this factor and its “natural” and direct impact on GDP. At times when the dependency ratio increased and the age structure worsened, the share of employed people in the total population grew faster and had a more significant impact on economic growth. Policymakers in the countries under review have realized that the increasingly unfavourable demographic picture requires changes in the labour market, and have resorted to various means, among which the most notable are the changes in the retirement age that some countries implemented during the second decade of the 21st century. Of course, changes in demographic structure will, *ceteris paribus*, negatively affect the ratio of employed to total population in the future. This will require adequate responses from policymakers, such as further raising the retirement age or other effective measures to stimulate employment, which are generally of limited scope.

We also remark that in most countries, the population was growing at a similar rate and made a uniform contribution to growth in different periods, even though the population structure changed. These two factors – the total population size and the age structure – together shaped the size of the labour force and thus the size of the labour factor in the Cobb–Douglas production function.

6. Conclusion

The paper conducted research based on the changing economic growth model for CEE countries. The analysis determined that population aging and population decline have significant effects on the economic growth of CEE countries. These effects have varied in intensity over the past three decades, but have not been a major determinant of growth prospects for most of the period under review. From 1993 to 2019, CEE economies relied on investment as the main driver of growth, with human capital and total factor productivity, and to a lesser extent employment growth, also contributing to the acceleration of economic activity. The increase in human capital through the education of the population of these countries particularly stands out.

Nevertheless, recently, population problems have become more pronounced. The unfavourable demographic picture, in terms of the size and age of the population, is increasingly emerging as a limiting factor for economic growth. Demographic parameters in some CEE countries are already at a level and with an impact that cannot be disregarded, and they will almost certainly have a strong negative effect on GDP in all CEE economies in upcoming period. Therefore, if the demographic picture does not change significantly, the countries covered by this analysis will need to compensate that by upgrading human capital, expanding material capital, and improving the factor productivity. However, significant growth in all these factors has already been evident in previous decades, but the dynamics of their further growth are questionable. It seems that the, with labor shortages, potential for growth of these factors is limited, which is an additional aggravating circumstance for the future growth of the CEE economies. Thus, these results show the contribution of demographic change to the economic growth of CEE countries so far, but also emphasize caution when it comes to future growth prospects.

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DOPRINOS DEMOGRAFSKOG FAKTORA PRIVREDNOM RASTU ZEMALJA CIE

Rezime: U ovom radu model rasta na bazi Kob–Daglasove proizvodne funkcije je prilagođen tako da obuhvati demografske aspekte činioca rada. Model je primenjen na 16 privreda Centralne i istočne Evrope, gde je izračunat doprinos pojedinačnih promenljivih privrednom rastu u razdoblju 1993–2019. godine. Prema očekivanjima, neki od osnovnih nalaza su da materijalni kapital, ljudski kapital i tehnologija predstavljaju glavne pokretače dosadašnjeg rasta ovih privreda, dok istovremeno populaciona kretanja uglavnom imaju blag negativan uticaj. Istraživanje naglašava trenutni značaj demografskih faktora i ukazuje na rizik da bi, ukoliko se održe sadašnji nepovoljni demografski trendovi — kao što su smanjenje broja stanovnika i promene starosne strukture u korist starije populacije — ti faktori mogli postati značajna determinanta usporavanja privrednog rasta u zemljama Centralne i istočne Evrope u narednom periodu.

Ključne reči: privredni rast, stanovništvo, demografske promene, Kob–Daglasova proizvodna funkcija, doprinos rastu, Centralna i istočna Evropa

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