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Socioeconomic development and life expectancy relationship: evidence from the EU accession candidate countries

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Abstract

This paper investigates the effect of the socioeconomic development on life expectancy at birth as an indicator of mortality or longevity in five EU accession candidate countries (Macedonia, Serbia, Bosnia and Herzegovina, Montenegro, and Albania). Using aggregate time series pool data on an annual level from UN and World Bank databases for the period 1990–2017 and Full Information Maximum Likelihood model, it was found that this connection between the socioeconomic conditions and life expectancy at birth is a prerequisite for longer life in all these five countries. Our dependent variable was the life expectancy at birth, and the background exploratory variables for the socioeconomic development were GDP per capita and infant mortality rate. The main results are that higher values of GDP per capita and lower values of infant mortality levels lead to higher life expectancy at birth suggesting that longevity of people in these five countries is increasing. These results are supported by our theoretical background and research framework hypotheses.

Keywords: GDP per capita, Infant mortality rate, FIML, EU accession candidate countries

Introduction

All countries, rich and poor, make efforts to improve the health of their populations. Not at the same rates or with the same success, but most attempt to reduce mortality and increase health (Girosi & King, 2007). Mortality analyses are of widespread interest among academics, policymakers, medical researchers, and others in order to direct the flow of funds in the most effective way possible to the population groups in most need. Mortality forecasts are of great importance in providing policy-relevant information, and therefore, governments making institutional arrangements for retirement and health care should be aware of the actual prospects of cohorts survival (Shkolnikov, Jdanov, Andreev, & Vaupel, 2011).The dynamics of population will continue being one of the most important and overwhelming factors in the society and economy of any country and region. The understanding and analyzing of current demographic trends and their expected results and consequences are useful in order to reach the desired socioeconomic consequences. At macro level, the maintaining, expanding, and improving the health of human populations are considered as one of the key policies for sustainable development (Bayati, Akbarian, & Kavosi, 2013). Due to the fact that the crude death rate is not a precise indicator of the mortality level or of the health

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conditions and living standards in a country, international publications and researchers nowadays regularly make use of life expectancy at birth in the analysis and the description of the level of mortality. Life expectancy at birth is a widely used summary indicator to describe population health along with longevity (Rabbi Fazle, 2013). Life expectancy is a convenient and important summary measure of mortality and more intuitive than mortality rates (Klenk, Rapp, Büchele, Keil, & Weiland, 2007). Thus, life expectancy at birth as a measure of mortality is a valid and important indicator of population's health status. Life expectancy at birth is used as a proxy of population health, and although health is a multi-dimensional concept, life expectancy is one of the most widely used indicators of population health (Sharma, 2018). Bilas, Franc, and Bošnjak (2014) state also that life expectancy is an important synthetic indicator for assessing economic and social development of a country or a region. Thus, according to them, defining good health implies to several socioeconomic preconditions such as reduction of poor education level, reduction of unemployment and insecurity, and improvement of life conditions.

In addition, life expectancy at birth reflects the overall mortality level of a population and summarizes the mortality pattern that prevails across all age groups—children and adolescents, adults, and the elderly (World Health Organization, 2014). The life expectancy is the integrated survivorship of the population across all ages (Missov, 2013). It is worth mentioning the showing of the difference between period and cohort life expectancy defined by Shkolnikov et al. (2011, p. 419): "While conventional (period) life expectancy is a synthetic statistic that can be interpreted as a measure of the average level of the hazard of death in a given calendar year, cohort life expectancy reflects the actual survival experiences of people born in a specific calendar year." Furthermore, also, Missov and Németh (2016) make a contribution to better understanding of life expectany with their finding that aggregate mortality measures like life expectancy, life disparity, entropy, and the Gini coefficient are only slightly sensitive to model misspecification, and therefore, according to them, fitting any model of the Gompertz family is sufficient to model these measures.[1] Life expectancy has improved substantially in the last few decades, as attention to health concerns and reduction of infant and child mortality have increased the average length of life (Mirkin, 2005). Despite these improvements, views concerning mortality among governments in developing countries have changed little. It is therefore not surprising that governments' views of the country's mortality level differ according to development level. As regards child mortality, after rapid improvements observed before 1990, a stagnation in progress has been recorded in the 1990s. Lack of progress in achieving health objectives, e.g., those citied in the Programme of Action and Millennium Development Goals, as Mirkin (2005) explains, may be as much due to wide inequalities within countries—wealthy and poor populations, urban and rural, male and female, as to inequalities between countries. Indeed, this attention in policy circles has substantially risen sharply with the adoption of the Millennium Development Goals (MDGs) that have set clear targets for many indicators

[1]Models that assume an exponentially increasing individual age-specific hazard of death that captures the senescence process we have address as the models from *Gompertz family*. Distributions of the *Gompertz family* may also contain an age-independent additive hazard, c accounting for extrinsic mortality and/or a dispersion parameter, and γ accounting for the distribution of unobserved heterogeneity. Source: Missov & Németh, 2016.

of well-being, including health well-being indicators such as infant mortality rate (IMR) (Cornia & Menchini, 2006). Concern for reducing inequality in health was evident also in the WHO "Health for All" strategy and with its related target in 1984 that by the year 2000, the actual differences in health status between countries and between groups within countries should be reduced by at least 25% (ibid).

The scope of the research paper is to link the key parameters of socioeconomic development with mortality prospects. Thus, this paper particularly investigates the relationship between socioeconomic development represented through GDP per capita and infant mortality rate as its background variables and life expectancy at birth, as an indicator of mortality or longevity and as a dependent variable. Indeed, European countries differ in many respects, in, e.g., new member states of the EU versus old member states and candidate states or according to different welfare regimes. Why these five countries were chosen? First, these five countries are EU accession candidate countries (European Commission, 2019). All of these countries are within the Balkan region. Thus, the paper considers a unique framework to support cross-national comparisons with regard to LE and socioeconomic development within these countries. Second, our research results also include analyses of the magnitude of differences measured across countries and even the results may be compared with the ones of current EU countries. In addition, we expect that the research will provide insights that will contribute in a number of ways in enriching extant demographic literature. Third, given the relatively absence of cross-nationally comparative analyses or generally rather old demographic literature reviews on some parts of the Balkan region, it is expected that this research will supplement the findings with data and analyses on a demographic research issues, specifically related with this region. It includes mortality or longevity prospects, the level of development and progressive changes that occur in life expectancy in relation to the socioeconomic development, and demographic evidence for comparable purposes, since we know that the pursuit of health and longevity are among the fundamental pillars of development. The paper is organized as follows: section 2 is about theoretical and hypotheses framework as well as for variables background, section 3 is about the country's comparisons in mortality and their socioeconomic specifics, section 4 presents the data and methods, section 5 contains the application of FIML method and provides the main research results, and we conclude in section 6.

Theoretical framework and variables background

In the first subsection ("Theoretical framework and major hypotheses"), we briefly introduce the theoretical and hypotheses framework and further the theoretical focus was directed towards its roots i.e., demographic transition process. After this part a wider theoretical and hypotheses review of literature was provided in this subsection. In the second subsection ("Variable background") the following background variables: GDP per capita and infant mortality rate have been included. This subsection presents further details about these variables and their relationship with life expectancy at birth as a dependent variable.

Theoretical framework and major hypotheses

The assumptions based on both theoretical and empirical results suggest that the expected changes in the life expectancy at birth as an indicator for past, present, and future dynamics of mortality levels primarily were and will be under significant influence of the changes in the socioeconomic development in these countries and especially with improving of the living standard and health conditions of their people. In this regard, Shkolnikov et al. (2011, p. 428) specified that "The prolongation of life into old and oldest-old ages changes the traditional balance between the different stages of the life cycle and has large-scale socioeconomic consequences that may be addressed in different ways." The current study is conducted to check whether socioeconomic development through its background variables (GDP per capita and infant mortality rate) have applicable effect on life expectancy at birth. Based on data and methodology that will be explained in section 4 the validity of our hypotheses framework will be tested. The hypotheses framework leads to a relevant research points and debates that will be discussed consequently in this section.

Income influences the condition of people's lives and is a main socioeconomic determinant of health (Bayati et al., 2013). Several studies considered income as one of the main determinants of health (ibid). The national living standards had a direct and positive impact on the demographic changes (direct effect of income on mortality or to the life expectancy). A higher living standard raises consumption aspirations and fosters the growth and the development. The national level of economic development operates on the nation's demographic change via the intermediate variables as mortality and life expectancy at birth, i.e., increasing longevity and improving the life expectancy of all ages and reducing the mortality risks in all age groups. Chamie (2005) pointed out that a further mortality declines also appear likely with increased concerns and changes with respect to life style, nutrition, and advances in medical technology.

The rich/poor divide is well known to demographers. It brings us back to familiar patterns that are observed in demographic phenomena and where the theory of the "second demographic transition" explains the processes. Societies where the structural process is in a later phase generate less economic growth and development. But the timing of the decline in infant mortality is also linked to a broader issue, a crucial one in the theoretical literature on the relation between life expectancy and GDP: the first demographic transition (Felice, Andreu, & Ippoliti, 2016). In economics, the unified growth theory holds that the demographic transition plays a crucial role in initiating the shift from stagnation to growth (Felice et al., 2016, p. 814): "The idea is that with the demographic transition, higher life expectancy leads to lower fertility and lower population growth, and thus to higher returns of human capital investments to those living longer." In turn, lower fertility and higher human capital both contribute to the rise of GDP per capita. However, the roots for the hypothetical framework bring us again back to the process of the first demographic transition. Typically, during the intermediate phase of the demographic transition when the fertility rate starts to fall, there are fewer dependent children who have to be supported. In that period, the number of working age people grows relatively faster than the number of children and the share of old dependent people has not yet increased. As Mason and Lee (2012) have explained the concept of second demographic dividend and its connections with a low fertility as a demographic factor; however, they have underlined that steady and continuing improvement in adult mortality are also important, as is the rising proportion of the population at the older ages. Thus, during this phase, more resources for investment in economic development and family welfare are available, and with all other things being equal, per capita income grows faster. Among a number of potential factors, the focus of the research is on the role of GDP per capita. In the long run, the trend in economic growth, as measured by GDP per capita, is very likely to be associated with the trend in mortality reduction, which is the main component captured by many of the stochastic mortality models.

One of the earlier benchmark studies of the income-health relationship is Preston (1975) who compared different countries' life expectancy and per capita income for different benchmark years (1900, 1930, and 1960) and proposed the "Preston curve" a non-linear and concave empirical relationship between the two (Stengos, Thompson, & Wu, 2008, p. 4). The concave Preston curve has provided the rationale for much of the empirical work that has followed. However, according to Stengos et al. (2008), simple health-per capita income relationships may suffer from endogeneity, especially when it comes to countries on the flat portion of the Preston curve, where health has reached such an advanced stage where additional improvements coming from income growth cannot be attained. In that case, it would be the reverse impact from health to income that would be important. Worldwide data on life expectancy does appear to be strongly correlated with economic development and employment. Improvements in economic conditions are an important force behind mortality decline. Sickles and Taubman (1997) showed evidence that life expectancy increases as a country improves its standard of living. Reviewing the theoretical focus and empirical work of Preston in 1976 on this topic, Sickles and Taubman (1997) showed that the data strongly suggest that longevity is an economic good, evidence that life expectancy increases as a country improves its standard of living long has been recognized since the higher income typically associated with development makes possible in part the consumption of goods and services that improve health. A number of cross-country studies have found a positive effect of life expectancy, or a negative effect of mortality on income per capita, but the debate is still ongoing. The relationship between health and GDP for 13 Organization for Economic Cooperation and Development (OECD) countries over the last two centuries revealed that GDP per capita and total GDP have a significant impact on life expectancy for most countries (Niu & Melenberg, 2013), and therefore, it was followed by lower mortality rates. A causal explanation of the dynamics by age and cohort effects and socioeconomic conditions might be a promising line of mortality research. As a good example, Ediev (2011) pointed out the longevity in the eastern European countries. The sudden change of socioeconomic conditions in the former Eastern Block countries that joined the European Union slowed down health deterioration in those countries and extended exposure durations to lower mortality levels. According to Ediev (2011), this was promptly reflected by the convergence of these countries to the western European trends.

In their study of the low-mortality population comprised of 132 countries from Europe, North America, most of Oceania and Latin America, large parts of Asia (excluding the high mortality area in Central and Southern Asia), as well as Northern Africa, Caselli et al. (2013), revealed strong correlation between life expectancy and the level of economic development for both sexes. Regardless of the diversity of these countries in various aspects, including medical standards, access to health care, and behavioral risk factors such as the prevalence of smoking, these differences were strongly related to economic development and contributed to wide variation in life expectancy levels. These authors emphasized that the economic stagnation or an economic crisis could have a stagnating effect on life expectancy, especially if there is an increase in the number of people without significant resources. Another issue that Caselli et al. (2013) found in their study was the universal availability of the European health systems, which according to them do not have the means to function as desired. Furthermore, they pointed out that in Eastern Europe people would also have to decrease their alcohol consumption and countries in this region would have to improve their health care systems. However, it is interesting for our research that as countries with low mortality from Eastern Europe in their study besides Bulgaria, Czech Republic, Romania, Russian Federation, and Ukraine, they included Serbia and Macedonia as well. In some other study, Caselli, Drefahl, Siegmundt, and Luy (2014) found that the impact of socioeconomic status on mortality is not just an issue of an individual's performance within the network of factors. These authors claim that the societal, political, and disease environment in which an individual lives is also important and could explain why socioeconomic status has different effects in different populations at different times. According to them, economic stagnation or economic crises could have a similar effect, especially if there is an increase in the number of people without significant resources.

Variables background

The use of real GDP per capita as a measure of economic development is widely documented (e.g., Ediev, 2011; Stengos et al., 2008; Wolpin, 1997). First, *GDP per capita* is relatively objective and easy to access, making the model more transparent. Second, the dynamics of the GDP per capita has been widely studied in the literature. Yet, there is a generally accepted measure for standard of living that economists refer to as the average real gross domestic product (GDP) per capita (Mpofu, 2013). Moreover, the trend in GDP per capita may capture the trend in the overall economy. It seems that the GDP per capita for our period of study may be a proxy of both purchasing powers during this period and of the level of economic development (Wolpin, 1997). In some cases, as with income, it is easy to demonstrate the consequence of including a proxy because income is an explicit component of the optimizing framework. The importance of income per capita on life expectancy has awakened interest over the years to both policy makers and economists. Avdeev et al. (2011) pointed out that the standard of living and economic potential of countries are reflected in gross national income per capita. It seems that the better economic position and the higher expenditures on health contributed positively to maintaining lower mortality levels. A large body of research has found strong links between GDP and actual mortality (e.g., Cutler, Deaton, & Llieres-Muney, 2006; Mpofu, 2013; Stengos et al., 2008). A well-established causal link goes from income to longevity. Many researchers argue that development should focus on income growth, since higher incomes indirectly lead to health improvements. The rapid health improvements over the last 40 years raise the question of the driving forces behind this trend. Most of the empirical studies, for example, assume that health improvements are the by-product of higher income as countries with higher income devote more resources for their health services, something that would translate into improved health status for their population (Stengos et al., 2008). The 20 ranked countries in the world measured by Human Development Index (HDI) show that countries with high quality of life and Life Expectancy Index have a high GDP per capita, i.e., higher ranked countries on the HDI generally display higher life expectancy, implying better health, and higher GDP per capita (Mpofu, 2013). Positive changes in mortality that have been observed in the former USSR from the middle of the 1960s were the results of economic growth and industrialization, but mortality levels were also influenced by various negative consequences of the industrial revolution (Andreev, Biryukov, & Shaburov, 1994). The mortality changes during 1992–1994 and 1995–1996 in Russia were connected with the implementation of the Russian social and economic reforms and with subsequently adaptation of their population to a large-scale political and economic stresses (Shkolnikov, Cornia, Leon, & Meslé, 1998; Shkolnikov, McKee, & Leon, 2001).

Analyzing the results from the Preston's article (1975) about life expectancy versus GDP per capita, Cutler et al. (2006) pointed that life expectancy is profoundly lower for countries with lower levels of per capita income and that there was also a positive relationship between income and health within countries—low-income people live shorter lives than high-income people in a given country. Through the twentieth century in the USA and other high-income countries, growth in real incomes was accompanied by a historically unprecedented decline in mortality rates that caused life expectancy at birth to grow by nearly 30 years (ibid, pp. 97). Accordingly, improvements in life expectancy in the USA have been matched by similar improvements in other rich countries. Lutz and Kebede (2018) do not question the basic assumption that income growth and health are closely linked. Their multivariate results from a balanced panel of 174 countries (both developed and developing) over the period 1970–2010 in 5-year intervals strongly confirmed what their analysis suggested: raising educational attainment was even stronger driver of increasing life expectancy and falling child mortality than income.

The other background variable, aside from income, *infant mortality rate*, is important to reflect children's well-being and socioeconomic development (United Nations, 2017). Pozzi and Fariñas (2015) emphasized that the traditional use of infant mortality as an indicator of development and modernization acquires greater relevance if it is used together with child mortality, taking into account the socioeconomic determinants affecting the child mortality. In the advanced stages of the first demographic transition, there are not much room for child mortality to further decline substantially, and as a consequence, more people survive to adult and old ages. The infant mortality rate (IMR), defined as the number of deaths in children under 1 year of age per 1 000 live births in the same year, has in the past been regarded as a highly sensitive (proxy) measure of population health. According to Baker and Fugh-Berman (2009), infant mortality is the single most important determinant of life expectancy. They further point that because life expectancy is calculated as an average; hence, death rates in younger age groups have the greatest impact and that the disparities in IMRs could account for most differences in longevity. As Rabbi Fazle (2013) also discussed, high infant and child mortality rates result in lower values of life expectancy at birth than at older ages. This imbalance in life table according to him disappears only when the crossover occurs and happens when the inverse of the infant mortality becomes equal to the life expectancy at age 1.

The doubling of life expectancy seen over the last 150 years provides one of the most remarkable insights for the human population rise. Initial gains in life expectancy came from reductions in infant mortality and young adult mortality, whereas since the 1950s progress has been driven by survival improvement at older ages (Barthold Jones, Lenart,

& Baudisch, 2018). Using Siler model, these authors have shown that gains in life expectancy through either bringing down infant mortality or decreasing the level of senescent mortality inevitably result in an increase in the proportion of life share. The compelling evidence and work of Barthold Jones et al. (2018) from the last decades showed that a survival improvement among the elderly has been propelled by the onset of senescent mortality being postponed. Explaining a study with a Siler model with two different (constant) rates of mortality decline: one for infant and one for non-infant mortality, Missov and Lenart (2011) came to conclusion that Siler model converges with time to mortality schedule of population described on a period basis as levels of and improvements in infant mortality become negligibly small. In addition, Shkolnikov et al. (1998) noticed that the steep growth of life expectancy in 1985–1987 and its fall in 1988–1994 for Russian population and the variation in death rates over the period among children and the elderly had very limited influence on changes in life expectancy at birth in Russia.

However, infant mortality and life expectancy trends are obviously unequally distributed globally. Hence, it seems that the life expectancy and infant survival are both often better in the developed countries, as compared to that of the developing countries or within the less developed countries. The link between infant mortality and life expectancy, and the tendency for less developed countries to have higher level of infant mortality and lower life expectancy at birth, is one of the key explanations for the socioeconomic inequalities that exist across these countries. This study demonstrates that socioeconomic inequalities and/or development matter for mortality and life expectancy. Child survival is highly correlated with the level of development (United Nations, 2017). This reflects the apparent association between the causes of infant mortality and other factors that are likely to influence the health status of whole populations such as their economic development, general living conditions, social well-being, rates of illness, and the quality of the environment (Reidpath & Allotey, 2003). Due to technological advancement, reduced maternal and child mortality, and improved health care delivery system, people from most of the countries can enjoy high survival chances (Zaman, Hossain, Mehta, Sharmin, & Mahmood, 2017). Thus, in our research, we use the infant mortality variable as an indicator for the overall development and health of the population, including its longevity or life expectancy.

Cornia and Menchini (2006) clarify that the measurement of average well-being and of its distribution among the population, as well as cross-country comparisons, faces fewer methodological problems and does not require the adoption of arbitrary hypotheses and statistical conventions. In the same way, the definition and meaning of the variables used—infant mortality rate and life expectancy at birth, according to them, are less ambiguous than that of monetary aggregates. The use of life expectancy at birth as an indicator of health well-being faces additional problems of interpretation because such an indicator is in fact computed on the basis of the age-specific mortality rates observed for different cohorts at a moment in time. However, Cornia and Menchini (2006) noted that such rates do not reflect the real life chances of a person born in the reference year, as computation of such index would require to know the future risks of death at different ages for a person. In this regard, Glasen (2015, p. 5) defines life expectancy at birth measured in years as the average "number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life" over the whole population of each individual country.

Consequently, life expectancy at birth does not refer to any individual birth cohort but rather to a hypothetical cohort facing the age-specific death rates observed at the present time. In analyzing changes in infant mortality rate, life expectancy at birth, and life expectancy at age 1, Cornia and Menchini (2006) emphasized that progress continued without interruptions for all these indicators for both developing and developed countries, but they did not assess whether these gains achieved with a similar, faster or slower pace than in the past.

Countries comparison: socioeconomic and life expectancy specifics

The mentioned EU accession candidate countries (Macedonia, Montenegro, Serbia, Albania, and Bosnia and Herzegovina)[2] are all within the Balkan region, and there are common facets among them with respect to key institutional features and economic patterns (see, Eurostat, the statistical office of the European Union, 2019; European Commission, 2019). The five countries belong in the group of middle-income countries. These countries previously experienced a strong decrease in infant mortality, rising living standard, and better education, as well as advance in healthcare and medicine. All these influenced their mode of life and indirectly their health and the length of life. The key element in former Yugoslavia after World War II was the control of the socialism. A key goal of the socialist program was a transformation of the economy and society through intensive industrialization that would rapidly bring economic productivity, education, health, and equality in the region up to and even beyond (Arland & Philipov, 2007). The countries of former Yugoslavia and Central and Eastern Europe as well had considerable success in industrialization, increasing education, reducing mortality, and producing equality (ibid, pp. 25). There are some differences in terms of the economic and social situation between the five countries, which appear to be somehow related to their different levels of socioeconomic development and its demographic patterns, but the differences are not so large.

As can be seen from Fig. 1 the gross domestic income per capita in 2006 (based on US$) was US$ 2913 in Albania, US$ 3326 in Macedonia, US$ 3404 in Bosnia and Herzegovina, and then just a little more in Serbia, US$ 4130, and the highest level was noticed in Montengro with US$ 4405 (UN, 2018). Montenegro has also the highest level of GDP per capita in 2017 in comparison with the rest of four countries.[3] In all five countries, demographic behavior is thus relatively similar despite their socioeconomic differences. This is an important point, since Sebti, Courbage, Festy, and Kursac-Souali (2009) have proved also that the living standards and educational levels are classic determinants of demographic trends, with improvements in economic and cultural conditions generally being associated with progress in the first demographic transition. The future mortality trends of the five countries will be driven mainly by mortality in adult ages, primarily the old and oldest-old. However, additional gains in life expectancy are possible owing to further reductions of mortality at these older ages.

[2]Turkey is also an EU candidate country. Turkey was recognized as a candidate for full EU membership in 1999, and since then, its status has not changed. However, in this case, our research interest was strictly on the EU candidate countries from the Western Balkan region.

[3]GDP per capita in the enlargement countries is lower than that of the EU-28. Turkey and Montenegro registered GDP per capita between 40 and 60% below the EU-28 average, while Albania, Bosnia and Herzegovina, Macedonia, and Serbia were between 60 and 80% below the EU-28 average. Source: Eurostat

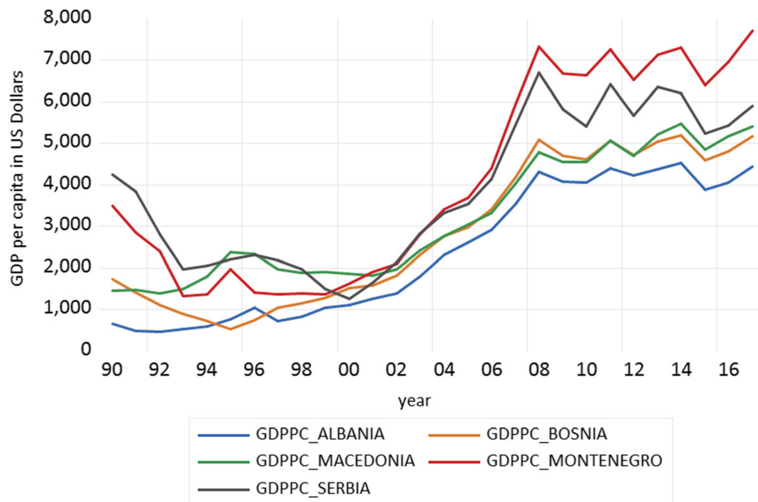

Fig. 1 GDP per capita in US dollars in EU accession candidate countries: 1990-2017: GDP per capita in US Dollars constant 2010 prices in the EU accession candidate countries 1990–2017. Source: UN databases. Author's design based on EViews 11 software using annual time series data from Albania, Macedonia, Serbia, Bosnia and Herzegovina, and Montenegro

A decomposition analysis of life expectancy into specific age groups showed that gains in life expectancy in western European countries came from older age groups as compared to the majority of former socialist countries (Čipin, Smolić, & Medžimurec, 2017). Therefore, it is expected (with reference to past trends) that a further extension of life expectancy at birth in all these five countries would be achieved through a decrease in mortality among the oldest old group of the population.

As regards infant mortality, a significant and impressive progress has been made at the end of the 2017, compared to 1991, particularly in Albania and Macedonia (Fig. 2).

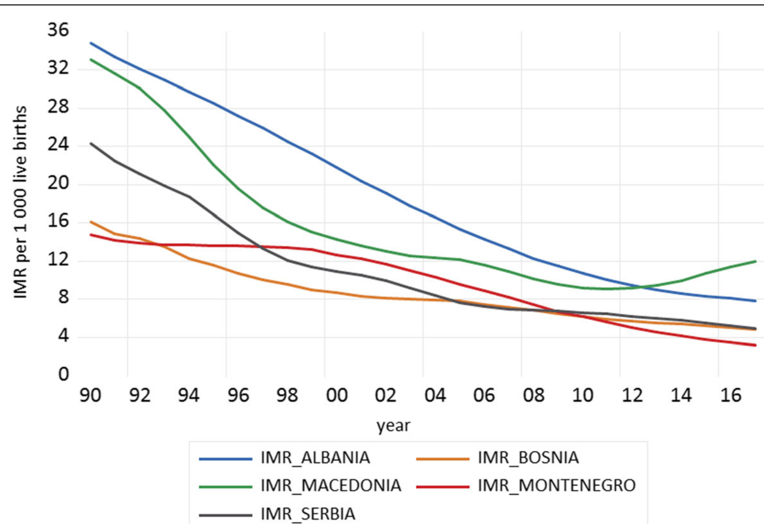

Fig. 2 Infant mortality rate in EU accession candidate countries: 1990–2017: Infant mortality rate per 1 000 live births in the EU accession candidate countries 1990–2017. Source: World Bank Group data. Author's design based on EViews 11 software using annual time series data from Albania, Macedonia, Serbia, Bosnia and Herzegovina, and Montenegro

Reduction of 50% or more, in relative terms, during these years were not rare, they were observed, for instance, in Serbia (− 77%), Macedonia (− 71.5), and Albania (− 57%). Such results are impressive, given that the levels were extremely high, around 33.3 in Albania for 1991 and 31.6 infant dates per 1000 live births in Macedonia in the same year. Such values would have been unthinkable for many European countries even 20 years earlier from 1991 and even if compared to their rates of infant mortality during 1970s with the rates of infant mortality in these two countries from 1991.[4] In the European Union as a whole, the infant rate was 3.6 in 2016 (Eurostat, 2019). In contrast, the infant mortality rates in Central and Eastern Europe remained rather high, exceeding 10 per 1000 live births everywhere apart from the Czech Republic and Slovakia, and even 20 per 1000 live births in some countries (Romania, Moldova) during 1990s (De Guibert-Lantoine & Monnier, 1997). Many of these countries have made a considerable headway in 1996, but it was a long time before they reached the very low values observed in the European Union; only the Czech Republic has already reduced its infant mortality to the level of Belgium or England and Wales.

The fall of the Iron curtain and the wars in former Yugoslavia opened a decade of political, economic, and social turmoil (Boulineau et al., 2016). According to Frejka (2010), the wars affected demographic trends significantly in Bosnia and Herzegovina, Croatia, Serbia, and Montenegro, less so in Slovenia and in Macedonia. In Bosnia and Herzegovina, the complex political events as well as the war impacted demographic trends and the availability of reliable statistics. That is why some of those countries involved in the wars of the region of former Yugoslavia did not improve as much as other European countries their mortality levels and the age-structure of their country. Hence, from the data about life expectancy at birth, which were used from the World Bank (section 4 and Fig. 3), we can see clearly that life expectancy at birth has been decreasing in Montenegro for the whole period of 1990s (from 74.6 years in 1991 to 73.3 and 73.2 years in 1999 and 2000, respectively). Life expectancy at birth has stagnated in Serbia during 1990s (between 71.0 and 72.0 years), and for Bosnia, there was a slight decrease of life expectancy only for the first half of the 1990s, and since 1994, there has been an increase.

Although having one of the lowest GDP per capita among our five countries—Albania boasts the highest life expectancy among many of the countries within our group (Fig. 3). Albania's life expectancy has increased by an average of six years during the past 25 years after the collapse of the country's communist regime. According to Eurostat, the statistical office of the European Union (2019) in 2016, life expectancy for men in the enlargement countries ranged from a low of 73.2 years in Serbia to 76.4 years in Albania (compared with 78.2 years in the EU-28). For women, life expectancy across the enlargement countries was slightly more homogeneous, ranging from a low of 77.5 years in Macedonia to 80.1 years in Albania (compared with 83.6 years for the EU-28). Eurostat data shows that Albania's life expectancy has increased by 1.5 years to 3 years compared to Montenegro and Serbia, respectively.

Data and methods

Data for the variable GDP per capita were obtained from UN National Accounts Main Aggregate database. The life expectancy variable data and infant mortality rate data were obtained from World Bank development indicators databases (World Bank, 2017). These

[4] https://www.ined.fr/en/everything_about_population/data/europe-developed-countries/birth-death-infant-mortality/ Source: INED, 2018

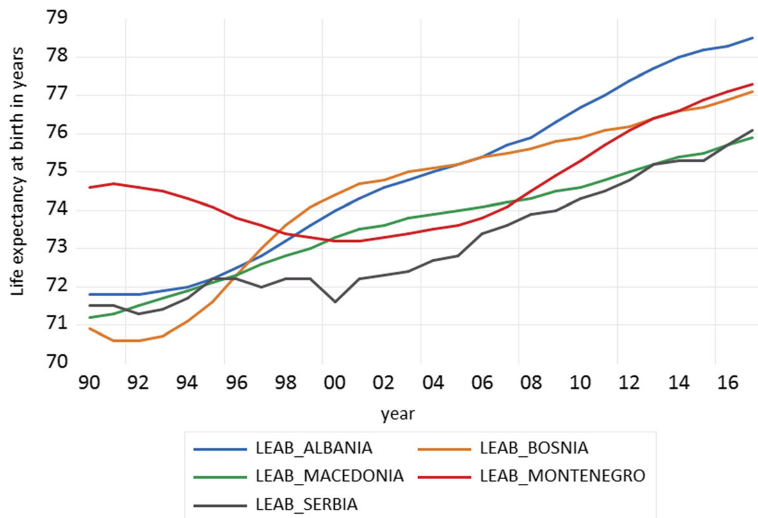

Fig. 3 Life expectancy at birth in EU accession candidate countries: 1990–2017: Life expectancy at birth in the EU accession candidate countries 1990–2017. Source: World Bank Group data. Author's design based on EViews 11 software using annual time series data from Albania, Macedonia, Serbia, Bosnia and Herzegovina, and Montenegro

data covers the period 1990-2017 and include the five EU accession candidate countries (Macedonia, Serbia, Bosnia and Herzegovina, Montenegro, and Albania). In addition, due to data gap about life expectancy at birth within World Bank database for Serbia for 1990, 1992–1996, and 1998–1999, additional data sources for Serbian life expectancy at birth for these years were used from the Statistical office of Republic of Serbia (2006). Thus, in the research, as aggregate time series with annual data level were included: The GDP per capita in US$ and infant mortality rate (as regressors) and life expectancy at birth (dependent variable). In order to examine the data at comparable level, the research was focused on regression model for the pooled cross-sectional time series with FIML method. Cross-section-specific time series are those that have values that differ between cross-sections. A set of these series are required to hold the data for a given variable, with each series corresponding to data for a specific cross-section (IHS Global Inc., 2013). Since cross-section-specific time series interact with cross-sections, they were defined in conjunction with the identifiers in pool object and there was applied estimation method that account for the pooled structure for the data. Having in mind that the aim was to estimate a complex specification that cannot easily be estimated using the built-in features of the pool object and that it is not available in pooled estimation, in these circumstances, the pool was used to create a system using both common and cross-section specific coefficients.[5] After the parameters of a system of equations were estimated, the likelihood function under the assumption that the contemporaneous errors have a joint normal distribution was estimated as well. Provided that the likelihood function is correctly specified, FIML is fully efficient (IHS Global Inc., 2013). The resulting system using FIML

[5]At this point, we take care to distinguish between systems of equations and models. A *model* is a group of known equations describing endogenous variables. Models are used to solve for values of the endogenous variables, given information on other variables in the model. Systems and models often work together quite closely. The parameters of a system of equations might be estimated, and then create a model in order to forecast or simulate values of the endogenous variables in the system. Source: IHS Global Inc., 2013, p. 513-514

method was further customized and estimated using all of the techniques available for system estimation. The restricted diagonal estimation was chosen to be set up zero restrictions on the off-diagonals of the residual covariance matrix. Only the diagonal elements of the residual covariance matrix that corresponded to the variances were estimated (IHS Global Inc., 2017). The life expectancy at birth function has two factors with five equations. Our full system can be written as in Eq. (1) and Eq. (2):

$$Y\Gamma + XB = E \qquad Assume: E \mid X \sim N\left(0, \Sigma \otimes I_T\right) \qquad -An\, MxM\, matrix \tag{1}$$

This case can be characterized by defining the M x M matrix of contemporaneous correlations, Σ. Y is the matrix of endogenous variables, X is the matrix of exogenous variables, Σ is cross-equation covariance matrix of the error terms. In Eq. (1) above, $\Gamma'_J = (-1\alpha'_j, 0)$ and $B'_J = (\beta'_j, 0)$, (see for example, IHS Global Inc., 2013, p. 543). Furthermore, I_T is identity matrix of order T and ⊗ denotes the Kronecker product (Balestra & Varadharajan-Krishnakumar, 1987).[6] The likelihood function can be written in the form as:

$$L(B, \Gamma, \Sigma|X) = (2\pi)^{-T/2}|\Sigma|^{-T/2}\ exp[tr\left\{-1\Big/_2 E'\Sigma^{-1}E\right\} \tag{2}$$

Taking account of the normalization rule and the zero restrictions, a typical structural equation, say the *j*th one, can be written as:

$$y_i = Y_j\alpha_j + X_jB_j + u_j = Z_j\delta_j + u_j, \tag{3}$$

where α and β are the parameters to be estimated and where $Z_j = [Y_jX_j]$,$\delta'_j = [\alpha_j\beta_j]$. The system was estimated by full information maximum likelihood (FIML) method. Over the years, a number of approaches for FIML estimation have been proposed. In our case, the standard Broyden-Fletcher-Goldfarb-Shanno (BFGS) algorithm with the simple interpretation of Marquardt steps was used. The standard model that was used has been shown in Eq. (4):

$$f(y_t, x_t, \beta) = \in_t, \tag{4}$$

where y_t is a vector of endogenous variables and x_t is a vector of exogenous variables. The Full Information Maximum Likelihood (FIML) estimator finds the vector of parameters β by maximizing the likelihood under the assumption that ϵ_t is a vector of *i.i.d.* multivariate normal random variables with covariance matrix Σ (see IHS Global Inc., 2017, p. 678).

Under the normality assumption, the log likelihood is given by:

$$LogL* = -\frac{T}{2}\log|\Sigma| + \Sigma_{t=1}^{T}\log\|\frac{\partial f_t}{\partial y'_t}\| - \frac{1}{2}\Sigma_{t=1}^{T} f'_t\Sigma^{-1}f_t \tag{5}$$

where $f_t = f(y_t, x_t, \beta)$. The log determinant of the derivatives of f_t captures the simultaneity in the system of equations. For the unrestricted and diagonal restricted covariance variants of the model, the first-order conditions for the variance parameters was used and then the likelihood was rewritten in concentrated form:

[6]The Kronecker product, denoted by ⊗, is an operation on two matrices of arbitrary size resulting in a block matrix. The Kronecker product looks scary, but it is actually simple. The Kronecker product is merely a way to pack multiples of a matrix **B** into a block matrix. If **A** is an n x p matrix, then the direct product **A** ⊗ **B** is the block matrix formed by stacking copies of **B** into the shape of **A** and multiplying the (i,j)th block by A_{ij}. Source: SAS software (2018).

Table 1 Results of FIML method for Life expectancy at birth

Estimation method: Full Information Maximum Likelihood (BFGS/Margquardt steps)				
Dependent variable: Life expectancy at birth				
Sample: 1990-2017				
Included observations: 28				
Total system (balanced) observations: 168				
Independent variables	Coefficient	Std.Error	t-statistics	Prob
GDP per capita	0.0151	0.0057	2.6340	0.0084
Infant mortality rate	-0.0317	0.0106	-3.0022	0.0027
Intercept_Macedonia	4.2634	0.0730	58.3816	0.0000
Intercept_Serbia	4.2415	0.0694	61.1425	0.0000
Intercept_Bosnia	4.2583	0.0162	69.5728	0.0000
Intercept_Albania	4.2917	0.0704	60.9425	0.0000
Intercept_Montenegro	4.2588	0.0667	63.8954	0.0000
Log Likelihood	-121.1991			
Avg. log likelihood	-0.8657			
Akaike info criterion	9.1571			
Determinant residual covariance	3.8223			
Schwarz criterion	9.4902			
Hannan-Quinn criter.	9.2590			

* Residual covariance matrix restricted to be diagonal in FIML estimation
**Convergence achieve after 175 iterations
***Coefficient covariance computed using outer product of gradients
Source: author's calculations based on EViews 11 software

$$LogL = \Sigma_{t=1}^{T} \log\|\frac{\partial f_t}{\partial y_t'}\| - \frac{T}{2} \log\left(T^{-1}\Sigma_{t=1}^{T} f_t f_t'\right) \quad (6)$$

The diagonal restricted estimator replaces the off diagonal terms in the latter matrix with zeros. The corresponding FIML estimator maximizes the concentrated likelihood with respect to the β (or equivalently, the full likelihood with respect to β and the free parameters of Σ (ibid., pp. 679). The estimator for β is asymptotically normally distributed with coefficient covariance which typically may be computed using the partitioned inverse of the outer-product of the gradient of the full likelihood or with the inverse of the negative of the concentrated likelihood.

Table 2 Results of FIML method for Life expectancy at birth for Macedonia, Serbia, Bosnia, Albania and Montenegro

country	Macedonia	Serbia	Bosnia	Albania	Montenegro
Observations	28	28	28	28	28
R-Squared	0.9098	0.8820	0.8684	0.9701	0.3578
Adjusted R-Squared	0.9026	0.8725	0.8579	0.9677	0.3064
S.E of Regression	0.0060	0.0072	0.0110	0.0055	0.0144
Durbin- Watson stat	0.2137	0.2310	0.0812	0.2621	0.0597
Mean dependent variable	4.2990	4.2924	4.3084	4.3154	4.3125
S.D dependent variable	0.0192	0.0203	0.0291	0.0304	0.0173
Sum squared resid	0.0009	0.0013	0.0030	0.0007	0.0052

Source: author's calculations based on EViews 11software

Main findings and discussions of the results

Table 1 presents the estimated common coefficients and regression statistics for FIML.

In Table 2 the regression statistics for each of the five countries can be seen. There are cross-equation coefficient restrictions that ensure symmetry of the cross partial derivatives. The log likelihood has to be maximized with respect to all of the parameters, subject to the symmetry conditions:

$$C\, vec\, \Omega_j = 0, \quad j = u, \lambda, \nu, \tag{7}$$

where C is a known $\frac{M(M-1)}{2} * M^2$ matrix of full row rank, and with writing the symmetry condition as in Eq. (7), the extracting the redundant elements of the different covariance matrices were avoided (Balestra & Varadharajan-Krishnakumar, 1987). With the Wald Coefficient Tests, the symmetry restrictions were tested. The system imposing the symmetry restrictions was estimated, and according to the probability value of our chi-square test statistics (prob = 0.2562), the null hypothesis of symmetry restrictions at 5% level was not rejected. The null hypothesis was not rejected at 5% level, and therefore, it can be concluded that the increase in the rate of GDP per capita as well as the reduction in the infant mortality rate have the same effect on life expectancy in all five countries. Since maximum likelihood assumes the errors are multivariate normal, it also was tested whether the residuals are normally distributed. In our case, ordinary residuals were produced. Residuals graph displays a separate graph of the residuals from each equation in the system. A group containing the residuals of each equation in the system is shown in Fig. 4.[7] The Jarque-Bera statistic rejects the hypothesis of normal distribution only for the third equation (Bosnia and Herzegovina) but not for the other equations. The value of the Jarque-Bera statistics for Bosnian equation (8.4894) was bigger than the critical value of the χ^2 distribution with 2 degrees of freedom, i.e., 5.991.[8] Based on the values of Jarque-Bera statistics for Macedonia, Serbia, Albania and Montenegro, respectively, 1.6507, 1.6101, 0.9128, and 2.6656 < 5.991, it can be concluded that the null hypothesis is not rejected, i.e., the residuals are normally distributed for these four equations (countries).

The results in Table 1 describe the system estimation specification using FIML method and provide coefficients and standard error estimates, z-statistics, p values, and summary statistics. From the results of the system of equations estimation in Table 1, it can be seen that all of the coefficients are positive and statistically significant, except the coefficient of the infant mortality rate, which is also significant but with negative sign. The residuals are picking up the effect of unobservable variables and also they are all positive and significant at 5% level. It means that higher values of the GDP per capita and lower values of infant mortality levels lead to higher life expectancy at birth suggesting that the longevity of people in these five countries is increasing. These results are supported by our theories and hypotheses. The infant mortality rate coefficient has a negative sign and is therefore thought to contribute appropriately to explain the trend in life expectancy. The results show that the life expectancy at birth is largely

[7]With the newest version of Eviews 11, we can now save our tables, graphs and spool outputs in LaTeX format

[8]See more for Jarque-Bera test statistics at: Bucevska (2009). *Econometrics with application in Eviews.* Skopje, Macedonia: University "Ss.Cyril and Methodius", Faculty of Economics-Skopje, pp. 403-404

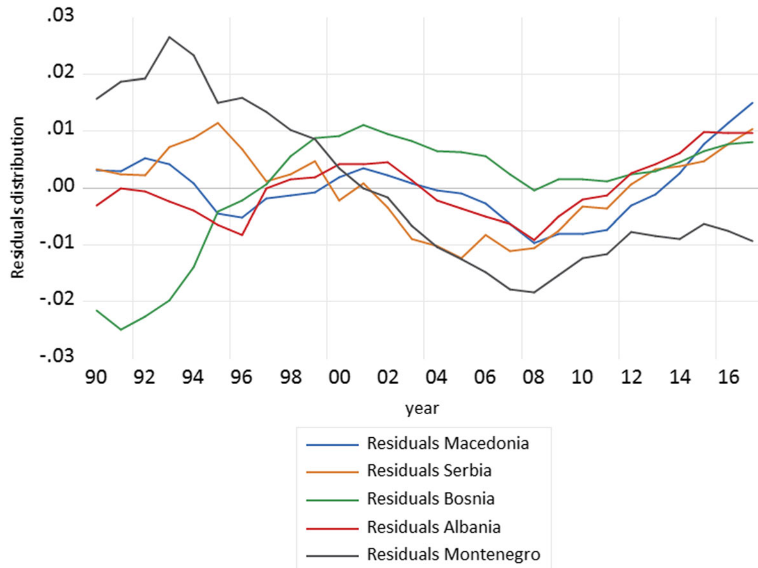

Fig. 4 Residuals graph for the EU accession candidate countries: 1990–2017: Residuals graph for the EU accession candidate countries: 1990-2017. Source: Author's design in Eviews 11 software

affected by the population health and socioeconomic development in the country; in other words, when population health and socioeconomic development in a country are getting better, infant mortality rate is decreasing; accordingly, the life expectancy at birth appears to have increased. GDP per capita increases the life expectancy at birth through increasing economic growth and development in a country and thus leads to the prolongation of longevity. The signs of both the GDP per capita and infant mortality variable are consistent with the research hypotheses and confirm the arguments for the effects of the socioeconomic development to longevity. This indicates that the arguments of the first demographic transition in terms of socioeconomic conditions have determined the scope and nature of the process of demographic transition in these five EU accession candidate countries.

The correlation between GDP and life expectancy seems well established (+ 0.67). However, from our results, it is not difficult to indicate that the socioeconomic development (the standard of living, economic conditions, poverty and inequality levels, and health conditions) play a major role in the rise of life expectancy and longevity. The increased economic development, higher living standard, and improved health remain as relevant factors for rise of life expectancy and prolongation in longevity. These findings are valid and relevant in our research study for all five countries. Especially, it is most relevant for Albania, Bosnia and Herzegovina, Serbia, and Macedonia, to some extent for Montenegro as well. The direct effect of the level of the economic development and material standards of living as measured through the GDP per capita has a strong direct effect to the life expectancy and longevity. The dominant feature of the estimated model is the straight line of positive influence that runs from economic conditions and the economic development and exerts influence over the life expectancy within these countries. This path is much stronger than any other direct or indirect connection. In other words, the economic conditions provide the explanatory power, and as a result, the direct path from economic conditions to the demographic event, in this case, life expectancy and longevity, could not be ignored. Although the findings on the relation of life expectancy and GDP per capita do not add anything new to the previous literature, this study clearly confirmed the findings from Cutler et al. (2006) which pointed out that life expectancy is profoundly lower for countries with lower levels of per capita income and that there was existed also a positive relationship between income and longevity within countries. Further, also Sickles and Taubman (1997) found evidence that life expectancy increased as a country improved its standard of living, and the results of our study showed the same findings. The results are also in line with the points and findings of Avdeev et al. (2011) regarding the relationship between GDP per capita and life expectancy.

There is a general notion from the theory that infant mortality is considered to be one of the best indicators of general social development. Infant mortality was important for measuring of improved living standard and health conditions of the people and socioeconomic development within these countries. Nowadays, the average IMR in Albania is 8.0 per 1000 births and about 5.0 in Serbia and Bosnia and Herzegovina, but rates range from a low of 3.2 in Montenegro to a high of 12.0 for Macedonia. The data show that lowest IMRs ranged from 3.0 to 8.0 in the four countries did not follow with the longest life expectancy, except maybe only for Albania (78.5) in 2017. The one country which have the highest IMRs lately (Macedonia) was not the country that had shortest life expectancy through the whole period of study with except of 2016–2017. Commonly for the five countries, IMR and the Life expectancy at birth (LEAB) are highly negatively correlated (− 0.64) and they move in an opposite direction, also known as inverse correlation. Thus, they are related in the sense that change in the one of the variable is accompanied by change in the other variable. This raises the question on the nature of the association between infant mortality rate and life expectancy at birth. Also, causality that runs one-way from life expectancy at birth to infant mortality rate was found. What we know from the variable background (section 2) is that the results are consistent with the existed link of infant mortality and life expectancy. There may be a third and fourth variable we have not considered, and these variables might be the explanation for the behavior of our two variables (IMR and LEAB) in order to define the cause and effect relationship between them. What is known is that the causes of both infant mortality and life expectancy are strongly related to those structural factors like economic development, general living conditions, social well-being, and the quality of the environment that affect the health of the entire populations and their longevity. Some other studies have shown similar results for other countries and cases: (see, for example, Reidpath & Allotey, 2003; United Nations, 2017; Zaman et al., 2017). Both lower level of infant mortality and higher GDP per capita in these five countries have valuable meaning for many aspects including better health and longer life of their population.

Sensitivity analysis

The sensitivity of the results was studied with respect to the countries and assumptions regarding the statistical model, the level of variation of life expectancy, and the individual effects of both explanatory variables. If looked at the equation statistics for each of the countries in Table 2, it can be noticed that highest value of adjusted R-squared of

0.97 has Albania. Furthermore, also high values of adjusted R-squared about 0.90 are found for Macedonia, 0.87 for Serbia, and 0.86 for Bosnia and Herzegovina. The lowest value of adjusted R-squared with only 0.36 is for Montenegro. Accordingly, we may say that indeed the strongest influences of the mentioned variables over the life expectancy at birth are for Albania and Macedonia, Bosnia and Herzegovina, and Serbia. Namely, 85 to 97%, of the variations of the life expectancy at birth, respectively, in these four countries during the period 1990–2017 are explained by the effects and influences of the selected independent (socioeconomic) variables: GDP per capita and infant mortality rate. The rest of 3 to 15% of variations are not explained by this model, and it is due to some other factors.

Looking at for the individual effects of both explanatory variables (infant mortality rate and GDP per capita) within each country, there are indeed interesting and relevant results. The most significant at 5% level negative effects of the infant mortality rate on life expectancy at birth was noticed for Bosnia and Herzegovina and Albania, almost equally important. Within all countries, the positive effect of the GDP per capita on life expectancy at birth in Serbia could be characterized as more considerable than in the other countries.

Conclusions

This paper examines the association between socioeconomic development and life expectancy at birth with both income per capita and infant mortality rate as background variables for the socioeconomic development. Hereby, data from five, previously understudied, EU accession candidate countries from 1990 to 2017 have been used. A further novelty in a demographic context is the usage of the FIML method. Both coefficients of the background variables show that the impact of a change in income per capita and infant mortality rate on life expectancy at birth have significant effects. It shows that the life expectancy at birth is largely affected by the population health and socioeconomic development in the country; in other words, when population health and socioeconomic development in a country are getting better, infant mortality rate has decreased; accordingly, the life expectancy at birth appears to have increased. GDP per capita increases the life expectancy at birth through increasing economic growth and development in a country and thus leads to the prolongation of longevity. It can be concluded that the increase in the rate of GDP per capita as well as the reduction in the infant mortality rate has the same effect on the life expectancy in all five countries. Causality that runs one-way from life expectancy at birth to infant mortality rate was found. Both lower level of infant mortality and higher GDP per capita in these five countries have valuable meaning for their longevity.

Abbreviations

BFGS algorithm: Broyden-Fletcher-Goldfarb-Shanno algorithm; EU-28: European Union-28 member states; FIML method: Full Information Maximum Likelihood method; GDPPC: Gross Domestic Product per capita; HDI: Human Development Index; LEAB: Life expectancy at birth; OECD: Organization for Economic Cooperation and Development; UN: United Nations; US$: United States Dollars; USSR: Union of Soviet Socialist Republics

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Author's contributions

I am solely responsible for the conception and design of the study. I fully and independently both carried out of the empirical analysis and interpreted the results of the manuscript. In addition, I am also fully responsible for any concept and ideas within the paper. I read and approved the final manuscript.

Authors' information
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https://unstats.un.org/
http://data.worldbank.org/indicator

Competing interests
The author declares that he has no competing interests.

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References
Andreev, E. M., Biryukov, V. A., & Shaburov, K. J. (1994). Life expectancy in the Former USSR and mortality dynamics by cause of death: Regional aspects. *European Journal of Population, 10*, 275–285.

Arland, T., & Philipov, D. (2007). Developmental idealism and family and demographic change in Central and Eastern Europe. In *European Demographic Research Papers* (Vol. 3). Vienna Institute of Demography, Austrian Academy of sciences.

Avdeev, A., et al. (2011). Populations and demographic trends of European countries, 1980-2010. *Population, 66*(1), 9–133. https://doi.org/10.3917/popu.1101.0009.

Baker, D., & Fugh-Berman, A. (2009). Do new drugs increase life expectancy? A critique of a Manhattan Institute Paper. *Journal of General Internal Medicine, 24*(5), 678–682. https://doi.org/10.1007/s11606-009-0954-4.

Balestra, P., & Varadharajan-Krishnakumar, J. (1987). Full information estimations of a system of simultaneous equations with error component structure. *Econometric Theory, 3*(2), 223–246. Cambridge University Press. https://doi.org/10.1017/S0266466600010318.

Barthold Jones, J. A., Lenart, A., & Baudisch, A. (2018). Complexity of the relationship between life expectancy and overlap of lifespans. *PLoS ONE, 13*(7), e0197985. https://doi.org/10.1371/journal.pone.0197985.

Bayati, M., Akbarian, R., & Kavosi, Z. (2013). Determinants of life expectancy in Eastern Mediterranean Region: A health production function. *International Journal of Health Policy and Management, 1*, 1–7.

Bilas, V., Franc, S., & Bošnjak, M. (2014). Determinant factors of life expectancy. *Collegium Antropologicum, 38*(1), 1–9.

Boulineau, E., et al. (2016). Western Balkans: Deep Integration with EU Relies on Internal Integration. In P. Beckouche et al. (Eds.), *Atlas of Challenges and Opportunities in European Neighbourhoods*. https://doi.org/10.1007/978-3-319-28521-4_5.

Bucevska, V. (2009). *Econometrics with application in Eviews*. Skopje: University "Ss.Cyril and Methodius" in Skopje, Faculty of Economics-Skopje.

Caselli, G., Drefahl, S. W., Siegmundt, C., & Luy, M. (2014). Future fertility in low fertility countries. In W. Lutz, W. P. Butz, & K. C. Samir (Eds.), *World Population and Human Capital in the Twenty-First Century* (pp. 226–272). Oxford: Oxford University Press.

Caselli, G., et al. (2013). Future mortality in low-mortality countries, Vienna Institute of Demography Working Papers, No. 6/2013

Chamie, J. (2005). Scenarios for the development of world population. *Genus, 61*(3-4), 69–89.

Čipin, I., Smolić, Š., & Medžimurec, P. (2017, 2015). *Life expectancy in Croatia in terms of eliminating certain causes of death*, *Proceedings from the fifth Demo Balk Conference: "The population of the Balkans at the dawn of 21st century", held in Ohrid, Republic of Macedonia, 21-24 October* (pp. 65–82). DemoBalk and Institute of Economics-Skopje, UKIM.

Cornia, G. A., & Menchini, L. (2006). *Health improvements and health inequality during the last 40 years. UNU-WIDER Research Paper, No. 10 /2006*.

Cutler, D., Deaton, A., & Llieres-Muney, A. (2006). The determinants of mortality. *Journal of Economic Perspectives, 20*(3), 97–120.

De Guibert-Lantoine, C., & Monnier, A. (1997). The demographic situation of Europe and the developed countries overseas: An annual report. *Population, 9*, 243 + 245–243 + 268.

Ediev, D. M. (2011). Life Expectancy in developed countries is higher than conventionally estimated. Implications from improved measurement of human longevity. *Population Ageing, 4*, 5–32. https://doi.org/10.1007/s12062-011-9040-x.

European Commission (2019).Comminication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions. 2019 Communication on EU Enlargement Policy. Brussels, 29.5.2019 COM (2019) 260 final

Eurostat, the statistical office of the European Union (2019). Enlargement countries -population statistics and database. Retrieved from: http://ec.europa.eu/eurostat/statistics-explained/index.php/Enlargement_countries_-_population_statistics

Felice, E., Andreu, J. P., & Ippoliti, D. C. (2016). GDP and life expectancy in Italy and Spain over the long run: A time-series approach. *Demographic Research, 35*(28), 813–866. https://doi.org/10.4054/DemRes.2016.35.28.

Frejka, T. (2010). *Cohort overlays of evolving childbearing patterns: How postponement and recuperation are reflected in period fertility trends. MPIDR Working paper WP 2010-026*.

Girosi, F., & King, G. (2007). *Demographic Forecasting*. Princeton: Princeton University Press.

Glasen, P. (2015). *Basic antecedents of life expectancy at birth. Linear regression modelling*. Munich: GRIN Verlag https://www.grin.com/document/311417.

IHS Global Inc. (2013). *EViews 8 User's Guide II*. Irvine: IHS Global Inc.

IHS Global Inc. (2017). *EViews 10 User's Guide II*. Irvine: IHS Markit.

INED (2018). Births, deaths and infant mortality: Birth and death rates (per 1000 inhabitants) and infant mortality rate (per 1000 live births). Retrieved from: https://www.ined.fr/en/everything_about_population/data/europe-developed-countries/birth-death-infant-mortality/

Klenk, J., Rapp, K., Büchele, G., Keil, U., & Weiland, S. K. (2007). Mortality and life expectancy: Increasing life expectancy in Germany: quantitative contributions from changes in age- and disease-specific mortality. *European Journal of Public Health, 17*(6), 587–592. https://doi.org/10.1093/eurpub/ckm024.
Lutz, W., & Kebede, E. (2018). Education and health: Redrawing the Preston curve. *Population and Development review, 44*(2), 343–361.
Mason, A., Lee, R.(2012). Demographic dividends and aging in lower-income countries. (NTA Working Paper funded by UNFPA, IDRC and NIH: NIA R37 AG025247)
Mirkin, B. (2005). Evolution of the national population policies since the United Nations 1954 World Population Conference. *Genus, 61*(3-4), 297–328.
Missov, T. I. (2013). Gamma-Gompertz life expectancy at birth. *Demographic Research, 28*(9), 259–270. https://doi.org/10.4054/DemRes.2012.28.9.
Missov, T. I., & Lenart, A. (2011). Linking period and cohort life-expectancy linear increases in Gompertz proportional hazards models. *Demographic Research, 24*(19), 455–468. https://doi.org/10.4054/DemRes.2011.24.19.
Missov, T. I., & Németh, L. (2016). Sensitivity of model-based human mortality measures to exclusion of the Makeham or the frailty parameter. *Genus, 71*(2-3), 113–135.
Mpofu, R. T. (2013). Standard of living, quality of life and per capita GDP: A South African experience. *Corporate Ownership & Control, 11*(1), 882–889.
Niu, G., Melenberg, B. (2013). Trends in mortality decrease and economic growth. *Netspare* discussion papers, DP 11/2013-071
Pozzi, L., & Fariñas, D. R. (2015). Infant and child mortality in the past. *Annales de démographie historique, 129*(1), 55–75.
Rabbi Fazle, A. M. (2013). Imbalance in life table: Effect of infant mortality on lower life expectancy at birth. *Journal of Scentific Research, 5*(3), 479–488. https://doi.org/10.3329/jsr.v5i3.14105.
Reidpath, D. D., & Allotey, P. (2003). Infant mortality rate as an indicator of population health. *Journal of Epidemiology & Community Health, 57*, 344–346.
SAS (2018). Statistical Analysis System, Analytics software & solutions, Accessed Oct 2018: https://www.sas.com/en_us/home.html
Sebti, M., Courbage, Y., Festy, P., & Kursac-Souali, A. K. (2009). Maghreb, Morocco, Marrakesh: Demographic convergence, socioeconomic diversity. *Population & Societies*, (459).
Sharma, R. (2018). Health and economic growth: Evidence from dynamic panel data of 143 years. *PLoS ONE, 13*(10), e0204940. https://doi.org/10.1371/journal.pone.0204940.
Shkolnikov, V., McKee, M., & Leon, D. A. (2001). Changes in life expectancy in Russia in the mid-1990s. *The Lancet, 357*, 917–921.
Shkolnikov, V. M., Cornia, G. A., Leon, D. A., & Meslé, F. (1998). Causes of the Russian mortality crisis: Evidence and interpretations. *World Development, 26*(11), 1995–2011 Elsevier Science Ltd. PII: SO305750X(98)00102-8.
Shkolnikov, V. M., Jdanov, D. A., Andreev, E. M., & Vaupel, J. W. (2011). Steep increase in best-practice cohort life expectancy. *Population and Development Review, 37*(3), 419–434.
Sickles, C. R., & Taubman, P. (1997). Chapter 11: "The economics of fertility in developed countries". In M. R. Rosenzweig & O. Stark (Eds.), *Handbook of Population and Family Economics* (pp. 561–643). Amsterdam: Elsevier Science B.V..
Statistical office of the Republic of Serbia (2006).Demographic statistics 2002-2003.RZS, Belgrade 2006
Stengos, T., Thompson, B. S., and Wu, X. (2008).The evolution of the conditional joint distribution of life expectancy and per capita income growth. Economics Publications and Research. Paper 44. http://digitalcommons.ryerson.ca/economics/44
UN (2018).United Nations Statistical Division - National Accounts main aggregate database: Retrieved from: https://unstats.un.org/
United Nations. (2017). Department of Economic and Social Affairs, Population Division (2017). In *World Mortality Report 2015*. New York: United Nations publication.
Wolpin, K. I. (1997). Determinants and consequences of the mortality and health of infants and children. In M. R. Rosenzweig & O. Stark (Eds.), *Handbook of Population and Family Economics* (pp. 483–557). Amsterdam: Elsevier Science B.V..
World Bank (2017).World Bank Open Data, free and open access to global development data, indicators, Retrieved from: http://data.worldbank.org/indicator
World Health Organization. (2014). *World Health Statistics 2014*. Geneva: WHO.
Zaman, S., Hossain, N., Mehta, V., Sharmin, S., & Mahmood, S. (2017). An Association of Total Health Expenditure with GDP and Life Expectancy. *Journal Of Medical Research And Innovation, 1*(2), AU7–AU12. https://doi.org/10.5281/zenodo.576546.

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