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Република Македонија
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Republic of Macedonia

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# DETERMINANTS OF LIFE EXPECTANCY: COMPARATIVE ANALYSIS FOR DIFFERENT GROUPS OF COUNTRIES USING PANEL REGRESSION

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**Abstract**

*This paper examines the factors that influence life expectancy at birth in three groups of countries (countries with high life expectancy, countries with medium life expectancy and countries with low life expectancy) using the panel regression model.*
*Four variables are included in the analysis, gross domestic product per capita, fertility rate, immunization and urbanization. Gross domestic product per capita (as an indicator of level of income and economic growth) and urbanization (as an indicator of social growth) prove to be statistically significant variables in all three groups. Fertility rate is significant in countries with low and medium life expectancy, while immunization is proven to be an insignificant variable.*
*The conclusion is that the main focus must be on the economic and social growth. Governments should implement measures that will provide employment and growth in salaries, and also they should create a budget that supports investment in infrastructure, health, education and clean environment. If these measures are implemented, in the long run, they should contribute to an increased quality of living and growth in life expectancy at birth.*

**Keywords:** Life expectancy at birth, panel regression, GDP per capita, fertility rate, urbanization

**JEL classification:** J11, J13, J17, J18

## Introduction

When speaking about one country's economic development, it is often referred to as its gross domestic product. Yet, when speaking about one country's demographic development and overall quality of life, the reference is to life expectancy. Life expectancy at birth is not just a mere number. It speaks a lot about how one country's government cares about its citizens by providing proper health and social care, education, clean environment and other important measures that improve the overall quality of life. Unfortunately, these most important provisions are not available for people all over the world. While in Africa the life expectancy at birth is around 50 years, the most developed countries have an average of approximately 81 years. This is no small difference and it only speaks about the world socioeconomic inequality.

Life expectancy at birth is actually a forecast for the future years of age that one person will live on average. If for every age group, the number of surviving persons is available, by adding up all of them, the total number of years for all surviving persons can be determined as follows:

$$N_x + \sum_{x}^{100} l_x$$

and the average life expectancy is:

$$e_x^0 = \frac{N_x}{l_x} - 0{,}5$$

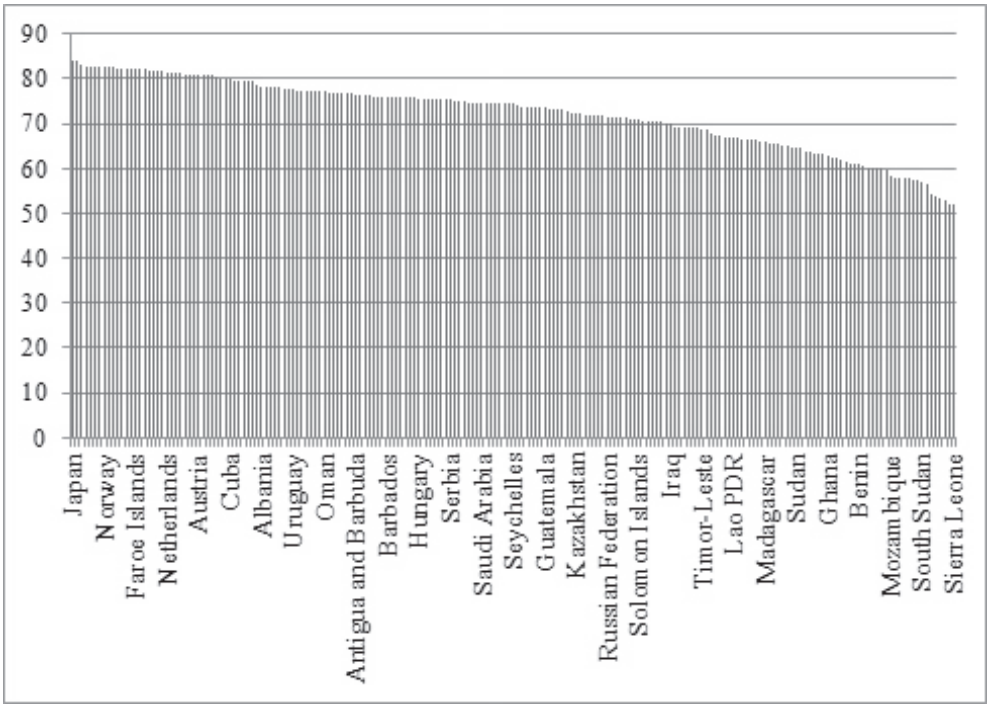
where $N_x$ is the sum of surviving persons, $l_x$ is the number of living persons at a certain age $x$.

Life expectancy at birth is determined by the achieved level of economic development of one country, and also by the improvement of its socioeconomic living conditions. Life duration also depends on the profession, place of residence, marital status, sex and the other (Risteski and Trpkova-Nestorovska, 2014).

The idea behind this research is to examine three different types of countries. All countries of the world for which the life expectancy at birth indicator was considered, were sorted from countries with the highest life expectancy to countries with the lowest life expectancy. They are presented in Figure1. The difference in this indicator is immense. At the top, life expectancy is above 80 years of age, and yet the lowest value of this indicator is about 50 years. All this speaks about the inequality in different parts of the world, an issue that is already known and vastly discussed.

For this research, three groups were formed, containing about ten countries. The first group consists of countries with low life expectancy, the second group contains countries with medium life expectancy and the third group has countries with high life expectancy.

*Figure 1. Life expectancy at birth in world countries in 2016*




Source: The World Bank, World Development Indicators, 2017

The idea is to examine these three groups by using the panel regression model in order to determine whether the same factors influence life expectancy at birth in different types of countries, or whether the factors vary. The examined factors were fertility rate, gross domestic product per capita, immunization and urbanization.

The composition of the paper is following: after the introduction, the second part refers to the literature review that examines similar research about life expectancy in different countries or country groups and different variables. The third part is reserved for data and research methodology explanation, and of course, elaboration of the empirical results. The fourth part is summary or conclusions drawn from this analysis.

## Literature review

There is significant literature that examines the determinants of life expectancy at birth, since it is a very important human development indicator in any country. Traditional variables mostly considered are gross domestic product per capita or gross national income per capita, level of education, urbanization, immunization, number of physicians, health expenditures,

fertility rate, access to drinking water, nutrition. Determinants may differ by the level of development of countries analyzed, and yet, some factors may remain the same.

In the analysis of 91 developing countries, Kabir (2008) uses multiple regression and probit frameworks only to reveal that socioeconomic factors like gross domestic product per capita, education, health expenditure, access to safe water and urbanization are not always to be influential as life expectancy at birth variables. He points out the importance of physicians availability, reduction of adult illiteracy and undernourishment as important factors to extend life expectancy.

With an accent on the Eastern Mediterranean, Bayati et al. (2013) perform panel regression for 21 countries and their conclusion is that in order to improve the health situation, the focus must be outside the health system, and it should center on the economic growth and the level of development. Policies for economic stabilization and thus, an increase in productivity and reduction of unemployment, have an important role in improving the health situation in the countries considered.

Husain (2002) also examines life expectancy at birth in developing countries. The main conclusion is that life expectancy can be improved if there is reduction in fertility and if the calorie intake is increased. The results are interesting and probably will not apply if used in European countries, but yet they apply in countries considered in his analysis: developing countries from South Asia, Sub-Saharan Africa, Latin America and the Caribbean.

On the other hand, determinants of life expectancy in 28 countries from the European Union are examined by Bilas et al (2014). The results confirm that gross domestic product per capita and level of education explain from 72,6% to 82,6% of the differences in life expectancy.

Life expectancy determinants in Southeastern Europe were analyzed by Trpkova-Nestorovska (2015). Using the cointegrated panel regression model for 12 countries, the research confirmed gross national income per capita, consumer price index and child immunization as most important factors that influence life expectancy at birth.

Gilligan and Skrepnek (2014) have done a research where they divide the countries in two groups, developed and less developed countries. The results confirm that gross domestic product per capita, health expenditures, literacy and immunization are statistically important factors of life expectancy in the developed countries. In less developed countries, the main determinants are immunization and number of doctors.

Life expectancy in less developed countries was analyzed by Rogers and Wofford (1989). They used data for 95 less developed countries and came to a conclusion that mortality is mainly determined by urbanization, industrialization and education, and additionally, access to safe water, physicians and adequate nutrition.

Gulis (2000) wanted to show if life expectancy is a possible environmental health indicator. His research proves this to be true. Life expectancy at birth related to other environmental variables can be used as an estimate of overall health impact of these variables. Literacy, which represents social environment, and access to safe drinking water, which represents natural environment, are the main variables in his linear regression model, responsible for 37% of overall life expectancy. The author draws his conclusion by analyzing 156 countries of the world.

## Data, research methodology and empirical results

In approximately 200 countries in the world, life expectancy at birth varies from 84 years in Japan, to 51,8 years in Sierra Leone in 2016. The purpose of this analysis is to select three groups of countries and to perform three panel regressions in order to examine if the factors that influence life expectancy at birth are different per group. At first, a list was formed, where countries were sorted by their life expectancy in 2016, from the highest to the lowest. From approximately 200 countries, three groups with approximately 10 countries each were selected. The groups could include more than 10 countries, yet for some of the countries not all data were available, so it was the author's decision to take a sample of 10 countries. The first group is composed of countries with the highest life expectancy at birth and includes the following countries: Australia, Canada, Iceland, Israel, Italy, Japan, Norway, Singapore, Spain and Switzerland. The second group is consisted of countries with medium life expectancy at birth, like: Armenia, Brazil, Bulgaria, Hungary, Latvia, Macedonia, Romania, Saudi Arabia, Serbia, Tunisia and Turkey. The third group contains the countries with the lowest life expectancy at birth: Burundi, Central African Republic, Chad, Cote d'Ivoire, Guinea-Bissau, Lesotho, Nigeria, Sierra Leone, Swaziland, Mali and Cameroon. Data are with annual frequency for the period 2000-2016 and the source is the World Bank's World Development Indicators database.

Regarding the data, the panel regression model is used, described in the following equation:

$$y_{it} = \alpha + \beta_{x_{it}} + u_{it}$$

where $y_{it}$ is the dependent variable, $\alpha$ is the intercept term, $\beta$ is a $kx1$ vector of parameters to be estimated on the explanatory variables, and $x_{it}$ is a $1xk$ vector of observations on the explanatory variables, $i$=1,…,$N$ and it stands for the cross-sectional unit (number of countries), while $t$=1,…,$T$ and it stands for the time period (Brooks, 2014).

Panel regressions use the following variables (explained in Table 1):

*Table 1. Variables included in the panel regressions*

| Name | Description of the variable |
|---|---|
| LEB | Life expectancy at birth represents the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to remain throughout its life. |
| FERT | Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year. |
| GDP | GDP per capita is the gross domestic product divided by midyear population. Data are in current U.S. dollars. |
| IMMUN | Child immunization measures the percentage of children ages 12-23 months who received DPT (diphtheria, pertussis and tetanus) vaccinations before 12 months of age or at any time before the survey. |
| URBAN | Urban population refers to people living in urban areas as defined by national statistical offices. |

Table 2 contains the results from the panel unit root tests. The tests used with panel series are very similar with the tests used for the single equation (Brooks, 2014). Despite the similarities, panel methods use specially designed tests.

*Table 2. Panel unit root tests (individual intercept)*

| | Levin Lin and Chu (p-value) | | |
|---|---|---|---|
| **Variable** | **LOW LEB panel** | **MEDIUM LEB panel** | **HIGH LEB panel** |
| **LEB** | 0,0000 | 0,0000* | 0,0000 |
| **ΔLEB** | 0,0000 | 0,0000* | 0,0654 |
| **FERT** | 0,0340 | 0,0000 | 0,0943 |
| **ΔFERT** | 0,0000 | 0,0000 | 0,8078 |
| **GDP** | 0,0001 | 0,0000 | 0,0007 |
| **ΔGDP** | 0,0000 | 0,0000 | 0,0001 |
| **IMMUN** | 0,0001 | 0,5853 | 0,8795 |
| **ΔIMMUN** | 0,0000 | 0,0002 | 0,0006 |
| **URBAN** | 0,0000 | 0,0000 | 0,0000 |
| **ΔURBAN** | 1,0000 | 1,0000 | 0,9968 |

* Individual intercept and trend;
Source: Author's calculations.

The panel unit root tests confirm that in the first group, with the lowest life expectancy at birth rates, all observed variables are stationary (for 0,05). The second group, with medium life expectancy at birth rates, has only one non-stationary variable, i.e. immunization, while the dependent variable is stationary if the individual intercept and trend is included in the test. The third group, with the highest life expectancy at birth rates, has two non-stationary

variables, fertility rate and immunization. Having this information available, the regressions will be performed according to the stationarity or non-stationarity of variables.

The results of the estimated panel regressions are presented in Tables 3, 4 and 5.

*Table 3. Estimated panel regression for low life expectancy birth rate countries*

| Variable | Coefficient | Standard error | t-statistics | Probability |
|---|---|---|---|---|
| FERT | -5,867688 | 0,403973 | -14,52493 | 0,0000 |
| GDP | 0,000853 | 0,000265 | 3,216654 | 0,0015 |
| IMMUN | -0,003255 | 0,014293 | -0,227696 | 0,8202 |
| URBAN | 0,145292 | 0,049993 | 2,906271 | 0,0041 |
| R-squared | | | | 0,983560 |
| Adjusted R-squared | | | | 0,981535 |
| Durbin-Watson statistics | | | | 0,439472 |

Note: Hasuman test statistic was 0,0000, thus the panel regression was estimated with fixed effects.
Source: Author's calculations.

*Table 4. Estimated panel regression for medium life expectancy birth rate countries*

| Variable | Coefficient | Standard error | t-statistics | Probability |
|---|---|---|---|---|
| FERT | 0,997883 | 0,328216 | 3,040328 | 0,0027 |
| GDP | 0,000205 | 0,000021 | 9,728984 | 0,0000 |
| IMMUN* | -0,029795 | 0,016588 | -1,796114 | 0,0742 |
| URBAN | 0,421280 | 0,045890 | 9,180248 | 0,0000 |
| R-squared | | | | 0,767157 |
| Adjusted R-squared | | | | 0,748205 |
| Durbin-Watson statistics | | | | 0,311620 |

Note: Hasuman test statistic was 0,0000, thus the panel regression was estimated with fixed effects.
*IMMUN was a non-stationary variable; regression performed with ΔIMMUN provided similar results (probability 0,9687).
Source: Author's calculations.

*Table 5. Estimated panel regression for high life expectancy birth rate countries*

| Variable | Coefficient | Standard error | t-statistics | Probability |
|---|---|---|---|---|
| FERT* | -1,488190 | 0,723486 | -2,056972 | 0,0414 |
| GDP | 0,000059 | 0,000005 | 12,88382 | 0,0000 |
| IMMUN* | -0,010604 | 0,029463 | -0,359898 | 0,7194 |
| URBAN | 0,239387 | 0,033949 | 7,051293 | 0,0000 |
| R-squared | | | | 0,731305 |
| Adjusted R-squared | | | | 0,708914 |
| Durbin-Watson statistics | | | | 0,335840 |

Note: Hasuman test statistic was 0,0000, thus the panel regression was estimated with fixed effects.

*FERT and IMMUN were non-stationary variables; regression performed with **Δ**FERT and **Δ**IMMUN provided similar results (probability 0,6110 for **Δ**FERT and 0,9478 for **Δ**IMMUN).

Source: Author's calculations.

The common conclusion drawn from the three regressions is that the variables GDP per capita and urban population have positive and statistically significant impact on life expectancy at birth rates. The level of income, measured by GDP per capita is the most common factor confirmed in many similar researches. It is interesting to compare it to the research made by Wilkinson, 1996. He states that if the GDP per capita increases above a certain threshold, it will no longer influence life expectancy at birth rates. Our research proves the opposite, since the GDP per capita is a statistically significant variable in low income countries (the group with low life expectancy at birth), medium income countries (the group with medium life expectancy at birth), as well as in high income countries (the group with high life expectancy at birth). So the general conclusion-the lower GDP per capita, the lower life expectancy stated by the World Bank, 1993, can also be confirmed by this analysis. Also, it is confirmed by Kabir (2008). Trpkova-Nestorovska (2015) finds a positive and statistically significant result between gross national income and life expectancy. Gross national income can be considered as the level of income in one country, and this positive correlation was found in papers such as Bilas et al. (2014), Gilligan and Skrepnek (2014) and Bayati et al. (2013) for different groups of countries.

Urbanization, just as GDP per capita, is confirmed by many analyses as a variable that has positive impact on life expectancy. It is understandable, since most urbanized areas have better living conditions, access to clean drinking water, education institutions, hospitals, easier access to food, clothing, technology etc. than rural areas. This relationship was confirmed by Kalediene and Petrauskiene (2000), and yet Kabir (2008) didn't find urbanization

as a significant determinant on life expectancy. It is important to point out that urbanization does not always mean good living conditions. Urbanized cities have parts with poor life conditions, and in such case, urbanization may have a reduced influence on life expectancy.

Fertility rate was a confirmed determinant in the groups with low and medium life expectancy, while it remains insignificant in the group with high life expectancy. In the first group, with low life expectancy, the relationship is negative; meaning as the fertility rate is declining the life expectancy is increasing. It is understandable, since most of these countries are very poor with extremely high fertility rates (around 5,3 children per woman). These are very high rates and they are declining in the observed period, while life expectancy is continuously increasing, thus the inverse relationship. The declining fertility is the effect of economic development and women's education. Yet, the slow decline is due to the relatively slow economic growth and slow process of education of women in many African countries (Pison, 2017). In the second group of countries with medium life expectancy, the fertility rate has a positive and statistically significant impact on life expectancy at birth rates, opposite of the first group. Yet, after a detailed consideration of data, it is clear that in these countries, the fertility rate is declining (the group has an average of 1,79 children per woman), while the life expectancy is rising, so the positive relationship is a more appropriate explanation. In the last group of countries with high life expectancy rates, the fertility rate proves to be insignificant. It is possible that in these highly developed countries, other factors have greater influence on life expectancy, such as health care and high quality of living (clean water, clean air, quality food, living a healthy lifestyle and the other).

The last variable, immunization, proves to be statistically insignificant in all three groups, meaning it does not influence life expectancy. Despite these results, the importance of vaccines in saving children's lives is well known, so it should be encouraged in every country of the world, regardless of the level of life expectancy or income.

## Conclusion

The purpose of this research was to find if there are any similarities in three groups of countries (formed by their level of life expectancy at birth) regarding the factors influencing life expectancy. Factors considered for the panel analysis were fertility rate, gross domestic product per capita, immunization and urbanization. The analysis proved that regarding the country group, the gross domestic product per capita as an indicator of the level of income and urbanization is a common factor that influences life expectancy at birth in all three groups. Fertility rate was found significant in the groups

with low and medium life expectancy, while immunization was not found to be a significant factor in any of these groups.

Life expectancy at birth is an indicator that speaks about the quality of living in one country. The higher the living standard, the more likely is that the country is highly developed, with a good economy, health and education system. Also, the cultural element is important here, like tradition, time spent with family and friends, time spent for relaxation, type of food consumed. These are also factors that contribute to better quality of living.

Thus, it is no surprise to point gross domestic product per capita and urbanization as main variables that influence life expectancy in all three groups. Gross domestic product is an indicator of one country's wealth, while urbanization indicates the country's progress. Basically, everything comes down to the economic and social development. Even the fertility rate or immunization are not as important as these two factors.

These conclusions are important for the governments all over the world. Economic development is very important, having a number of implications, so it must be taken seriously. Effective measures for generating good business conditions that create employment and proper salaries must be taken. Also, good fiscal policies are important, where capital investments in infrastructure, education and health are to be encouraged. Governments should also provide clean environment, meaning clean air, water and soil. There should be measures taken to increase citizens' conscience about the pollution and recycling, and fines should be implemented for greater efficiency. Even though some of these measures might seem unpopular at the begging, in the long run, their benefits are unprecedented, which also means increased life expectancy.

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# ДЕТЕРМИНАНТИ НА ОЧЕКУВАНОТО ТРАЕЊЕ НА ЖИВОТ: КОМПАРАТИВНА АНАЛИЗА ЗА РАЗЛИЧНИ ГРУПИ НА ЗЕМЈИ СО КОРИСТЕЊЕ НА ПАНЕЛ РЕГРЕСИЈА

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**Апстракт**

*Овој труд ги истражува факторите кои влијаат на очекуваното траење на животот кај три групи земји (земји со висока вредност на очекуваното траење на живот, земји со средна вредност на очекуваното траење на живот и земји со ниска вредност на очекуваното траење на живот) со користење на панел регресија.*
*Четири променливи се вклучени во анализата: бруто домашниот производ по глава на жител, стапката на фертилитет, имунизацијата и урбанизаицијата. Бруто домашниот производ по глава на жител (како индикатор на нивото на приход и економскиот раст) и урбанизацијата (како индикатор на социјалниот раст) се покажаа како статистички значајни променливи во сите три групи. Стапката на фертилитет е значајна кај земјите со ниско и средно ниво на очекувано трање на животот, додека имунизацијата се потврди како незначајна променлива.*
*Заклучокот е дека главниот фокус мора да биде на економскиот и социјалниот развој. Владите треба да имплементираат мерки кои ќе овозможат вработувања и раст во платите, како и да креираат буџет кој ќе поддржува инвестиции во инфраструктурата, здравството, образованието и чистата животна средина. Ако овие мерки се имплементираат, на долг рок тие ќе придонест за зголемен квалитет на животот и раст на очекуваното траење на животот.*

**Клучни зборови:** Очекувано траење на животот, панел регресија, БДП по глава на жител, стапка на фертилитет, урбанизација

**JEL класификација:** J11, J13, J17, J18