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Abstract: Increasing life expectancy at birth is a huge achievement for a society; however it also brings many challenges and requires a society to constantly adapt to demographic consequences. In our research, we investigate life expectancy determinants and the role of a country's education level among them. Using multiple regression analysis on cross-section data of 187 countries around the world we confirm our main research thesis that a country's education level is an important determinant of life expectancy at birth and three separate hypotheses regarding life expectancy determinants. The main contribution of this research is the empirically tested regression model of life expectancy determinants. The results of the research confirm a strong importance of a country's education level and imply that societies should encourage education among young people as well as education of adults through lifelong learning programmes.

Keywords: education level; learning; life expectancy determinants; gender inequality; school expectancy; regression model.

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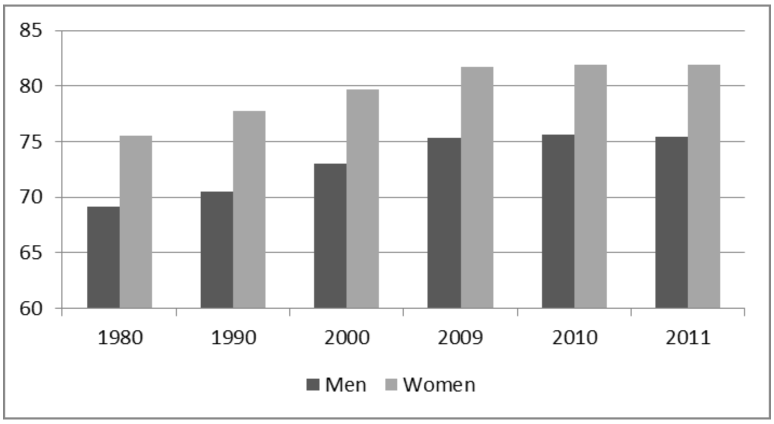
1 The phenomenon of extending life expectancy at birth over time

Life expectancy at birth increased by 21 years; from 46.6 years in 1950–1955 to 67.6 years in 2005–2010. In 2005–2010, on average, in less developed countries, people expected to live 24.6 years longer than in 1950–1955, and in developed countries on average 11 years longer. Despite this, life expectancy at birth in 2009 in less developed countries is about 11 years lower than life expectancy at birth in developed countries. Life expectancy at birth in least developed countries can be 21 years lower than that in developed countries (United Nations, 2009). The most significant determinant of population ageing is the long-run decline in fertility. If fertility rates decline below the level of simple reproduction and stay at that level for a long period of time, the proportion of elderly people in the whole population will start to increase (Trunk Širca et al., 2009). As a consequence of the increasing life expectancy at birth as well as low fertility, the number of persons aged 60 years or more increased to 737 million in 2009 and is expected to increase to 2 billion in 2050 (United Nations, 2009).

There is a greater variance in life expectancy at birth among undeveloped and less developed countries, while that variance is smaller among developed countries. The world life expectancy at birth is expected to increase by eight years from 2005–2010 to 2045–2050, and should reach 75.5 years. The regional differences and the differences between less developed and developed countries are expected to decrease. Today, 38% of new born babies are expected to survive until their 80th birthday; however in 2045–2050 more than 50% of new born babies will be expected to survive until their 80th birthday and, if they live in developed countries, up to even 65% (United Nations, 2009).

Figure 1 Life expectancy at birth in the EU(27), 1980–2011

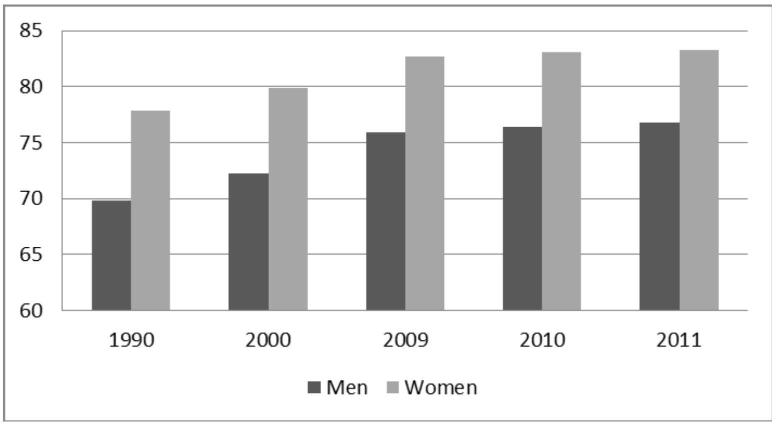


Source: Eurostat (2013)

Figure 1 shows the increasing life expectancy at birth from 1980 to 2011 in EU(27). In 1980, life expectancy at birth was 69 for men and 75 for women, whereas in 2011 it increased by more than five years for both sexes.

In Slovenia, life expectancy has also been increasing for both sexes and is even a little higher compared to the EU(27) averages. From 1990 to 2011 life expectancy increased in Slovenia by more than seven years for men and by more than five years for women (Figure 2).

Figure 2 Life expectancy at birth in Slovenia, 1990–2011



Source: Eurostat (2013)

The highest life expectancy of women at birth is in Japan and is 86 years old. In the 31 top ranked countries for life expectancy, life expectancy of women is 82 years or more. Out of these 31 countries, 11 of them are developing. By 2045–2050 life expectancy of women is expected to increase by up to 91 years in Japan and at least up to 86 years in the 35 top ranked countries. Assuming projected mortality in the middle of the 21st century, 59% of all baby girls born in the world in 2045–2050 should survive until their

80th birthday, which is 15% longer than in 2005–2010. In the 52 top ranked countries, up to 70% of baby girls born in 2014–2050 should survive until their 80th birthday (United Nations, 2009).

The world average life expectancy for both sexes at the age of 60 years is expected to increase from 19.7 years in 2005–2010 to 22.4 in 2045–2050, that is for more than 13%. Over the same time period it is expected to increase from 16.2 to 18.5 at the age of 64 and from 7.9 to 9.1 at the age of 80. In the case of developed countries, life expectancy at birth is expected to increase in the same time period by 7% (by 13% in less developed countries) and life expectancy at the age of 80 years by 24% (by 21% in less developed countries) (United Nations, 2009).

Below, we will present some previous investigations which explore the causes for an increase of life expectancy.

2 Previous studies on determinants of life expectancy at birth

Many authors found that the standard of the (public) health system, the implementation of new drugs and healthy eating and lifestyle to be important determinants of life expectancy at birth. The development and mass production of antibiotics and drugs against tuberculosis, malaria, pneumonia, jaundice, cholera, sexually transmitted diseases after 1940, and general improvement of health services significantly contributed to the increase of life expectancy at birth (Acemoglu and Johnson, 2007). Zheng et al. (2014) prove the importance of healthy eating habits as a crucial factor of general health and life expectancy at birth. Undernourishment as well as overnourishment is a risk factor for several illnesses and even death.

Different researchers reveal the importance of a society's education level for life expectancy at birth. Babnik and Trunk Širca (2014) point out how intergenerational cooperation is an important source of individual learning, and a vehicle for creation, transfer and retention of knowledge. Blackburn and Cipriani (2002) and Hansen (2012) found that higher educated individuals live healthier lives, which consequently positively impacts theirs life expectancy at birth. They normally have more knowledge about the importance of recreation and healthy living as well as more money and other conditions needed to implement these ideas into their lives. A positive association between level of education and life expectancy at birth is confirmed also by Valkonen et al. (1997). A higher education level among young women positively affects their reproductive health and their status in a family, community and society. More educated women are less likely to get infected with HIV which further increases life expectancy at birth (Bloom, 2006). An interesting study by Zhang and Zhang (2005) reveals that increasing the length of formal education among young people positively affects their professional career and improves their living standard and consequently life expectancy at birth. However, on the other hand prolonged education and personal career oriented values delay marriage and births which decreases the aggregated fertility level. This may further lead to an accelerated population ageing and negative effects on human capital and aggregate economy (Čepar and Bojnec, 2014).

The educational system differs from country to country and according to the average level of education achieved in the country they put emphasis on different levels of education. In the case of Slovenia, where the expected years of schooling are 17, the greatest emphasis is on higher education. Ocvirk and Trunk Širca (2012) showed that in the past decade higher education has been affected by a number of changes, including the higher rates of mass education, internationalisation, growing importance of knowledge-based economies and increased global competition. However, Gomezelj Omrzel and Trunk Širca (2008) argue that it is necessary to evaluate knowledge no matter where anyone has obtained it. 70% of the population of Slovenia is already involved in tertiary education, Wiechetek and Trunk Širca (2014), Rožman et al. (2014) and Trunk Širca et al. (2006) discuss the competences of young graduates when entering into the labour market. Arzenšek et al. (2014) and Dermol et al. (2013) take this school of thought further, saying that acquired knowledge in itself, which is possessed by an individual, is not enough for the development of society; it is necessary to develop appropriate mechanisms for the transfer of knowledge into practice (Bojnec and Fertö, 2011).

Another group of authors reveal a positive impact of mortality decline on life expectancy at birth. Bloom (2011) showed that the infant mortality rate decreased from 139 infant deaths per 1,000 inhabitants in 1950 to 43 infant deaths per 1,000 inhabitants in 2011, while in the same time period life expectancy at birth increased by more than 20 years. Jayachandran and Lleras-Muney (2009) investigated a decline in mortality of mothers giving birth in Sri Lanka. They found out that a 70% decline in mortality of mothers giving birth increases life expectancy of women at the age of 15 by 4.1%.

Williamson and Boehmer (1997) investigated an impact of gender inequality on life expectancy at birth using multiple regression analysis on a sample of 97 countries across the world. They found that education of women, their economic status (labour market participation) and their reproductive autonomy have a significant positive impact on their life expectancy at birth.

Singh and Siahpush (2014) reveal a negative correlation between rurality rate and life expectancy at birth. In the USA in 2005–2009, life expectancy at birth in big metropolis was 79.1 years, while in smaller but still urban cities 76.9 years and in rural areas 76.7 years. The difference among these life expectancies at birth is increasing through time. The reasons for lower life expectancy at birth in rural areas are higher rates of heart diseases, unintentional injuries, chronic obstructive lung diseases, lung cancer, strokes, suicide and diabetes.

There is a negative association between the number of births per 100 women aged 15–19 and life expectancy at birth. Teenage pregnancy and motherhood is associated with lower education of young women, lower income and living standard and consequently lower life expectancy at birth (Singh and Darroch, 1999).

Marmot (2006) stresses that economic activity, as well as the level of economic standard is an important determinant of life expectancy at birth. He shows that countries with higher GDP per capita have higher life expectancy at birth. Besides, the growth of life expectancy at birth is higher in countries with higher GDP per capita than in countries with lower GDP per capita. Moreover, economic globalisation increases life expectancy at birth more than political and social globalisation (Bergh and Nilsson, 2010; see also Trunk and Stubelj, 2013). However, Kabir (2008) believes that economic determinants are not really significant for life expectancy at birth. Based on his regression analysis and probit modelling on data for 91 countries, he came to the conclusion that income and GDP are not important, while social security and health system, literacy and poverty prevention play a crucial role in determining life expectancy at birth. Similarly, Novak (2014) discovers that personal unemployment has different effects on personal well being and thus life expectancy, depending on other general economic conditions like general unemployment rate.

3 The research hypotheses, methodology, assumptions, limitations and data used

In this section, we present the research hypotheses and the methodology which was used to achieve the goals of the research and to test the research hypotheses. Following this, we present the assumptions on which our research is based as well as its limitations in a sense of its scope, geographical limits and time frame. Finally, the most important data used in this investigation is explained.

3.1 The research hypotheses

It is obvious from the review of the relevant theory as well as from previous studies and research, that there are many different determinants of life expectancy at birth. In our research we wanted to find the most important determinants of life expectancy at birth and to statistically test the importance of education level among these determinants on the cross-section data of 187 countries around the world for two chosen years 2005 and 2010. Our 'main research thesis is that a country's education level is an important determinant of life expectancy at birth'. In order to test the main research thesis, we set the following three hypotheses.

Hypothesis 1 Gender inequality negatively impacts life expectancy at birth.

Hypothesis 2 Expected years of schooling positively impact life expectancy at birth.

Hypothesis 3 Expected years of schooling is one of the strongest determinants of life expectancy at birth.

3.2 Methodology

In order to test the main research thesis and the three hypotheses, we ran several multivariate regression models. First, we collected secondary data from the United Nations' Human Development Report (United Nations, 2005, 2013). The data refers to several demographic and socio-economic variables of 187 countries from around the world for the year 2005 and 2010. The statistical observation units were individual countries. The cross-section data enabled us to exclude any time related effects from the analysis. The cross-section demographic and socio-economic data were properly arranged, transformed and entered into a statistical computer package SPSS, which was used for regression analysis.

In the regression analysis, life expectancy at birth was used as a dependent variable to measure average life span of a country's population. Several socio-economic variables were used as explanatory variables. Based on the literature review we set the theoretical assumptions about the relationships and association among variables used and set initial regression models which were tested on the available data on the 187 countries from around the world. We tested the following general form of the regression model:

$$\textit{Life expectancy at birth} = \alpha + \beta_1 \times \textit{determinant}_1 + \ldots + \beta_n \times \textit{determinant}_n + \textit{error term } \mu$$

Using regression analysis we estimated parameters of the models and chose the best fitting models based on the standard error of the models, adjusted determination coefficient, F-test and t-tests for the year 2005 and 2010. The best regression models for both years were then compared to test the results for any differences and for the time robustness.

3.3 Research assumptions and limitations

Assumptions of our study are mostly related to the indicators which are used to measure socio-economic determinants of life expectancy at birth. We assume that indicators measured and calculated within the Human Development Report to proxy life expectancy determinants are methodologically adequate and correct. Life expectancy at birth is used as a dependant variable in regression analysis measuring an average human life span by countries. Methodological assumptions of regression analysis were also tested and are presented with the results of our research.

Limitations of our study narrow the scope of investigation and refer to some methodological problems which are mostly related to missing values for some country's indicators. We use aggregate country data for a sample of 187 countries around the world; we are limited to the year 2005 and 2010 and are focusing on socio-economic determinants only.

3.4 Data used

All secondary data was collected from the databases of United Nations which were acquired through the United Nations Development Programme – Human Development Report (United Nations, 2005, 2013). Besides data on life expectancy at birth we used the following data for the explanatory variables in the regression analysis of life expectancy determinants:

- public health spending (spending on public health as a percentage of GDP)
- gross domestic product per capita (gross domestic product per capita, expressed in US dollars)
- gender inequality (a composite measure that reflects the potential loss due to inequality between female and male sex through three dimensions: reproductive health, empowerment and the labour market)
- expected years of schooling (the expected number of years of schooling upon school entry)
- employment ratio between women and men (the ratio between female and male working population (aged 15–64) who are actively involved in the labour market)

- ratio between men and women with at least upper secondary education (the ratio between women and men aged 25 years or older with secondary or higher education attainment);
- urban population (population living in areas classified as urban areas, according to the criteria of each particular country); and number of births per 100 women aged 15–19 years (number of births to women aged 15–19 per 100 women aged between 15–19 years).

The data refers to socio-economic variables by 187 countries around the world for the year 2005 and 2010.

4 Econometric results – regression model of life expectancy determinants

In order to test each of the three hypotheses and our main thesis we ran several multivariate linear regression models. In all the regression models, we analysed the explanatory power of the independent socio-economic variables as well as the strength and the direction of the association between the dependent variable (life expectancy at birth) and independent variables (socio-economic variables). Using regression coefficients, we tested the existence and the direction (positive/negative) of the association and impact that was assumed for each determinant in each hypothesis. Using adjusted determination coefficient we tested the share of the variance that was explained by the independent variables. Using t-tests we tested statistical significance of each individual explanatory variable, while by using F-test we tested statistical significance of the regression models as a whole. During regression analysis we ran many different models, however only those which were statistically significant and those with highest explanatory power were selected for interpretation in this paper. The various theoretical views and interpretations of the other researchers were thus upgraded with our own original empirical findings regarding the interrelation between socio-economic variables and life expectancy at birth. Here we present the final regression model results for the year 2010, and next for the year 2005.

First, we included into the regression analysis all the initially collected independent socio-economic variables. After we excluded statistically insignificant explanatory variables and those which were too correlated with each other, we came to the following final model for the year 2010 (Table 1) and for the year 2005 (Table 2).

As we can see from Tables 1 and 2, all the regression coefficients in the final models for both years are statistically significant ($p < 0.05$ for all betas) and there is no multicolinearity in the model included determinants, since the tolerance is always greater than 0.1 and VIF is less than 10 for all the variables.

From the regression results for the year 2010 (Table 1) we may conclude that statistically significant determinants for life expectancy at birth are expected years of schooling (positive impact), gender inequality (negative impact), employment ratio between women and men (negative impact), urban population (positive impact) and number of births per 100 women aged 15–19 years (negative impact).

Table 1 Final regression model results for 2010

Model	*Unstandardised coefficients*		*Standardised coefficients*	*T*	*Exact significance level (p)*	*Correlation coefficients*		*Multicolinearity*	
	B	*Standard error*	*Beta*			*Bivariate*	*Panel*	*Tolerance*	*VIF*
Constant	67.890	4.534		14.974	0.000				
EYS10	1.087	0.274	0.330	3.967	0.000	0.771	0.330	0.277	3.606
GI10	–0.136	0.041	–0.260	–3.285	0.001	–0.715	–0.278	0.305	3.275
ER10	–0.113	0.024	–0.229	–4.658	0.000	–0.192	–0.379	0.791	1.265
UP10	0.070	0.027	0.163	2.547	0.012	0.656	0.219	0.470	2.129
NB10	–0.527	0.160	–0.226	–3.301	0.001	–0.716	–0.279	0.410	2.441
$R^2 = 0.753$					Adjusted $R^2 = 0.743$				
F-statistics = 78,533 (exact significance level = 0.000)					N =187				

Notes: Dependant variable: life expectancy at birth.
Legend: EYS10 – expected years of schooling in 2010; GI10 – gender inequality in 2010; ER10 – employment ratio between women and men in 2010; UP10 – urban population in 2010; NB10 – number of births per 100 women aged 15–19 years in 2010.

Source: Own calculations based on data obtained from United Nations (2013)

Table 2 Final regression model results for 2005

Model	*Unstandardised coefficients*		*Standardised coefficients*	*T*	*Exact significance level (p)*	*Correlation coefficients*		*Multicolinearity*	
	B	*Standard error*	*Beta*			*Bivariate*	*Partial*	*Tolerance*	*VIF*
Constant	81.811	5.277		15.502	0.000				
EYS05	0.599	0.271	0.186	2.209	0.029	0.773	0.190	0.229	4.358
GI05	–0.256	0.049	–0.469	–5.200	0.000	–0.756	–0.414	0.200	5.010
ER05	–0.165	0.025	–0.318	–6.543	0.000	–0.248	–0.496	0.687	1.456
UP05	0.061	0.028	0.133	2.197	0.030	0.678	0.189	0.442	2.260
NB05	–0.348	0.150	–0.161	–2.323	0.022	–0.747	–0.199	0.337	2.970
$R^2 = 0.788$					Adjusted $R^2 = 0.779$				
F-statistics = 97.097 (exact significance level = 0.000)					N = 187				

Notes: Dependant variable: life expectancy at birth in 2005.
Legend: EYS05 – expected years of schooling in 2005; GI05 – gender inequality in 2005; ER05 – employment ratio between women and men in 2005; UP05 – urban population in 2005; NB05 – number of births per 100 women aged 15–19 years in 2005.

Source: Own calculations based on data obtained from United Nations (2013)

Surprisingly, from the regression results for the year 2005 (Table 2) we may conclude, that statistically significant determinants of life expectancy at birth in 2005 are exactly the same as in case of the year 2010, which is a good signal for the model robustness.

From the regression results for the year 2010, we can read the following. If the expected years of schooling are increased by one year, life expectancy at birth is increased by 1.087 years (by 0.599 years for the model from 2005), keeping other variables constant. If the gender inequality is increased by 1 percentage point (measuring the relative potential loss due to the gender inequality), life expectancy at birth is decreased by 0.136 years (by 0.256 years for the model from 2005), keeping other variables constant. If the employment ratio between women and men is increased by 1 woman per 100 men, life expectancy at birth is decreased by 0.113 years (by 0.165 years for the model from 2005), keeping other variables constant. If the urban population is increased by 1 percentage point, life expectancy at birth is increased by 0.070 years (by 0.061 years for the model from 2005), keeping other variables constant. If the number of births per 100 women aged 15–19 years is increased by 1 birth, life expectancy at birth is decreased by 0.527 years (by 0.348 years for the model from 2005), keeping other variables constant.

The fair strength and direction of the association between life expectancy at birth and each explanatory variable is additionally confirmed by the bivariate and partial regression coefficients (Tables 1 and 2).

Adjusted determination coefficient for the regression model for the year 2010 (adj. $R^2 = 0.0743$) tells us that the variation of all in the model included determinants together explain 74.3% of the variability of life expectancy at birth. In case of the regression model for the year 2005 that explained variance is even 77.9% (adj. $R^2 = 0.779$). That is quite a lot, so we may conclude that the explanatory power of both regression models is relatively high. F-test in case of both models additionally confirms the statistical significance of both models as a whole.

In order to ensure the validity of regression model results, we also tested if the general assumptions of the regression analysis are fulfilled. We found that in the case of both models the distributions of all in the analysis included variables are close enough to normal distribution. The distributions of regression errors, with average close to zero, also confirm the normal distribution. The scatter diagram shows that regression errors exhibit no particular pattern and are evenly and randomly distributed over the area. There is no heteroscedasticity since constant variance of the errors is observed (homoscedasticity). All the necessary assumptions are fulfilled, so we may conclude that both regression models are efficient and unbiased.

5 Key findings

Using regression analysis we identified main socio-economic determinants of life expectancy at birth. Higher expected years of schooling and higher share of urban population increase life expectancy at birth, higher gender inequality, higher employment ratio between women and men and higher number of births per 100 women aged 15–19 decrease life expectancy at birth. Since in both regression models we also found gender inequality as one of the statistically significant determinants of life expectancy at birth, which decreases life expectancy at birth, we may 'confirm our first hypothesis that gender inequality negatively impacts life expectancy at birth'.

Similarly, we found out that expected years of schooling of a country are associated with life expectancy at birth in the same country. Moreover, based on the regression analysis results, higher expected years of schooling statistically increase life expectancy at birth significantly which enables us to 'confirm our second hypothesis that expected years of schooling positively impact life expectancy at birth'. The expected years of schooling in the world increased from 9.1 years in 1980 to 12.5 years in 2012. In Slovenia, expected years of schooling increased from 12.2 years in 1990 to 16.4 years in 2012 and are on average four years higher than the world average.

Not only is education level an important determinant of life expectancy at birth, we can see that expected years of schooling is actually the most important determinant when taking into account the regression model for the year 2010. Unstandardised as well as standardised regression coefficient beta for the variable expected years of schooling is the highest among all the beta coefficients in that model. In the case of the regression model for the year 2005 unstandardised coefficient beta for the variable expected years of schooling is the highest; while standardised coefficient beta is among the highest (third highest). So, we may definitely 'confirm also our third hypothesis that expected years of schooling is one of the strongest determinants of life expectancy at birth'. Moreover, the model for the year 2010 and partially the model for the year 2005, shows that expected years of schooling is actually the strongest determinant.

One would expect GDP per capita to be one of the life expectancy determinants in the regression model, as it is suggested by some previous research of life expectancy determinants previewed in chapter 2. Our analysis does not prove that GDP per capita is not one of the life expectancy determinants; however GDP pre capita was dropped out of the final regression model, due to its strong correlation with the other determinants in the final regression model. Higher GDP per capita is reflected in higher expected years of schooling, in lower gender inequality, in lower teenage births and similar. If we kept GDP per capita in our final model, it would suffer from multicolinearity problems.

To sum up, based on the results of our empirical investigation, we may confirm our three hypotheses as well as the main research thesis that 'a country's education level is an important determinant of life expectancy at birth'.

6 Conclusions and implications

Throughout the vast body of empirical research which is presented in literature we may find various examples of determinants of life expectancy at birth. Most of the previous studies as well as our research prove some similar determinants of life expectancy at birth.

However, regarding the employment ratio between women and men, the results of our research were unexpected at least at first sight.

In accordance with the regression results, the ratio leads to lower life expectancy at birth, which would mean that higher female employment has a negative impact on life expectancy at birth. This may be explained as such: a higher ratio may on the one hand result in higher employment of women but on the other hand it may also result in lower employment of men.

Lower male employment rate and thus a higher ratio can mean the deteriorating situation on the labour market and thereby lower the general economic situation and lower the standard of living of a country, as well as lower life expectancy at birth in this country.

Higher employment of women (and consequently, a higher ratio) can also be a sign of high female employment in manufacturing especially in the developing world, which is usually associated with a lower standard of living and, consequently, lower life expectancy at birth.

In contrast, the lower employment rate of women (and consequently, a lower ratio) in many places may be due to the higher standard that enables a woman in accordance with an agreement with her partner to remain at home and devote herself to caring for the family, which is typical for developed countries with higher life expectancy at birth. Due to this, it is recommended in the context of further research to separate the developed countries from the underdeveloped and separately examine the determinants of life expectancy at birth in the developed and in the underdeveloped world.

Our findings regarding positive impact of urban population; the negative impact of gender inequality and the negative impact of the number of births per 100 women aged 15–19 on life expectancy at birth mostly confirm and support previous research regarding life expectancy determinants.

In view of the findings of other researchers regarding determinants of life expectancy at birth, slightly stand out our findings about the importance of education and the educational level of each country. In this regard, our research builds on previous research by identifying the utmost importance that the education of the population has on the quality of their lives and, consequently on the length of their life expectancy.

Country should strive for a policy of promoting education for all ages. In addition to efforts to raise the level of education of young people which are outlined for Slovenia in the National Higher Education Programme 2011–2020 and in similar documents in other developed countries, it is necessary to continue the policy of developing the lifelong learning system. Lifelong learning system policies should provide the most efficient further education, restoration and acquisition of new skills and competencies also with an older population, which is becoming an increasingly important age group of the population in terms of education due to demographic changes related to the increase in life expectancy at birth.

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