10. LIFE EXPECTANCY FROM THE PERSPECTIVE OF GLOBAL AND INDIVIDUAL WEALTH AND EXPENDITURES: A GRANGER CAUSALITY STUDY OF SOME EU COUNTRIES

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Abstract

Increasing life expectancy will generate great benefits for a country, such as less expenditure for the public sector, a greater economic growth, and more active persons in the work field. In this respect, a country can improve its economic situation by identifying and controlling the factors that exert an influence on life expectancy. Previous studies in the field have intensively approached this topic, but the results obtained are still conflicting. The objective of our paper is to continue research and investigations in accordance with previous studies, by analyzing the influence of four explanatory indicators (GDP, health expenditures, individual income and household consumption) on life expectancy (as a dependent variable in the case of males and females) in the particular case of European Union, and seven countries in the EU (Romania, Czech Republic, Bulgaria, Hungary, Poland, Lithuania and Slovakia). In order to achieve our research objective, we used the Toda-Yamamoto approach of the Granger causality for the data collected for the period 1995-2017. Our study reveals the fact that only in the particular case of Bulgaria the GDP and final consumption do influence life expectancy for men. Wages were found to influence life expectancy only for females in Romania and for men in Poland, thus suggesting differences between genders. Some inverse causalities were also demonstrated. We believe that our research will have

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theoretical implications by deepening the knowledge in the field regarding life expectancy, and also practical implications allowing the identification of the factors that influence life expectancy (important for countries to take appropriate action). Our research brings value to the field, by analyzing in a unitary manner (same data source, same methodology, same geographical coordinates) the effect of four different explanatory variables, with economic substance, on life expectancy from 2 perspectives: male and female. Also, we analyze the particular case of seven countries in the EU, with similar economic backgrounds, to see if results can be extrapolated. Unfortunately, the results obtained are debatable and generally mixed. Further research is needed in order to identify the underlying causes of the results obtained.

Keyword: life expectancy, influence, economic, Granger causality, VAR, Toda-Yamamoto procedure.

JEL Classification: *I15*

1. Introduction

Increasing life expectancy is a major objective of each country around the globe. Healthy people are more active in the work field and contribute more to the economic growth of a country, for a long period of time. Moreover, if the population is healthy, the expenditure of the public sector reduces. Therefore, each country is interested to increase both men and women life expectancy. But what are the factors that influence life expectancy? If we can identify them, we can also find optimal solution to improve and control this economic indicator.

Previous researches in the field have extensively addressed this topic. We can find studies that analyze the connection between GDP or economic growth and life expectancy (Echevarría and Iza, 2006; Wang et al., 2015; Felice et al., 2016; Korkmaz and Kulunk, 2016; etc.). But the results reported are mixed. One explanation for the conflicting results can be the inversed "U" shape relationship between economic growth and life expectancy that some previous studies discuss (Hansen, 2012; etc.). Other studies bring in to discussion the connection between income and life expectancy (Laditka and Laditka, 2016; etc.), between health expenditures, GDP and life expectancy (Chaabouni and Saidi, 2017; Mladenović et al., 2016; Obrizan and Wehby, 2018; Jaba et al., 2014; Asiskovitch, 2010; Halicioglu, 2011), and also the household consumption and their influence (El Mekkaoui de Freitas and Martins, 2014; Kumara and Samaratunge, 2017; etc.). Regardless of the various studies carried out previously, no general or definite conclusion can be drawn in respect to above mentioned factors' influence, on both life expectancy and the directionality of the connection between variables.

In these conditions, the main question remains. What are the factors that influence life expectancy? And what is the directionality of the links between those factors and life expectancy?

In order to try and find some answers to these questions, our paper studies the Granger causality connection between four major variables (GDP, government expenditure on health, wages and salaries and final consumption household) and life expectancy at birth for the European Union and several countries in the European Union (Romania, Czech Republic, Bulgaria, Hungary, Poland, Lithuania and Slovakia). Our main objective is to see if the four previously mentioned variables do influence life expectancy of men and women and to see if this is a general valid hypothesis for EU and some of the EU countries with similar environment and conditions.

We consider that this analysis may be important for several reasons. First, as a research implication, it will add to previous studies by deepening the knowledge regarding the factors that have an influence on life expectancy by applying the Toda-Yamamoto approach of the Granger causality the in the particular case of EU and several EU countries. What is specific to our paper is the combined analysis of four different variables on life expectancy from two perspectives: male and female life expectancy. Secondly, we consider that our research will also have some practical implications. By identifying the factors that influence life expectancy and their impact, we can better support the understanding of the importance of economic and individual growth and of the investment in healthcare, and also the adoption of improvement measures at a national level for each country. We believe that our results will help public authorities from each country in comprehending the importance of healthcare system investment, the importance of increasing people's personal income, of decreasing income inequality, and also of maintaining a high level of GDP, all for the health of the citizen. In other words, if we can identify the factors that possess an influence on life expectancy, countries will be able to take appropriate action in order to improve the current situation.

We have chosen to analyze the EU particular case because of the influence that EU has as a whole on the global economy. Moreover, we considered that if our variables influence life expectancy at a global level, for the EU case, then they will also have an influence in the particular case of each country included in the EU. For particular country analyses, we used seven countries, namely Romania (the authors' country), Czech Republic, Bulgaria, Hungary, Poland, Lithuania and Slovakia. The reason behind our decision to analyze these specific countries was the fact that they present multiple similarities (similar economic environment, similar values, similar economic context, former communist economies etc.). By choosing similar countries, our analysis will become more robust and the results more relevant if the differences among the subjects analyzed are not significant.

We believe that these measures will help us to reach a higher relevance of the tests and support our research findings.

The research pursues the following objective: the assessment of the existence of Granger causality between some economic indicators (the authors chose the economic growth, represented by the GDP per capita, for better comparability, health expenditures, household consumption, wages and salaries), considered as independent variables, and the life expectancy at birth as dependent variable (distinct analyses are realized for males and females' life expectancies).

Four research hypotheses have been defined:

H1. Economic growth (GDP per capita) Granger causes the life expectancy at birth for both men and women;

H2. The expenses for health by the central governments cause, in Granger sense, the life expectancy at birth for both men and women;

H3. The final consumption of households Granger causes the life expectancy at birth for both males and females;

H4. Wages and salaries Granger cause the life expectancy at birth for both men and women.

The paper includes the following sections: literature review relevant for the research hypotheses pursued (second chapter), the results of the research (third chapter) and, finally, the conclusions, research limitations and future research directions.

2. Literature review

Life expectancy is an important topic in the international literature, which presents a multitude of factors that influence the population's health indicators. Our research is focused only on four factors that have an impact on life expectancy: GDP, health expenditures, wages and salaries, and household consumption. In the first part, we analyze the correlation between wealth and life expectancy, and in the second part of the literature review, we study the potential connection between expenditures and life expectancy.

2.1. Wealth and life expectancy

Why should we connect wealth to life expectancy? The answer is simple. We start with a basic assumption: that life expectancy is influenced by economic factors, among which poverty is included (see Xinming et al., 2010). So, if poverty influences the life span, so will wealth of a nation and of an individual. Therefore, the correlation between wealth and life expectancy is analyzed in this paper from two perspectives, a global and an individual one. From a global point of view, we study the link between GDP, as a global indicator, and life expectancy. From an individual point of view, we focus on the influence of wages and salaries, or personal income, which may impact the life expectancy of a person.

In accordance to our research hypothesis, we expect that an increase in the GDP (per capita), as an indicator of a country's wealth, and an increase in the personal salary or income of an individual, as an indicator of a person's wealth, to generate a positive impact on life expectancy. But is our hypothesis supported by previous studies?

Let's first take a look at the influence of the GDP on life expectancy. Can we have a connection? Poverty is influenced by GDP, because GDP is related with better living conditions and an increase in public healthcare investments (Wang et al., 2015). Thus, we may conclude that GDP can positively influence life expectancy, as suggested by the studies of Wang et al. (2015). Korkmaz's and Kulunk (2016) apply Granger causality test for 10 OECD countries also shows a unidirectional causality effect from economic growth to life expectancy at birth.

So, there is a base for our theory that GDP has a positive influence on life expectancy. But what about the other way? There are studies that also present the impact of life expectancy on economic growth. Gallardo-Albarrán D. (2018), finds a positive connection between health (that influences income variation) and economic development. Using the Granger causality, Neofytidou and Fountas (2020) also report that income (per capita and per total) is influenced by life expectancy (overall, but also for males and females). Cervellati and Sunde (2011) consider that life expectancy has a positive effect on growth for post-transitional countries and a negative effect for pre-transitional countries. Desbordes (2011) also argues for a non-linear effect of life expectancy on income per capita which is influenced by the initial life expectancy level of each country. Thus, for the countries where life expectancy was initially below 43 years, high life expectancy has an initial negative impact on income per capita. A positive impact may be found for countries where the initial life expectancy was over 53 years. Kunze's (2014) findings support previous studies, by presenting a non-linear connection between life expectancy and economic growth that depends on the transfers of bequests between generations.

There are also studies that report a bidirectional relationship between GDP and life expectancy. Felice et al. (2016) apply the Granger test to study the causality correlation between life expectancy and GDP in two countries: Italy and Spain. By splitting the time series in two sub-periods, the authors find that life expectancy determines a GDP growth and that the economic growth positively influences life expectancy (with some exceptions for the periods and the countries that are being analyzed). Korkmaz and Kulunk (2016) also mention that previous studies consider economic growth to positively influence life expectancy and that life expectancy has a positive influence on economic growth.

So, although there are numerous studies that approach the connection between life expectancy and GDP, the results regarding the intensity and the direction of the connection are mixed (see Echevarría and Iza, 2006). Hansen (2012) states that the relationship between GDP per capita and life expectancy at birth has a "U" shaped evolution, the effect of health on wealth being hard to determine. In this "U" shape relationship, the turnaround value for life expectancy appears to be at around 45 years. Echevarría and Iza (2006) consider that if life expectancy increases, the growth in GDP per capita will decrease, considering social security, due to a decline in the active population.

In the light of these findings, our research question still remains. Does GDP influence life expectancy or not? Is it that the connection has a reversed sense?

In regard to our second wealth indicator, the income can also be considered a factor that influences life expectancy. Laditka and Laditka (2016) demonstrate that unemployment can be correlated with a short life expectancy. Moagar-Poladian et.al. (2017) discuss on the role of research and innovation and creation of knowledge, factors interconnected with education, in the development of a durable competitive economy, which creates the premises to reward all actors, including the employees, with higher incomes, and also the proper environment to create jobs – lower unemployment.

The income is not the only factor that can influence life expectation. When we talk about income, we should also take in to account income inequality. Income inequality is correlated with a decrease of the health of the population (Detollenaere et al., 2018). Babones (2008) also considers that inequality in national income is correlated with life expectancy. This aspect makes our analysis regarding the influence of wages and salaries on gender more relevant. Is there an income inequality between men and women? Is this inequality reflected on life expectancy?

2.2. Expenditures and life expectancy

The correlation between expenditures and life expectancy is also analyzed from a global and individual perspective. From a global point of view, we study the link between public healthcare expenditures and life expectancy. From an individual point of view, we focus on the influence of household consumption or household expenditure on the life expectancy of a person. In accordance to our research hypothesis, we expect that an increase in governmental expenditures in the health care sector, as an indicator of a country's expenditures, and an increase in household consumption, as an indicator of a person's expenditure, to generate a positive impact on life expectancy. This dimension is also characterized by the phenomenon of international migration of doctors from the public health system, outlined by Păunică et al. (2017), we consider that this factor can affect the quality of the medical system, despite the impact investments (mainly by public authorities).

Previous studies confirm that an increase of the health expenditures can generate an increase in life expectancy (see Obrizan and Wehby, 2018; Jaba et al., 2014), thus identifying health expenditure as an influence factor of life expectancy in the developing countries (Asiskovitch, 2010). Halicioglu (2011) also finds, in his analysis on Turkey, that food availability or nutrition, and health expenditures influence life expectancy. Although health expenditure can be public or private, previous research concluded that public investment generates a greater increase in life expectancy (Asiskovitch, 2010; Linden and Ray, 2017).

The literature also associates expenditures with life expectancy indirectly, thorough the GDP. For example, Chaabouni and Saidi (2017) test the causal relation among carbon dioxide emissions, health expenditures and the growth of GDP in 51 countries and find evidence of a bidirectional causal relation between health expenditures and economic growth. Mladenović et al. (2016) use the Granger causality to analyze the connection between health care expenditures and GDP growth rate, in order to improve GDP forecasting. Their findings support the fact that health care expenditures influence the most the growth of the GDP rate forecasting. From these studies we can conclude that health expenditures have a positive impact on GDP. And if the GDP is a factor that influences life expectancy, we can state that health expenditures are a determinant of life expectancy.

The primary care system also has a mitigating effect in the negative relation between income inequality and population's health (Detollenaere *et al*., 2018). But other studies stress the importance of other governmental expenditures, other than health care expenditures. van den Heuvel and Olaroiu (2017) consider that, in fact, social protection expenditures are the main element that influences life expectancy. Social spending on education and incapacity programs may also increase life expectancy (Reynolds and Avendano, 2018).

In terms of household expenditures, a surplus will generate a decrease in household savings, while and a deficit will increase them (El Mekkaoui de Freitas and Martins, 2014). Diseases and hospitalization determine financial constraints that can generate a reduction in food consumption for households (Kumara and Samaratunge, 2017).

3. Methodology and data

The analysis of Granger causality, in this paper, is based on the Toda-Yamamoto procedure, and follows the guidelines described by Giles (2011), adapted to the properties of the variables included in the dataset and to the software application used (EViews®). Toda-Yamamoto method is suited to the characteristics of the variables – not stationary. Instead of working with differences, susceptible to be affected by distorted information, the authors chose to keep the levels of the variables, as the method affords the analysis of variables with various orders of integration (see Tachiwou Aboudou, 2009, Chirila and Chirila, 2017).

The methodology is based on the following steps:

a. assessment of the maximum degree of integration (*dmax*) between the variables paired by each research hypothesis. By applying the Augmented Dickey-Fuller unit roots test, the individual order of integration can be measured. The configuration of the ADF test included a maximum of four lags, default criterion for lag selection – SIC and the option trend and intercept.

b. setup of an unrestricted VAR for the two variables corresponding to each research hypothesis. The (initial) VAR model was configured with 2 lags (software default) and then adjusted by interpretating the information criteria, from a maximum of four lags. First, the value provided by at least three (out of five) criteria is considered, if available. If no majority is reached, then the Schwarz Info Criterion is preferred.

c. all models are tested for proper specification (the quotations describe EViews® labels): AR Roots stability test; Autocorrelation (LM test) – for the maximum number of lags suggested by the software: for all tests, the optimum number of lags plus one extra lag; Normality ("Cholesky of covariance – Lutkepohl orthogonalization method");

Heteroskedasticity: “White test, no cross terms”. In the cases where stability or autocorrelation tests failed, the lag length of the model was increased, unit by unit, until the tests were passed (Giles, 2011). In case of non-compliance with either normality of heteroskedasticity tests, that model is marked as unsuitable for further analysis (Hatemi-J, 2004).

d. The well-specified VAR models are modified, by including the additional lags specified by the maximum order of integration, as exogenous variables (see Giles, 2011), and the updated models were tested for Granger causality, by applying the “VAR Granger Causality/Block Exogeneity Wald Tests” (EViews® label).

e. Interpretation of the results. For all statistical tests applied during the data analysis process, the significance level was set to 0.05.

All data were extracted from the Eurostat database. The datasets cover the interval 1995-2017 (annual frequency).

- The data about life expectancy is combined from two data sources: for the interval 1995-2003, the source dataset is named *Healthy life years (1995 - 2003)*, code [*hlth_hlye_h*], data updated on 13.05.2019, and for 2004-2017, data were extracted from the dataset with the name *Healthy life years (from 2004 onwards)*, code [*hlth_hlye*], last updated on 02.07.2019.

For the European Union, the second dataset includes a break, as from 2004 to 2010 are included data for *European Union - 27 countries (2007-2013)*, and from 2010 onwards data for *European Union - 28 countries*. The authors decided to merge the two subsets, and for the common year, 2010, to choose the value for the member that has allocated values in the subsequent years (that is, *European Union - 28 countries*).

This solution is supported by the fact that the three subsets describe the evolution of the structure of the European Union (expansion of 2004 and then the admission of the 28th member). Since the dataset is based on a geographical dimension that respects the historical evolution of the EU, and the data do not reflect a summarized value, to be influenced by the correlation more states – more people (population) – higher values of the actual data, the authors appreciate this solution to be appropriate to the scope of this study.

- The source for *GDP per capita* is the dataset named *Main GDP aggregates per capita*, code *[nama_10_pc]*, from which the values indicators for all countries, except Romania, were extracted. Data were last updated on 07.01.2020. For Romania, the values for the interval 1995-2002 are marked as confidential. The chosen solution was to calculate these values on the basis of the dataset “*Percentage of EU28 total per capita (based on million euro), current prices”*, which is available as a subset of the “*Main GDP aggregates per capita [nama_10_pc]*)”. From 2003 onwards, the values in the original Eurostat data were kept. This solution is substantiated by the fact that all data are provided by Eurostat, thus allowing the application of the methodology on data extracted from the same data source.
- The indicators *Final consumption of the households* and *Wages and salaries* are drawn from the dataset with the name *GDP and main components (output, expenditure and income)*, code *[nama_10_gdp]*, last updated on 07.01.2020. Data are measured in *current prices, million euro*.
- All values for *Total general government expenditure on health* are taken from the dataset *General government expenditure by function (COFOG)*, code *[gov_10a_exp]*, updated on 09.12.19. For the interval 1995-2000, the values for the member *European Union*

- *15 countries (1995-2004)* are considered, and for 2001-2017, the values for *European Union - 28 countries* are included in the analysis.

The variables were given the following codes:

- *M_****: Life expectancy in absolute value at birth – males;
- *F_****: Life expectancy in absolute value at birth – females;
- *GC_****: Gross domestic product at market prices, current prices;
- *HF_****: Total general government expenditure on health, general government sector, as per COFOG99;

*WS_****: Wages and salaries;

*FC_****: Final consumption of the households;

*** *Country codes*, allocated as follows- EU: European Union, RO: Romania, BG: Bulgaria, HU: Hungary, LT: Lithuania, SK: Slovakia, CZ: Czech Republic, PL: Poland.

4. Results and discussions

4.1. Test of research hypothesis H1

The characteristics of the models used and the results of the Wald tests are described in table 1. Only the models for Bulgaria, Czech Republic, and Romania (males), and respectively Bulgaria, Czech Republic, European Union, Romania, and Poland (for women) are robust enough to be used in the final steps, and were re-configured to comply with the Toda-Yamamoto procedure.

Table 1

Wald test results, research hypothesis *H1*

Dependent variable	Lag length after tests	*dmax*	*Chi-sq*	*Prob.*
M_BG	4	1	12.595	0.013
M_CZ	1	1	0.008	0.926
M_RO	4	2	5.700	0.222
F_BG	4	1	5.524	0.237
F_CZ	1	1	0.023	0.878
F_EU	4	1	4.123	0.389
F_PL	1	1	8.62E-05	0.992
F_RO	2	2	1.693	0.428

Source: Authors' own representation, based on respective test results.

The first research hypothesis is validated only in the case of Bulgaria, the GDP per capita Granger causes the life expectancy at birth for men. However, in the case of Romania, the reverse causality is observed, that is *M_RO* Granger causes the Gross Domestic Product per capita for Romania (*Chi-sq* = 11.84139, and *p-value* = 0.0186). The other models could not be set to be compliant with the specification tests, so the authors were unable to estimate the existence of Granger Causality.

Also, in the cases of Bulgaria and the European Union, the life expectancy at birth for females is proven to Granger cause the GDP per capita (the results are in line with those obtained by Neofytidou and Fountas, 2020, and Gallardo-Albarrán, 2018), while the reverse causality is not validated. No other Granger causality is found. Moreover, the results do not crosscheck with the ones obtained for the life expectancy – males (therefore, an aspect which suggest some differences, worthy to be subsequently pursued).

The results obtained from the tests corresponding to the *H1* research hypothesis support only in part the economic theory according to which economic growth of any country, and by extension, of any geographical area formally delimited, is influenced by the life expectancy and vice versa. The only Granger causality that was proven converges with the findings of Korkmaz and Kulunk (2016), who validate the unidirectional causality GDP towards life expectancy (this implies that no reverse causality was found in their study), and the contribution of Felice et al. (2016), who emphasize the Granger causality posed by the GDP on life expectancy in most of their cases. The limited similarity of the results with the achievements of other authors is an incentive to pursue other methods that are able to measure the correlation and/or causality between economic growth and life expectancy, or to analyze the first differences or elasticities of the tested variables. However, it can be appreciated that the results are generally aligned with the general trend in the literature – in other works, the results are not convergent and do not apply to all countries.

4.2. Test H2 research hypothesis

The authors have synthesized, in Table 2, the characteristics of the six models that passed the specification criteria and were tested for Granger causality: the final maximum lag, the maximum order of integration, and the values of the Wald test results. No other model could be configured to pass all four specification tests. No model allows for the validation of the hypothesis.

Table 2

Wald test results, *H2* research hypothesis

Dependent variable	Lag length after tests	*dmax*	*Chi-sq*	*P-level*
M_HU	1	1	0.022	0.881
M_LT	1	1	2.861	0.090
M_RO	1	2	0.992	0.319
F_BG	3	1	0.501	0.918
F_HU	4	1	0.893	0.925
F_RO	2	2	0.924	0.630

Source: Authors' own representation, based on respective test results.

In the case of Hungary, the life expectancy is found to Granger cause the health expenditure variable, and this is the only causality found in the case of the two variables studied under the second research hypothesis, even it does not help to validate *H2*. The results are not in line with the theoretical foundation – increased expenses on healthcare by the government should lead to better health status of the population and a higher life expectancy, regardless its form (at birth or correlated with various grouping of the population, by age interval). The fact that no causality exists with the life expectancy as dependent variable is contradicting the results of Obrizan and Wehby (2018), Jaba et al. (2014), Halicioglu (2011) etc. This could mean that the government investments in health area influence other indicators – encouraging the authors of this paper to seek other possible causalities (preserving the same causal variable).

4.3. Test of H3 research hypothesis

Similar with the observations encountered in the previous sections, not all models have passed the specification test stage. For the VARs that permitted the application of the Wald test, the relevant parameters are represented in table 3.

Table 3

Wald test results: *H3* research hypothesis

Dependent variable	Lag length after tests	*dmax*	*Chi-sq*	*P-level*
M_BG	3	2	24.826	0.000
M_CZ	1	1	0.052	0.818
M_HU	1	1	0.001	0.967
M_LT	2	1	2.989	0.224
M_PL	1	1	0.000	0.983
M_RO	1	2	3.815	0.431
F_HU	1	1	0.039	0.842
F_LT	3	1	6.414	0.093
F_PL	1	1	0.016	0.897
F_RO	2	2	2.398	0.301

Source: Authors' own representation, based on respective test results.

The parameters in table 3 outline the fact that the final consumption of households causes, in Granger sense, the life expectancy at birth for males only for Bulgaria. In Lithuania, the reverse causal relationship is validated in both cases. All other models are characterized by Chi-sq values that contradict the hypothesis according to which the final consumption Granger causes the life expectancy. The limited ability of the datasets to help validate this hypothesis fall in line with the conclusion drawn from the studies such as El Mekkaoui de Freitas and Martins (2014) and Kumara and Samaratunge (2017): results that cannot be generalized.

4.4. Test of H4 research hypothesis

The models that allowed the application of Wald test for Granger causality are described in table no. 4.

Table 4

Wald test results: *H4* research hypothesis

Dependent variable	Lag length after tests	*dmax*	*Chi-sq*	*P-level*
M_CZ	1	1	0.062	0.803
M_HU	1	2	0.080	0.776
M_PL	3	1	9.902	0.019
M_RO	4	1	6.918	0.140
F_CZ	2	1	1.153	0.561
F_EU	4	1	2.160	0.706
F_HU	1	2	0.332	0.564
F_PL	1	1	0.000	0.987
F_RO	4	1	10.226	0.036

Source: Authors' own representation, based on Wald test results.

The only countries for which the Granger causality is outlined are Poland and Romania: wages and salaries Granger cause the life expectancy for men (in Poland) and for women (in Romania), supporting the idea that measures aimed at increasing the salaries might contribute to a better quality of life, including life expectancy – the population would become more interested in allotting personal funds for preventive and corrective health-related actions (sport, housing in "greener" areas, better, and more expensive, medical care and treatment, without omitting health monitoring devices). In the actual context of the COVID – 19 pandemics, the risk associated with some diseases is a serious factor to be considered in the decisions aimed towards providing higher wages and salaries, and, in the authors' opinion, this applies in any domain involving management of human resources. To be noted, in the case of the European Union model, the Wald test outlines the fact that life expectancy for women Granger causes the wages and salaries. The paper of Laditka and Laditka (2016) emphasizes the opposite expression of our research hypothesis: the correlation between unemployment and (considering the results of Xinming et al., 2010) poverty (the inverse of higher wages and salaries) and shorter life expectancy.

5. Conclusions

Due to its importance, life expectancy is a much-debated topic in the economic literature. By increasing the life expectancy of the population, a country will have great benefits. First, the retirement age can increase, the population being active on the work field for a longer period of time. Second, the volume of expenses incurred by state can decrease if the health of the population is improved. All these factors can generate an increase of the economic development of a country, which is a major objective for every economy around the globe. In this context, it's extremely important to identify the variables that will have an influence on life expectancy. Once we identify the elements that influence life expectancy, we can use them in order to take appropriate measures to increase the population lifespan.

Although previous studies in the field have debated this topic, by analyzing the influence of different variables on life expectancy, variables such as GDP or economic growth (Echevarría and Iza, 2006; Wang et al., 2015; Felice et al., 2016; Korkmaz and Kulunk, 2016; etc.), income (Laditka and Laditka, 2016; etc.), health expenditures and GDP (Chaabouni and Saidi, 2017; Mladenović et al., 2016; Obrizan and Wehby, 2018; Jaba et al., 2014; Asiskovitch, 2010; Halicioglu, 2011), and also the household consumption (El Mekkaoui de Freitas and Martins, 2014; Kumara and Samaratunge, 2017; etc.), the results generated are not consistent, and cannot be considered to be applicable for all countries.

These mixed results found in previous studies, relevant on our research topic, were the main motivation for this paper. Our objective was to test the influence of four explanatory variables, namely GDP, health expenditures, individual income (wages and salaries) and household consumption, on life expectancy, which we considered to be the dependent variable. We intended to test the influence of the four elements on life expectancy both in the particular case of males and females, to see if there is a difference by gender. We chose to study the case of European Union, and the particular case of seven countries, members of UE (Romania, Czech Republic, Bulgaria, Hungary, Poland, Lithuania and Slovakia) for the time frame 1995-2017. We decided to analyze the case of EU because of its importance on the global economy and the seven countries of EU were chosen due to the fact that they present many similarities, especially with Romania, mainly in regard to the economic environment, so we can be able to draw comparable conclusions. Romania is a member of the European Union, and the inclusion of the EU in the study is also supported by this fact.

The mentioned time frame was determined by the availability of data. In order to achieve our research objective, we used the Toda-Yamamoto approach of the Granger causality test, because most of the variables are non-stationary in their levels, and we wanted to work with the levels, at least for the time being.

Our paper brings value to the field by including in the analysis four different variables, all of them carrying economic substance that can influence life expectancy, for both genders, taken as separate applications of the research methodology. In accordance with the findings of the literature review, the application of the Granger causality test for the eight selected cases has produced mixed results. Some of the models, which are required by the specific methodology to be processed, presented various issues and could not be properly configured to comply with all tests (from the viewpoint of this methodological issue, indicated in Hatemi-J, 2004, who outlines the possibility of achieving debatable Wald test coefficients in the case of models with issues of normality and/or heteroskedasticity, applied in this paper, restrict the possibilities to check for Granger causality). Other models, well specified, have not proven the existence of causality in Granger sense. Very few of the tested VARs outline the fact that life expectancy at birth is Granger caused by the other variable included in the model.

The first and third research hypotheses are validated only for Bulgarian men, where the GDP per capita and final consumption of households cause, in Granger sense, the life expectancy at birth for men (for females, only the reverse causality is demonstrated in *H1*). These results are correlated with the study of Korkmaz and Kulunk (2016). The second research hypothesis could not be validated.

Also, we can see that for Romania, life expectancy for females can be improved through wages and salary, the same statement applies for Poland in the case of men (research hypothesis *H4)*, results that are confirming, in our opinion, the fact stated by Laditka and Laditka (2016): correlation between unemployment and shorter life expectancy.

Some inverse causalities (where life expectancy Granger causes the independent variable described in the research hypothesis) are found, and the authors intend to use these aspects in future researches.

Although the testing of the hypotheses did not lead to statistically significant results, we were still able to draw some interesting findings. We can see that for Bulgaria, life expectancy can be increased (for men), and the policy makers can act on improving the GDP of the country and on the final consumption of the households (even if no such causality is found for women, appropriate measures cannot be reasonably expected to lead to negative consequences).

Despite the fact that the results were not general true for the other countries, and the fact that government expenditure on health appears to not influence life expectancy, we still took a step forward by improving the knowledge in the field, by identifying the elements that do not have a causality-like impact on life span and by demonstrating that the particular case of a country do influence the results. For example, what is true for Bulgaria may not be for other countries. It is true, also, that results confirming causalities that can be capitalized in order to increase the quality of life, and a good example in this respect is the pursue of an increased life expectancy at birth, can be considered in evaluating, even by using qualitative analysis, the effects of the measures taken by the governments of the countries where such causalities are demonstrated. These measures that can be qualified as “good practices” in this respect can be implemented by other governments, with (at least expected) favorable effects on their own population.

Knowing this, we can further develop our research and understanding of the subject by trying to see and understand why this is the case. In this context, we believe that our study may have practical and theoretical implication, setting the stage for future studies in the field.

As the literature review section emphasizes the contributions of, for example, Obrizan and Wehby (2018); Jaba et al. (2014), Asiskovitch (2010), Halicioglu (2011), these researches constitute an incentive for the authors of this paper to further pursue the research on this topic. There are many other factors that influence life expectancy at birth, and the other indicators measuring the health status for the population of a country or region. Our future research direction will include a more detailed analysis of life expectancy, by including other factors that may exert an influence and by trying to find an explanation for the result obtained. Why for some countries the hypothesis are validates and not for others? In our future research we will also like to take in to account the limitation that we encountered during this study.

One of the major limitations of the study was posed by the availability of data, which leads to the future research aim of the authors, to extend the study to include all the member countries of the European Union, and to test the causality posed by other influence factors, attested as such by the relevant scientific literature in the field. This aim is supported by the results obtained by Felice et al. (2016), the link between GDP and life expectancy for Italy and Spain. Another limitation that should be noted, as an aspect correlated with the source data used is the limited number of observations, in each dataset, which posed restrictions on the acceptable maximum of the lag length. Subsequently, the application of additional methods, or the analysis of elasticities or first differences (acceleration) of the variables is one of the targets assumed by the authors in the future.

We consider that pursuing the study in these directions might provide results that are more significant in describing the economic factors that influence life expectancy at birth.

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