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Master Thesis:

THE IMPACT OF HEALTH ON ECONOMIC GROWTH: A PANEL DATA INVESTIGATION.

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Contents

Abstract

In this study, using an unbalanced panel of 21 economies and a very large time period ranging from 1821 to 2008, we investigate the relationship between health and economic growth. We follow modern econometric techniques that include panel cointegrating analysis and panel Granger causality in order to examine the link both in the short-run and in the long-run. We, also, employ fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) methods to estimate the cointegrating equations. Moreover, we distinct the impact of health standard of the two genders on total and per capita GDP. We find that total life expectancy, male life expectancy, and female life expectancy have all a positive and statistically significant effect on both total and per capita income in the short-run and the long-run, too. As a consequence, we suggest that health should be considered as an important ingredient of the economic performance of an economy.

1. Introduction

One of the most significant matters in social sciences is to comprehend why some economies are so affluent while others are not (Acemoglu, 2009). The importance of this issue lies in the fact that income differences affect welfare to a great extent. Additionally, the operation of each economy can be disclosed by studying income differences among them. As a consequence, an important question for economic theory and specifically of growth/development theory is to find out the determinants of growth, which account for income differences. One of the most important contributors to subsequent growth is the human capital, which entered the growth models some decades ago. New endogenous growth theories, specifically, emphasize productivity maximization through technology improvement and the increase of human capital based on education solely. However, education is not the only fundamental aspect of human capital. Health constitutes an important form of human capital too and therefore should not be neglected. Some researchers even support that the health is a better predictor of economic growth than education (Barro, 2013; Knowles and Owen, 1995).

Growth theory first appeared in bibliography in the 1980s starting with the work of Romer (1986). In the 1960s the models included in growth theory were basically neoclassical ones. Moreover, they were based on the works of Ramsey (1928), Solow (1956), Swan (1956), Cass (1965),and Koopmans (1965). Some researchers believe that higher income implies better levels of health. A great deal of the literature has proved that the higher the income is, the easier the approach is on goods and services that produce health and longer and better life, such as nutritious diet, safe water, better sanitation, and better-quality medical care and public health infrastructure. Nevertheless, many studies in recent years examine the issue of reverse correlation; i.e. the health status of an economy may affect its growth. As a result, the questions that we want to answer in this study are the following: "Does the health status of a country have an impact on its economic performance?", or "Is there any possibility that the improvement in health influences not only social life but also economic life?". And if the answer to both questions is yes, then we also need to answer: "In which direction?".

Health improvements can variably enhance economic growth. There are indeed many ways in which health improvement can influence and more specifically increase growth (Bloom & Canning, 2008). A direct way is through productivity.

Healthier employees are generally more energetic and physically/mentally robust. They, as a consequence, produce more and get higher wages. Furthermore, it is expected that they take less leaves of absence from work due to health reasons of their own or of a member of their family.

However, productivity can be affected by health in an indirect way, too, through education, savings and labor market participation. Changes in health standards can increase education in different ways. Healthier children can accomplish more and they are less likely to be absent from school. Additionally, it is less likely that students will leave school in order to take care of a member of their family. Most importantly, the decrease of mortality and morbidity increases the motivation to invest on education, and as a result human capital investments rise and lead to higher productivity. As for the savings, when someone expects a longer lifespan, they have a higher incentive to save for retirement. Moreover, illness leads to great out-of-pocket medical expenditures, thus reducing current and accumulated savings. As a result, health implies an increase in business investments, leading to higher wealth. Finally, the impacts of health on labor supply are not that clear. The motivation of healthy employees to work harder increases due to the longer life expectancy and the greater wages they earn. In addition, they consider that finding work is not something difficult and they also spend less time to sickness. As a consequence of these two effects, labor supply rises. On the other hand, higher wages and lower medical costs of healthy people might decrease the incentive to work. Other ways in which productivity can be indirectly influenced are fertility, and population age structure.

There are different ways that one can use in order to examine the relationship between health and economic growth. First of all, the link between health and growth can be conducted on an either individual level or on regional level within an economy. Some researches use microeconomic evidence and tools and other macroeconomic evidence and tools. By using microeconomic studies a researcher can calibrate their results and find the magnitude of the impact of health at an aggregate level. However, by using macroeconomic data they can estimate the aggregate relationship directly. Furthermore, different proxies of health are also considered in bibliography. Macroeconomic approaches consider life expectancy, health expenditure, adult survival rate (ASR) and others. As for microeconomic ones, the indicators of health level considered are malnutrition, anemia, exposure to disease in utero and during childhood, and others. Additionally, one can differentiate studies

based on the kind of countries they examine in their study, whether for example they are developed, developing or in fewer cases underdeveloped. Finally, another differentiation among studies is the methodology they use. In the next section we present some of these studies.

The main scope of this work is to investigate if there is a relationship between health and economic growth in both the short-run and the long-run and in which direction. We use life expectancy at birth as a proxy of health and total GDP and per capita GDP as indicators of growth. An innovation and advantage of our study is that we provide two sections (sections 5.4 and 5.5) where we distinct life expectancy of males from that of females and present their impacts on total and per capita GDP separately. We follow the macroeconomic approach of estimation. Specifically, we employ a cointegrating analysis and present both equilibrium relationships and error correction models (ECMs). The advantage of the macroeconomic approach over the microeconomic one is that the latter ignores the individual impacts of health capital on society, as it measures the effect of individual's health status based on only their own income. As a result, it doesn't take into account the so-called externalities. However, macroeconomic regressions capture the externalities, but they still suffer from omitted variables bias. Nevertheless, we do not face such a problem as an equilibrium relation does not depend on the extension of the information set. In other words, if there exists a cointegrated relation, then it is invariant of the absence of some variables (Swift, 2011).

The contributions of our study are the following. First, we use a very long time period ranging from 1821 to 2008, which includes not only the medical improvements that started in the 1940s and mentioned in Acemoglu and Johnson (2007) study, but also the earlier ones (second half of 19^{th} century) for some of the economies considered in our study (as our panel is unbalanced). Second, we use panel data methods in order to estimate the desired links. The advantage of the specific data dimension is that it is more appropriate for analyzing growth dynamics (Durlauf and Quah 1998). Moreover, it increases the number of observations, which in our case is too large (2233). Third, we follow modern econometric techniques such as panel cointegrating analysis and panel Granger causality. Finally, we distinct, as referred before, between life expectancy of males from that of females and investigate their impact on growth separately.

Our main result is that health standards have a strong positive and statistically significant effect on the economic performance of a country both in the short-run and in the long-run. An 1% rise in life expectancy at birth implies an about 3.6% and 5% rise of per capita and total GDP in the long run, respectively. Moreover, 1.1%-1.6% (depending on the model considered) of the previous year's discrepancy between life expectancy and total GDP will be eliminated this year. On the other hand, 1.4%-2% of the increase of per capita GDP in the long-run that was resulted due to the increase of life expectancy will be realized every year. As we can see, based on the cointegrating coefficient and the adjustment error, the impact of health on total GDP is greater than the impact of health on per capita GDP in the long-run. A reason can be the fact that the increase of life expectancy leads to the increase of the population, too. Additionally, if the growth rate of life expectancy increases by 1%, the growth rate of total GDP will rise by around 0.16%-0.19% (depending on the model considered). Also, a 1% increase of the growth rate of life expectancy will lead to again 0.16%-0.19% (depending on the model selected) increase of the growth rate of per capita GDP. As a result, health improvements have the same effect on total and per capita GDP in the short-run. The positive relation running from the growth rate of life expectancy to both total and per capita GDP is, also, consistent with the results of the panel Granger causality test.

Also, the impact of gender health level on total and per capita GDP is statistically significant and of similar size, which implies that both male and female health status affects economic growth of a country to the same extent. Furthermore, the results of the impact of both male and female life expectancy on total and per capita GDP are very similar with the results of the impact of the aggregate population health standard on, again, total and per capita GDP. Finally, we show that there is a two way causality between the growth rate of male life expectancy and both the growth rate of total and per capita income. In the case of female life expectancy, however, there is two way causality, but it is weaker from life expectancy to both total and per capita GDP. Health brings benefits not only to the social life of the man, but also to the economic standard of the economy. As a consequence, policy makers should not neglect the impacts of health on economic performance. On the contrary, they should utilize it as a tool to accelerate economic growth. Even the poorest countries can invest in health interventions that are low-cost and at the same time have large-scale effects on people's health, leading to a rise in productivity.

2. Literature Review

2.1. Studies based on panel dataset

2.1.1. Using life expectancy as a health indicator

In order to investigate the determinants of economic growth and using a panel of around 100 countries from 1960 to 1990, Barro (1996, 2013) concluded that the growth rate is positively influenced by higher initial schooling and life expectancy, lower fertility and government consumption, better maintenance of the rule of law, lower inflation, and finally improvements in the terms of trade (for a given initial level of real per capita GDP). Moreover, for given values of these parameters, the starting value of real per capita GDP is negatively related to the growth rate. The theoretical model that Barro uses is the neoclassical one, where the growth rate depends negatively to the initial current level of per capita output and positively to the long run or steady state per capita output. He employed the method of three-stage least squares (3SLS) adding, also, a set of instruments. Including the log of life expectancy at birth to the set of the independent variables, as indicator of health status, yielded that there is a significantly positive relation between life expectancy and growth rate. Specifically, the coefficient on the logarithm of life expectancy is 0.042. Moreover, some researchers suggest allowing a fixed effect for each country in order to avoid the problem of underestimation of convergence due to the imperfect measures made to keep the long run per capita output fixed. This can be employed, according to some researchers, by taking first differences of the determinants of the long run or steady state GDP per capita. However, Barro supports that this method has an important disadvantage- it does not take into account the cross-sectional information, which is the main strength of the data. So, that is the explanation of the reverse sign that appears for the coefficient of life expectancy, -0.082, which yields after employing this method. Additionally, he employed ordinary least squares (OLS) taking the means of the variables, and so making the data cross-sectional. As a result, he found that the coefficient in question is 0.0172. Finally, running a seemingly-unrelated (SUR) method yielded that this coefficient is 0.038. In either case, we observe a positive link between health indicator and the growth rate.

Barro (2003) , also, uses 71 countries for the time period 1965-75, 86 countries for 1975-85 and 83 countries for 1985-95 in a panel set up. His estimation is based on 3SLS. The dependent variable is growth rate of real per-capita GDP. Moreover, the instruments are the logarithm values of per capita GDP, life

expectancy, and fertility rate in 1960, 1970, and 1980. The system he uses consists of dummies for different time periods. He chose life expectancy at age one as the indicator of health level, as it turned out to have the most explanatory variable comparing to the other two variables, life expectancy at birth and life expectancy at age five. The estimation results show that better health leads to higher economic growth. Then estimating the equation by alternative measures of health (infant mortality rate, life expectancy at birth, life expectancy at age five, and malaria), yields that all variables are statistically significant except for malaria. As a result, according to Barro, for a fixed per capita GDP, high initial human capital enhances growth.

Barro and Lee (1994a) examining the sources of economic growth use 85 economies for the time period 1965-75 and 95 economies for 1975-1985. In order to allow for the correlation of country random effects, they estimate their model by SUR method. Life expectancy at birth, which is used as an indicator of health status, is positive and highly significant in growth regressions (growth rate of real per-capita GDP is the dependent variable of the equations). Additionally, separating the countries that are below the median ($1350 in1980) from the ones that are above the median, they find that life expectancy has larger effect on growth in the case of the poorer countries.

Bloom et al. (2001, and 2004) investigate the contribution of human capital in terms of schooling and health to economic growth. They demonstrate an aggregate production function based on which a country's output is a function of both its inputs and the efficiency with which they are used. The inputs considered are physical capital, labor and human capital, which has three dimensions the ones of education, experience, and health. Moreover, the efficiency is considered as the total factor productivity (TFP). They estimate a panel of 104 countries for the time period 1960-1990 (every 10 years) with nonlinear two stage least squares. The authors conclude that health has a positive and statistically significant effect on economic growth. Specifically, one year improvement in a nation's life expectancy increases its output by 4%.

Ecevit (2013) investigates the relationship between health and economic growth. The indicators that he chose for health and economic growth are life expectancy at birth and real per capita domestic product, respectively. He uses a panel of 21 organization for economic co-operation and development (OECD) countries from 1970 to 2010, where the data is annual. He employs panel cointegration and

causality tests. Finally, he finds that the effect of life expectancy at birth on real per capita GDP is positive and statistically significant and that life expectancy Granger causes real GDP per capita.

Additionally, Peykarjou et al. (2011) examine the relationship between economic growth and health in Organization Islamic Conference (OIC) member states. They use panel fixed effects method for the period 2001-2009. They conclude that the increase of life expectancy enhances economic growth in the specific countries. However, there is a negative relation between fertility rate and economic growth.

According to all the above studies, there is a positive impact of health standard on economic growth. Nevertheless, there are some researchers, who support the opposite. Acemoglu and Johnson (2007) use a panel dataset consisting of 75 countries from western Europe, Oceania, the Americas, and Asia for the time periods 1940-1980 and 1940-2000. They use two stage least squares (2SLS) estimation considering mortality from tuberculosis, pneumonia, malaria and other 12 infectious diseases as an instrument of life expectancy. They conclude that there is a small positive impact of life expectancy on total GDP over the first 40 years, and a little bit greater one over the next 20 years. However, it is not enough to compensate for the increase in population. As a result, GDP per capita decreases due to the increase in life expectancy. The same result, also, yields for the GDP per worker.

Caselli et al. (1996) use a panel of 97 countries including 5-year periods from 1960 to 1985. Running a regression based on Barro and Lee (1994b) with both a 3SLS and pooled OLS yields a positive statistically significant impact of health on economic growth. However, estimating the regression by generalized method of moments (GMM), in order to eliminate the problems of correlated individual effects and endogenous explanatory variables, they find a negative but statistically insignificant effect of life expectancy on growth real per capita GDP.

2.1.2. Other health indicators

Moreover, Bloom and Canning (2005) compare the impact of health on economic growth between their macroeconomic production function model and a microeconomic calibration based on wage regressions of Weil (2001). They use a panel of countries for the time period 1960-1995, where the observations are every five years. The parameters are estimated with the nonlinear least square method, and the instruments of the current growth rates of the factor inputs are the lagged growth

rates of the inputs. The health indicator in their analysis is the ASR. Bloom and Canning find that health has a positive and statistically significant effect on labor productivity. Finally, their findings are consistent with the ones that Weil (2001) concluded.

Bhargava et al. (2001) examine the link between health and economic growth. They use as indicator of health ASR at 5-year intervals. They use panel dataset to estimate different models for the time period 1965-90. Discriminating between developed and developing countries, they find that there is a significant impact of ASR on low income countries. Analytically, a 1% change in ASR leads to about 0.05% increase in growth rate, for poorest countries. However, accounting for developed economies, Bhargava et al. (2001) found that ASR have negative effect on growth rates.

Aguayo-Rico et al. (2005) examine the link of health and economic growth using a panel data analysis for 52 countries for the time period 1970-80 and 1980-90 with both OLS and generalized least squares (GLS). They evaluate the Solow model with human capital. Their model consists of four variables the growth rates of physical capital, labor, schooling and health indices. Moreover, they built a health index based on four determinants of health lifestyles, environment, health services and socioeconomic conditions. The result of this work is that health parameter has a positive statistically significant impact on economic growth, especially when the specific health index, called "total health" is used.

In their work Dimou and Chletsos (2011) examined the relationship between health expenditure and economic growth, which was evaluated as an annual percentage change of GDP. They used panel data analysis for 28 countries of OECD for the time period 1990-2008. The independent variables of the model are the lagged imports (%GDP), gross fixed capital formation (%GDP), final consumption expenditure (%GDP), the country's savings (%GDP), the GDP deflator and the annual percentage change in total health spending. As a result of this project, they found out that health expenditure has a slight, but statistically significant impact on economic growth.

2.2. Studies based on time series and cross-sectional data

The answer to the outcomes of Acemoglu and Johnson (2007) study is given by Swift (2011), who states that the full effects of better health will appear some

decades later. In particular, according to Bleakly (2006), this time period is around 60 or 65 years.

Moreover, Swift (2011) sheds light to the issue of the relationship between health and economic growth. According to Swift (2011), health improvement has as a result the growth of the economy, first, due to the increase of population and so of total GDP. And second, due to the rise of human and physical capital, which increase productivity and GDP per capita. Using the Johansen multivariate cointegration analysis for 13 OECD (developed) countries for the last two centuries (from 1820-2001 or 1921-2001, depending on data availability), he found that there is a long run or cointegrating relationship between life expectancy and both total GDP and GDP per capita for all the countries. Analytically, a 1% rise in life expectancy in the long run leads to an average 6% rise of total GDP and a 5% rise in GDP per capita. As for each country alone, GDP per capita ranges from 3% for England and Wales and 9% for Australia, Canada and Norway. Also, it is important to note that only 3.5% of the long run rise in GDP per capita due to the increase in life expectancy will be realized in each year. As a result, it will be needed 20 years in order to take place a 50% adjustment or 65 years for 90% adjustment. This implies that the overall effect of health improvement on economic growth can be realized only after a long period of time. Moreover, Swift (2011) found that total GDP and GDP per capita have a positive effect on life expectancy for most countries. Finally, he concluded that the link between the health and economic growth does not change over the periods estimated. This means that the relationships between the variables in question are not affected by major causes of illness and death.

Akram et al. (2008) examine the effect of two health indicators (life expectancy and infant mortality) on economic growth in the case of Pakistan. Cointegration, error correction and Granger causality analysis are employed for the time period 1972-2006. They find that the specific health indicators affect GDP per capita and that they also cause it. Moreover, they conclude that this relationship holds only in the long-run and that in the short-run there is not a significant link.

Bakare and Sanmi (2011) used time series from 1970 to 2009 in order to investigate the impact of health expenditure on income in Nigeria. They included in their model GDP, health expenditure, capital formation and labor force. Based on the neoclassical Solow production function and running the regression with OLS, they found that health expenditure has a significant and positive effect on gross domestic

product (GDP) of Nigeria. Analytically, an increase of health expenditure by 1% increases GDP by 69%.

Knowles and Owen (1995) based on Mankiw, Romer, and Weil's empirical growth model try to investigate the effect of health capital on economic growth. They use a shortfall of average life expectancy at birth from 80 years (80-LE) as a proxy for health measure, and the log difference GDP per working-age person as a dependent variable. Their sample consists of 84 non-oil economies for the tome period 1960-1985. Knowles and Owen (1995) estimations of both restricted and unrestricted regressions using OLS and 2SLS show that there is a strong and robust relationship between health and income per capita.

Ashraf et al. (2009) using a simulation model examine the impact of health on GDP per capita. They distinct health in two types. The first one is life expectancy as a summary calculation of general health status. Employing the simulations based on the assumption that life expectancy rises from 40 to 60, they find that per capita output may increase by around 15% in the long-run. However, 30-40 years after the shock, income might decrease by up to 5%. Furthermore, based on the second type of health, which is the eradication of malaria and tuberculosis, they conclude the following: First, even if we eradicate both diseases will lead to an unimportant effect of a few percentage points of GDP per capita not only in the short-run, but also in the long-run. Second, these effects have different impacts on income per capita. Specifically, eradication of tuberculosis raise GDP per capita in the short run. On the other hand, eradication of malaria lowers it.

Study	Income Proxy	Health Proxy	Methodology	Time Period	Sample	Main Result(s)
Acemoglu and Johnson (2007)	Total GDP, per capita/worker GDP	Life expectancy at birth	Panel data 2SLS	1940-80 and 1940-2000 (10 yearly)	N=75	Small positive effect on total GDP, but negative on per capita and per worker GDP
Aguayo-Rico, Guerra-Turrubiates, Montes (2005)	Growth rate of absolute GDP	Health index (calculated based on health lifestyles, environment, health services, and socioeconomic conditions)	Panel data OLS, GLS	1970-90 (10 yearly)	N=52	Positive effect
Akram, Padda, and Khan (2008)	GDP per capita	Life expectancy and infant mortality	Time series Cointegration analysis and ECM	1972-2006	N=1 (Pakistan)	Positive effect in the long run, and no relation in the short-run
Ashraf, Lester , and Weil (2009)	GDP per capita	Life expectancy at birth, malaria, and tuberculosis	- Simulations			Positive effect at first, but after 30-40 years negative effect
Bakare and Sanmi (2011)	Total GDP	Health expenditure	Time series OLS	1970-2009	N=1 (Nigeria)	Positive effect

Barro (1996, and 2013)	Growth rate of real GDP per capita	Life expectancy at birth	Panel data 3SLS, OLS, SUR	1960-1990	N=100	Positive effect
Barro (2003)	Growth rate of real GDP per capita	Life expectancy at age one	Panel data 3SLS	1965-75 or 1975-85 or 1985-95 (10 yearly)	N=71 N=86 N=83	positive effect
Barro and Lee (1994a)	Growth rate of real GDP per capita	Life expectancy at birth	Panel data SUR	1965-75 or 1975-85 (10 yearly)	N=85 N=95	Positive effect and greater in the case of poorer countries
Bhargava, Jamison , Lau, and Murray (2001)	Growth rate of GDP per capita	ASR, and life expectancy	Panel data	1965-90 (5-yearly)	N=92	Positive (negative) effect in the case of low (high) income economy
Bloom, and Canning (2005)	Total GDP	ASR	Panel data Nonlinear least squares	1960-95 (5-yearly)	-	Positive effect
Bloom, Canning, and Sevilla, (2001, and 2004)	Growth rate of total GDP	Life expectancy	Panel data Nonlinear two least squares	1960-90 (10-yearly)	N=104	Positive effect

Caselli, Esquivel, and Lefort (1996)	Growth rate of real per capita GDP	Life expectancy at birth	Panel data 3SLS, pooled OLS, and GMM	1960-85 (5-yearly)	N=97	Positive effect with 3SLS and pooled OLS method, and negative effect with GMM method
Dimou , and Chletsos (2011)	Percentage change of GDP	Percentage change of total health expenditure	Panel data	1990-2008	N=28 (OECD)	A slight positive effect
Ecevit (2013)	Real GDP per capita	Life expectancy at birth	Panel data Panel cointegration and causality analysis	1970-2010	N=21 (OECD)	Positive effect in the long run
Knowles, and Owen (1995)	Log difference of GDP per working-age person	Average life expectancy at birth from 80 years	Cross-section OLS, 2SLS	1960-85	N=84	Positive effect
Peykarjou, Gollu, Gashti, and Shahrivar (2011)	Growth rate of GDP	Life expectancy in adults	Panel data Fixed effects	2001-2009	N=15 (OIC)	Positive effect
Swift (2011)	Total GDP Per capita GDP	Life expectancy at birth	Time series Cointegration and ECM	1821-2001 or 1921-2001	N=12 (OECD)	Positive effect on both total and per capita GDP in the short-run and the long-run

3. Data

In this study we are going to investigate both the short-run and the long-run relationship between health and economic growth. We use for this purpose life expectancy at birth as an indicator of health. Specifically, we examine the relationship between health and both GDP per capita and total GDP. Furthermore, we distinguish life expectancy between the two sexes, in order to investigate the effect of life expectancy of male and female on GDP per capita and total GDP, separately. So, we use five variables in our analysis. The first one is GDP per capita and has been taken from Maddison (2013)[1]. The second one is total GDP and is the output of the multiplication of GDP per capita and national population, where national population was taken by Maddison (2013). Both per capita GDP and total GDP are expressed in terms of 1990 international dollars. The last three variables we use in our study are total life expectancy at birth, male life expectancy at birth and female life expectancy at birth and they have been taken from the Human Mortality Database[2]. Below we present a table with the variables we use and their sources.

Variable	**Source**
Total GDP	Author's calculation
GDP per capita	Maddison (2013)
Total life expectance at birth	Human Mortality Database
Male life expectance at birth	Human Mortality Database
Female life expectance at birth	Human Mortality Database

Note that the variables were selected based on the availability of the data for the time period 1821-2008 that we consider. Getting a clue at the growth regressions of the literature we observe that except for health parameter, other variables (education, investment) are often included. Nevertheless, we do not take into account any of them as they are not available in the time period we use. However, according to Juselius (2006), this fact should not cause any problem in our estimations, as the cointegrating relation does not depend on the size of the information set. In other

[1] http://www.ggdc.net/maddison/maddison-project/home.htm
[2] http://www.mortality.org/cgi-bin/hmd/country.php?cntr=AUS&level=1

words, the inclusion or not of additional variables in the model will not affect the equilibrium relationship, if it exists.

Furthermore, we use data for 21 countries all of which, apart from Bulgaria, are OECD members. Moreover, the time span differs from country to country. The longest time period is ranging from 1821 to 2008 and the shortest from 1951 to 2008. As a result, we have an unbalanced panel data dataset. The following table shows the countries we consider in our analysis, the notation we use and the time span of each one.

Country	**Notation**	**Time period**
Australia	AU	1921-2008
Austria	AT	1947-2008
Belgium	BE	1919-2008
Bulgaria	BG	1951-2008
Canada	CA	1921-2008
Denmark	DK	1835-2008
Finland	FI	1878-2008
France	FR	1821-2008
Hungary	HU	1950-2008
Ireland	IE	1950-2008
Italy	IT	1872-2008
Japan	JP	1947-2008
The Netherlands	NE	1850-2008
New Zealand	NZ	1948-2008
Norway	NO	1846-2008
Portugal	PT	1940-2008
Spain	ES	1908-2008
Sweden	SE	1821-2008
Switzerland	CH	1876-2008
United Kingdom	UK	1922-2008
United States	US	1933-2008

Finally, we should mention that some of the advantages of panel data are that they give “more informative data, more variability, less collinearity among variables, more degrees of freedom and more efficiency” (Gujarati, 2004 p.637). Also, using panel data structure is more appropriate for analyzing growth dynamics (Durlauf and Quah, 1998).

4. Methodology

4.1. Stationarity and spurious regressions

We know that in order to run a regression with standard regression techniques such as OLS, the variables of the equation should be covariance stationary. A variable covariance stationary when its mean and all autocovariances are finite and stable (do not change over time). In the case that the data are covariance stationary, conventional estimators are well behaved. If they are not covariance stationary, e.g. they are integrated process of order one or I(1), they have nonstandard asymptotic distributions and different rates of convergence. Suppose the model below:

$$y_t = \mu x_t + e_t \qquad (1) \quad \text{with} \quad E[e_t] = 0$$

Assume that both y_t and x_t are covariance-stationary processes, then e_t will be covariance stationary, too. In this case, we can consistently estimate the coefficient and μ by using OLS only if $E[x_t e_t] = 0$. Moreover, as the sample size increases, the distribution of the OLS estimator converges to a normal distribution with mean value equal to population value. If there is no relationship between y_t and x_t, that is, they are independent random walks and $\mu = 0$, then the equation (1) is a spurious regression. Referred to this issue, Granger and Newbold (1974) proved that the results we get from OLS regression are spurious. In other words, we can reject the null hypothesis that the parameter μ is zero, although it is in fact zero. The asymptotic theory has been derived by Phillips (1986) about a decade later and as a result, he explained the results of Granger and Newbold (1974). He showed that the random walks y_t and x_t are first-difference stationary processes and that the OLS estimator does not have its usual asymptotic properties when the variables are first-difference stationary.

Due to the fact that Δy_t and Δx_t are covariance stationary, we can regress Δy_t on Δx_t. However, if y_t and x_t are cointegrated, the specific regression will lead to misspecification. The fact that y_t and x_t are I(1) and $\mu \neq 0$ means that the residuals could be either integrated of zero or one degree. In the second case, that is e_t is I(1), the asymptotic theory for the OLS estimator has been provided by Phillips and Durlauf (1986). If $e_t = y_t - \mu x_t$ is integrated of zero order, I(0), then the two variables, are cointegrated. In other words, if both two variables are non-stationary processes, I(1), and their linear combination is a stationary process, I(0), the variables are called cointegrated.

When the variables are not covariance stationary, cointegration analysis is the one that can provide a framework for estimation, inference, and interpretation.

4.2. Im, Pesaran and Shin unit root test

Consequently, the first thing we do here is to investigate the stationarity of the series in question. The basic test we use for this scope is the Im Pesaran and Shin (IPS) (2003) unit root test. Analytically, consider an AR(1) process:

$$y_{it} = \rho_i y_{it-1} + X_{it}\delta_i + \iota_{it} \qquad (2)$$

Where i=1,…., N cross-section units and t=1,…., T time series. The X_{it} indicates the exogenous variables in the model, ρ_i the autoregressive coefficients and ι_{it} the error term (is assumed to be iid). If, $|\rho_i| < 1$, y_i is said to be weakly (trend-) stationary. On the other hand, if $|\rho_i| = 1$, then y_i contains a unit root.

The IPS test characteristic is that it combines individual unit root tests in order to lead to a panel result. In other words, it considers that the autoregressive coefficients differ across the cross-sections. Im, Pesaran and Shin (IPS) choose a different ADF regression for each country, which is:

$$\Delta y_{it} = \alpha_i y_{it-1} + \sum_{j=0}^{\rho_i} \beta_{ij}\Delta y_{it-j} + X'_{it}\delta + \iota_{it} \qquad (3)$$

The null hypothesis is,

H_0: $\alpha_i = 0$, for all i

The alternative,

$$H_1 = \begin{cases} \alpha_i = 0 & \text{for i=1,2,3,...,N}_1 \\ \alpha_i < 0 & \text{for i=N}_1\text{+1, N}_1\text{+2,...,N} \end{cases}$$

They estimate the separate ADF regressions and get the average of the individual ADF regressions:

$$t_{TN} = [\Sigma_{i=1}^{N} t_{iTi}(\rho_i)]/ N \qquad (4)$$

where t_{iT}(pi) is the ADF t-statistic for country i based on the country-specific ADF regression (Eq. 4).

Moreover, the modified IPS standardized t- statistic is:

$$W_{t_{NT}} = \frac{\sqrt{N}\left[t_{NT} - N^{-1}\sum_{i=1}^{N} E(t_{iT}(p_i))\right]}{\sqrt{N^{-1}\sum_{i=1}^{N} Var(t_{iT}(p_i))}} \rightarrow N(0,1) \qquad (5)$$

Consequently, the IPS test shows if the series have unit root. If they don't have a unit root, then we say that they are stationary. If they have a unit root, then they are non-stationary. In the first case we are able to run a regression by using OLS and get the results of it, which informs us about the relationship of the variables we care about in the long-run. In the second case, when the series are non-stationary, we test for stationarity in their first differences. When the degree of integration of the series is notified, we continue to test for cointegration the variables. For panel data structure there are three types of cointegration tests: the Pedroni, Kao and Fisher. The first two are based on the Engel-Granger approach. The last one relies on the approach of Johansen.

4.3. Cointegration tests

4.3.1. Engle-Granger cointegration test

The Engle-Granger (1987) cointegration test is based on the examination of the residuals of a spurious regression, with I(1) variables. We say that the variables are cointegrated if the residuals that we get by regressing the variables to each other are I(0). If they are I(1), then the variables are not cointegrated.

4.3.1.1. Pedroni cointegration test

As for the Pedroni (1999, 2004) test, it allows intercept and trend coefficients across cross-sections to be heterogeneous. The regression that is estimated is the following:

$$y_{it} = \kappa_i + \nu_i t + \xi_{1i}x_{1i,t} + \xi_{2i}x_{2i,t} + \ldots.. + \xi_{Mi}x_{Mi,t} + f_{i,t} \qquad (6)$$

Where i=1, …. , N, t=1,…., T, m=1,…., M and y,x are integrated of order one, in other words, I(1).

The general idea is to get the residuals from the above regression and then to test if the residuals are I(1) by running the auxiliary regression:

$$f_{it} = p_i f_{it-1} + w_{it} \qquad (7)$$

The null hypothesis of the test is that there is no cointegration between the variables. And the alternative that $p_i=\upsilon<1$ for all i (homogeneous alternative) or $p_i<1$ for all i (heterogeneous alternative). The first alternative refers to the within-dimension test or panel statistic test and the second to the between-dimension or group statistic test. We should also mention that, in the case of the Pedroni cointegration test, there are four panel statistics and three group panel statistics. In the first ones, the first-order autoregressive term does not change across the cross

sections. However, in the group panel statistics the term varies across the cross sections.

4.3.1.2. Kao cointegration test

On the other hand, the Kao (1999) test, although it follows the same approach, it specifies cross-section specific intercepts and homogeneous coefficients on the first stage.

4.3.2. Johansen-Fisher cointegration test

As for the Johansen-Fisher type panel cointegration test, Fisher (1932) provides a combined test taking into account the outcomes of the individual independent tests. Maddala and Wu (1999), based on the Fisher's result, derive an alternative test for cointegration in panel data. They combine tests from individual cross-sections and as a result they get a test statistic for the full panel set.

The fact that the variables are cointegrated means that there is long-run or equilibrium link between the variables. According to Granger Representation Theorem, when two variables are cointegrated their relationship can be given by an Error Correction Model (ECM) (Gujarati, 2004). As a result, in order to describe both short-run dynamics and long-run equilibrium simultaneously we run a simple vector error correction model (VECM) with none and one lag with OLS. Before we analyze these models, we are going to present the FMOLS and DOLS estimators.

4.4. FMOLS and DOLS

4.4.1. FMOLS

The FMOLS estimator was proposed by Phillips and Hansen (1990). It employs a semi-parametric correction in order to minimize the problems that are caused by the long run correlation between the cointegrating regression and stochastic regressors innovations. The specific estimator is asymptotically unbiased and has fully efficient mixture normal asymptotics. So, it permits us to do standard Wald tests using asymptotic Chi-square.

Assume that $\hat{u}_{1t}$ is taken by the following equation:

$$y_t = X_t'\eta + D_{1t}'\zeta + u_{1t} \qquad (8)$$

where $D_t = (D_{1t}', D_{2t}')'$ are deterministic trend regressors. Moreover, the stochastic regressors X_t are given by the system of equations:

$$X_t = \Gamma'_{21} D_{1t} + \Gamma'_{22} D_{2t} + \varepsilon_{2t}$$
$$\Delta\varepsilon_{2t} = u_{2t} \qquad (9)$$

We can, also obtain $\hat{u}_{2t}$ as $\hat{u}_{2t} = \Delta\hat{\varepsilon}_{2t}$ by the level regressions

$$\mathrm{X}_t = \hat{\Gamma}'_{21} D_{1t} + \hat{\Gamma}'_{22} D_{2t} + \hat{\varepsilon}_{2t} \qquad (10)$$

or difference regressions

$$\Delta\mathrm{X}_t = \hat{\Gamma}'_{21} \Delta D_{1t} + \hat{\Gamma}'_{22} \Delta D_{2t} + \hat{u}_{2t} \qquad (11)$$

Based on $\hat{u}_t = (\hat{u}_{1t}, \hat{u}_{2t})'$ residuals we measure $\hat{\Omega}$ and $\hat{\Lambda}$ long-run covariance matrices. The modified data will be

$$y_t^+ = y_t - \hat{\omega}_{12} \hat{\Omega}_{22}^{-1} \hat{u}_2 \qquad (12)$$

and the bias correction term

$$\hat{\lambda}_{12}^{+} = \hat{\lambda}_{12} - \hat{\omega}_{12} \hat{\Omega}_{22}^{-1} \hat{\Lambda}_{22} \qquad (13)$$

The FMOLS estimator will be given by:

$$\hat{\theta} = \begin{bmatrix} \hat{\eta} \\ \hat{\zeta} \end{bmatrix} = \left(\sum_{t=1}^{T} Z_t Z_t' \right)^{-1} \left(\sum_{t=1}^{T} Z_t y_t^+ - T \begin{bmatrix} \hat{\lambda}_{12}^{+\prime} \\ 0 \end{bmatrix} \right) \qquad (14)$$

where $Z_t = (\mathrm{X}_t', D_t')'$.

Furthermore, according to Hansen (1992), the Wald statistic for the null hypothesis Rθ=r is given by:

$$W = \left(R\hat{\theta} - r \right)' \left(RV\left(\hat{\theta}\right) R' \right)^{-1} \left(R\hat{\theta} - r \right)' \qquad (15)$$

where $V\left(\hat{\theta}\right) = \hat{\omega}_{1.2} \left(\sum_{t=1}^{T} Z_t Z_t' \right)^{-1}$ and has an asymptotic χ_g^2 – distribution, where g is the number of restrictions imposed by R.

We should bear in mind that the FMOLS method provides consistent estimates of β coefficients (the coefficients of the cointegrating equation) in small sample sets, eliminates endogeneity in the regressors, and the serial correlation in the errors (Ramirez 2006 and Kao, Chiang 2000).

4.4.2. DOLS

In order to eliminate the feedback in the cointegrating equation Saikkonen (1992) and Stock and Watson (1993) proposed DOLS as an asymptotically efficient estimator. The cointegrating equation is given by:

$$y_t = X_t'\eta + D_{1t}'\zeta + \sum_{j=-q}^{r} \Delta X_{t+j}'\phi + u_{1t} \qquad (16)$$

Least-square estimates of η have the same asymptotic distribution as those yielded by FMOLS, as long as the long-run correlation between the u_{1t} and u_{2t} is soaked up by lags q and leads r of the differenced regressors that are included in the above regression.

4.5. Engle-Granger two-step methodology

We follow the Engle-Granger two-step method (Brooks, 2008), which is: a) we examine the order of integration of the variables. If they are all I(1) and cointegrated we run the cointegrating regression with FMOLS and DOLS and take the residuals (RESID). Note that the Engel-Granger cointegration test is suggested. Nevertheless, except for the Pedroni and Kao panel cointegration tests (they are both based on the Engle-Granger approach), we present in our analysis the Johansen panel cointegration test, b) we run the ECMs with OLS using the residuals from the first step. Analytically, the cointegrating equation will be:

$$LGDP_t = \beta LLF_t + RESID_t \qquad (17)$$

where β is the FMOLS and DOLS estimator based on which method (FMOLS or DOLS) we employ. Moreover, the estimated cointegrating vector is (1–b), where b the FMOLS and DOLS estimator of β, respectively. Note that in the Engle-Granger two-step method the OLS methodology is suggested. However, due to the fact that we have panel data we employ FMOLS and DOLS (as literature suggests) in order to get the cointegrating regressions. ECMs will be, respectively:

$$DLGDP_t = \beta_1 DLLF_t + \gamma_4 RESID_{t-1} + \varepsilon_t \quad (18)$$

$$DLGDP_t = \beta_2 DLLF_t + \beta_3 DLGDP_{t-1} + \beta_4 DLLF_{t-1} + \gamma_2 RESID_{t-1} + \varepsilon_t \quad (19)$$

where DLGDP is the first difference of the logarithm of GDP per capita, DLLF is the first difference of logarithm of life expectancy, $DLLF_{t-1}$ and $DLGDP_{t-1}$ are one-period lagged values of the above variables, $RESID_{t-1}$ is the ECT and ε_t is iid. Notice that RESID has been estimated from the cointegration equation. Equation (19) will show us if DLGDP per capita depends on DLLF, the one period lagged values of DLGDP per capita and DLLF and the $RESID_{t-1}$. The last one can be thought of as an equilibrium error (or disequilibrium term) occurred in the previous period. If it is non-

zero, the model is out of equilibrium and vice versa. The coefficient β is a long-run parameter and β_1, β_2, β_3, β_4 are short-run parameters. Hence, the vector error-correction model (VECM) has both long-run and short-run properties. Moreover, γ_1, γ_2 show us in what time period DLGDP per capita will restore to the long-run equilibrium. In other words, they measure the speed of adjustment to the long-run equilibrium. Finally, all variables in VECM are stationary, thus there is not spurious regression problem. In the same way, equation (18) states that the change of the logarithm in GDP per capita from the previous period consists of the change in the logarithm of life expectancy from the previous period plus a part γ_1 of the deviation RESID, which equals to $LGDP_t$-βLLF_t, from the equilibrium. Note, also, that $DLGDP_t = \beta DLLF_t + \varepsilon_t$ is the equilibrium relationship and γ_1*$RESID_{t-1}$ or γ_1*($LGDP_t$-βLLF_t) is the equilibrium error for equation (18) and γ_2*$RESID_{t-1}$ or γ_2*($LGDP_t$-βLLF_t) for equation (19). It accounts for the deviation of the pair of variables from the equilibrium (Green, 2002).

4.6. Granger Causality

Finally, we test the variables in question for Granger causation. There are variables that are correlated, but they do not cause each other. Thus, correlation doesn't imply causation. Granger (1969) tried to find an approach that will test if x causes y or , in other words, y is Granger-caused by x. He wanted, first, to examine how much of the current value of y is explained by its lagged values. And second, if including lagged values of x predicts better the variable.

The bivariate regressions in a panel data dimension are:

$$y_{i,t} = \sigma_{0,i} + \sigma_{1,i} y_{i,t-1} + ... + \sigma_{l,i} y_{i,t-l} + \tau_{1,i} x_{,it-1} + ... + \tau_{l,i} x_{i,t-l} + \pi_{i,t} \quad (20)$$

$$x_{i,t} = \sigma_{0,i} + \sigma_{1,i} x_{i,t-1} + ... + \sigma_{l,i} x_{i,t-l} + \tau_{1,i} y_{,it-1} + ... + \tau_{l,i} y_{i,t-l} + \pi_{i,t} \quad (21)$$

Where t accounts for time period dimension of the panel and i for cross-sectional one. There are two approaches based on which someone can employ Granger causality. The first one is assuming that all coefficients are the same for each cross-section and the second one that they differ. We follow the second technique, which is adopted by Dumitrescu-Hurlin (2012). In a mathematical view it means that:

$$\sigma_{0,i} \neq \sigma_j, \sigma_{1,i} \neq \sigma_{1,j}, ..., \sigma_{l,i} \neq \sigma_{l,j}, \forall i, j$$

$$\tau_{1,i} \neq \tau_{1,j}, ..., \tau_{l,i} \neq \tau_{l,j}, \forall i, j$$

Granger Causality equations are employed for each cross-section individually. Then average Wbar statistics are taken. Note that the Zbar statistic, which is the

standardized version of the above statistic is appropriately weighed in unbalanced panels.

5. Results

In this section we are going to analyze the effect of health on economic performance of a country. As we referred, previously, we use life expectancy at birth as a proxy of health. So, after employing the appropriate unit root and cointegration test, we run panel cointegrating regressions and error correction models in order to investigate the link between health and economic growth. Below we present sub-sections that are related to the relation between life expectancy and both total and per capita GDP, between male and female life expectancy and per capita GDP, and between male and female life expectancy and total GDP.

5.1. The relationship between GDP per capita and life expectancy at birth

5.1.1. Descriptive statistics and stationarity

We start our analysis with GDP per capita. First, we present a table (table 1) with descriptive statistics. Specifically, table 1 presents the means and standard deviations of the level value of per capita GDP for each country, separately.

Table 1: Descriptive statistics

Countries	Mean	Std. Dev.	Obs.
AT	12603.29	6313.890	62
AU	11679.27	5946.972	88
BE	10495.94	6205.490	90
BG	5007.822	1716.663	58
CA	12004.50	6630.940	88
CH	11354.05	6454.237	133
DK	7235.676	6762.254	174
ES	6222.909	5039.390	101
FL	6865.299	6537.205	131
FR	6042.413	6073.180	188
GB	11357.50	5702.278	87
HU	5556.303	1646.648	59
IE	10361.23	6770.130	59
IT	6337.988	6041.146	137
JP	12073.79	7117.957	62
NE	7606.867	6247.269	159
NO	6871.102	7641.734	163
NZ	12616.77	3199.728	61
PT	7001.588	4416.211	69
SE	6095.014	6552.526	188
US	16646.61	7634.822	76
All	8540.500	6798.094	2233

It would be, also, useful to take a look at the graphs of the logarithm of this variable for each country separately. So, we present them below.

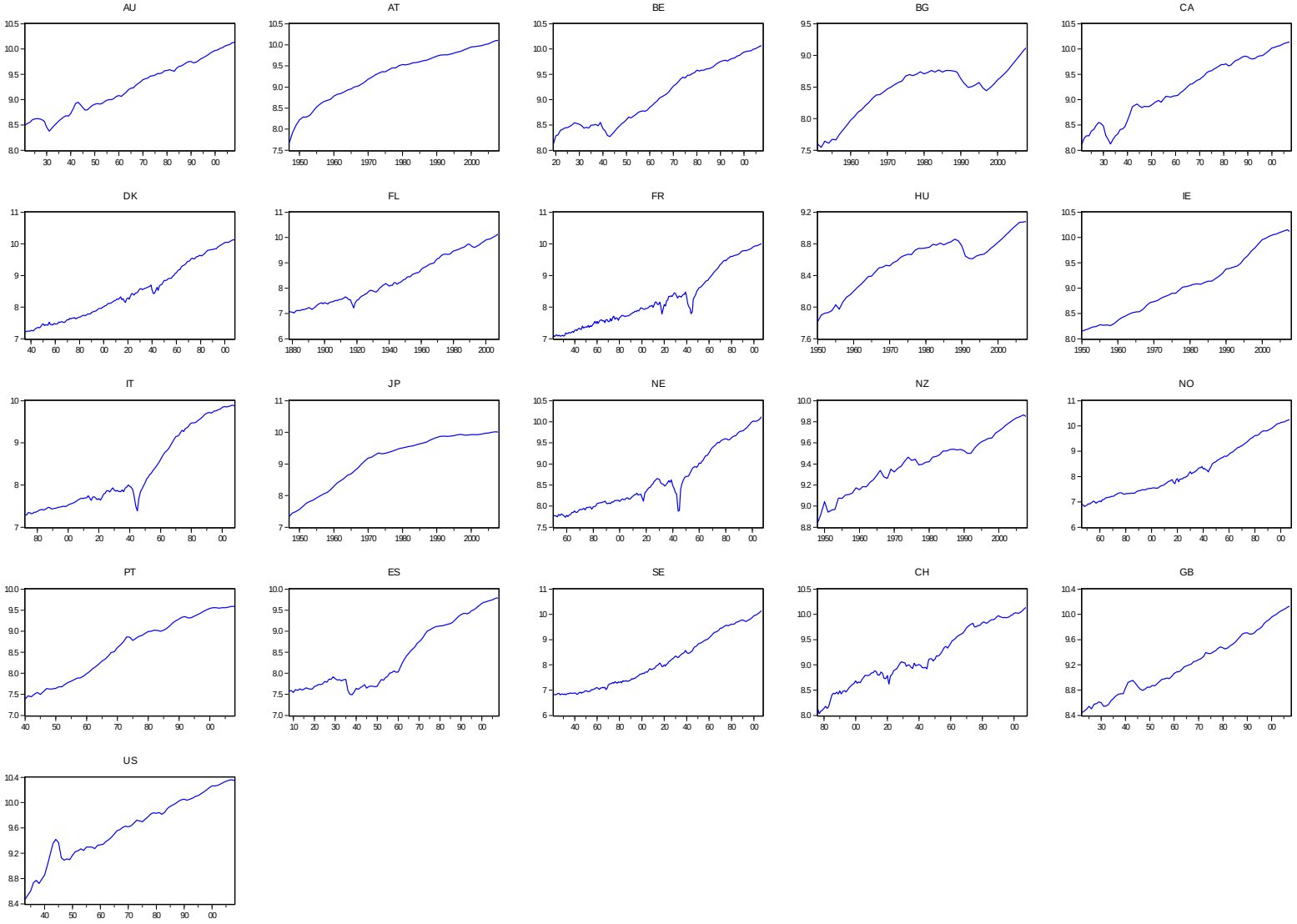
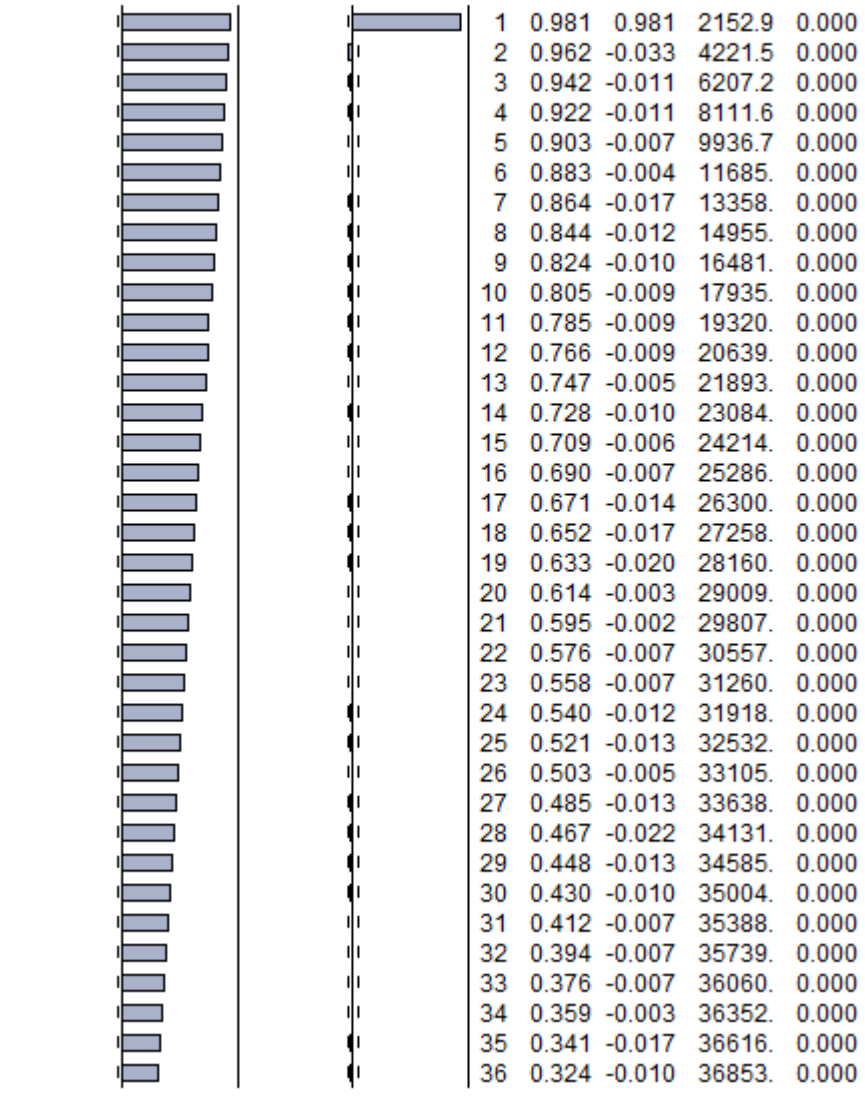


Figure 1: log GDP per capita

As we can see from the above graphs, and we know from the theory, in none of the 21 countries GDP per capita is stationary. On the contrary, it is trending and potentially I(1). Moreover, from the sample autocorrelation function below yields also that the series is probably non-stationary. As we observe, even up to a lag of 36 quarters, the autocorrelation coefficients are very high. Also, autocorrelation coefficient starts at a high value and declines very slowly toward zero as lag lengths.

Sample: 1821 2008
Included observations: 2233



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.981	0.981	2152.9	0.000
		2	0.962	-0.033	4221.5	0.000
		3	0.942	-0.011	6207.2	0.000
		4	0.922	-0.011	8111.6	0.000
		5	0.903	-0.007	9936.7	0.000
		6	0.883	-0.004	11685.	0.000
		7	0.864	-0.017	13358.	0.000
		8	0.844	-0.012	14955.	0.000
		9	0.824	-0.010	16481.	0.000
		10	0.805	-0.009	17935.	0.000
		11	0.785	-0.009	19320.	0.000
		12	0.766	-0.009	20639.	0.000
		13	0.747	-0.005	21893.	0.000
		14	0.728	-0.010	23084.	0.000
		15	0.709	-0.006	24214.	0.000
		16	0.690	-0.007	25286.	0.000
		17	0.671	-0.014	26300.	0.000
		18	0.652	-0.017	27258.	0.000
		19	0.633	-0.020	28160.	0.000
		20	0.614	-0.003	29009.	0.000
		21	0.595	-0.002	29807.	0.000
		22	0.576	-0.007	30557.	0.000
		23	0.558	-0.007	31260.	0.000
		24	0.540	-0.012	31918.	0.000
		25	0.521	-0.013	32532.	0.000
		26	0.503	-0.005	33105.	0.000
		27	0.485	-0.013	33638.	0.000
		28	0.467	-0.022	34131.	0.000
		29	0.448	-0.013	34585.	0.000
		30	0.430	-0.010	35004.	0.000
		31	0.412	-0.007	35388.	0.000
		32	0.394	-0.007	35739.	0.000
		33	0.376	-0.007	36060.	0.000
		34	0.359	-0.003	36352.	0.000
		35	0.341	-0.017	36616.	0.000
		36	0.324	-0.010	36853.	0.000

Then we employ the IPS unit root test for the variable in question, that is the logarithm of per capita GDP. Below we get two tables, table 2, which shows the results for the panel as a whole and table 3, which presents the results for each country separately. Moreover, in each table we have two cases. In the first one we

assume individual intercept, but in the second both individual intercept and trend. We should note that the number of the observations in the two cases are 2140 and 2157, respectively and the number of lags is selected based on the Akaike information criterion (AIC).

Table 2: IPS unit root test

Log of GDP per capita		
H_0: unit root	t-stat.	Prob.[+]
Individual effects	5.0837	1.0000
Individual effects & trend	-2.71695	0.0033*

[+]Probabilities are computed assuming asymptotic normality.
Note: * denotes rejection at 1% level.

Table 3: IPS unit root test

Log of GDP per capita								
	country-by-country ADF t-statistics							
	Individual effects				Individual effects and trends			
Cross section	**t-stat.**	**Prob.[+]**	**Lags**	**Obs.**	**t-stat.**	**Prob.[+]**	**Lags**	**Obs.**
AU	-0.2477	0.9268	10	77	-2.4468	0.3533	10	77
AT	-7.1966	0.0000*	0	61	-7.4798	0.0000*	0	61
BE	0.3725	0.9807	3	86	-2.5686	0.2955	2	87
BG	-1.8745	0.3417	1	56	-3.1572	0.1046	6	51
CA	-2.3490	0.1597	11	76	-3.7935	0.0216**	2	85
DK	1.3634	0.9989	2	171	-2.0278	0.5817	0	173
FL	1.1025	0.9974	4	126	-2.1336	0.5219	4	126
FR	0.9677	0.9962	7	180	-1.7211	0.7381	5	182
HU	-1.4618	0.5456	1	57	-2.3494	0.4011	4	54
IE	-0.0467	0.9498	1	57	-2.2699	0.4429	1	57
IT	0.5147	0.9867	2	134	-1.8135	0.6929	2	134
JP	-3.6076	0.0089*	10	51	-1.5360	0.8039	10	51
NE	0.6091	0.9896	2	156	-1.8933	0.6533	2	156
NZ	-1.5190	0.5173	0	60	-3.7013	0.0298**	0	60
NO	2.0287	0.9999	0	162	-1.6383	0.7735	0	162
PT	-1.4510	0.5518	4	64	-0.2487	0.9905	4	64
ES	0.7281	0.9922	1	99	-1.7189	0.7356	1	99
SE	2.1905	0.9999	0	187	-2.4255	0.3652	0	187
CH	-1.1185	0.7073	1	131	-2.4872	0.3340	0	132
GB	0.3174	0.9779	2	84	-2.8179	0.1951	1	85

US	-0.0199	0.9529	10	65	-4.7066	0.0015*	1	74

[+] Probabilities are computed assuming asymptotic normality.
Note: * and ** denote rejection at 1% and 5% level, respectively.

The null hypothesis is that there is unit root in the series. So, as we can see from table 2, when we include only individual effect the null hypothesis is accepted even at 10% confidence interval (probability=1>10%). However, if we include both individual effect and linear trend, it is rejected at 1% confidence interval as probability equals to 0.033, which is smaller than 1%. As a result, the series is non-stationary according to the first case and stationary according to second one.

As for table 3, looking at each country alone we observe that in the case of individual effect the null hypothesis is rejected at 1% confidence interval only in 2 cases, for Austria and Japan. That is, there is unit root for the 19 countries of the 21 that we investigate. As for the case of individual effect and trend we see, again, that only for 4 of the 21 countries the null hypothesis is rejected and these are Austria and United States at 1% level, and Canada and New Zealand at 5% level. Note, also, that the fourth and eighth column of table 3 give us the number of lags that is selected by AIC in the case of inclusion of only individual effect and both individual effect and trend. Additionally, in the fifth and ninth column we can see the observations for each country in both cases.

As in both cases the results are driven by a small number of countries, we conclude that there is a unit root in the panel. We therefore proceed to consider the first difference of the series.

First, we plot the graphs of the first difference of the logarithm of per capita GDP.

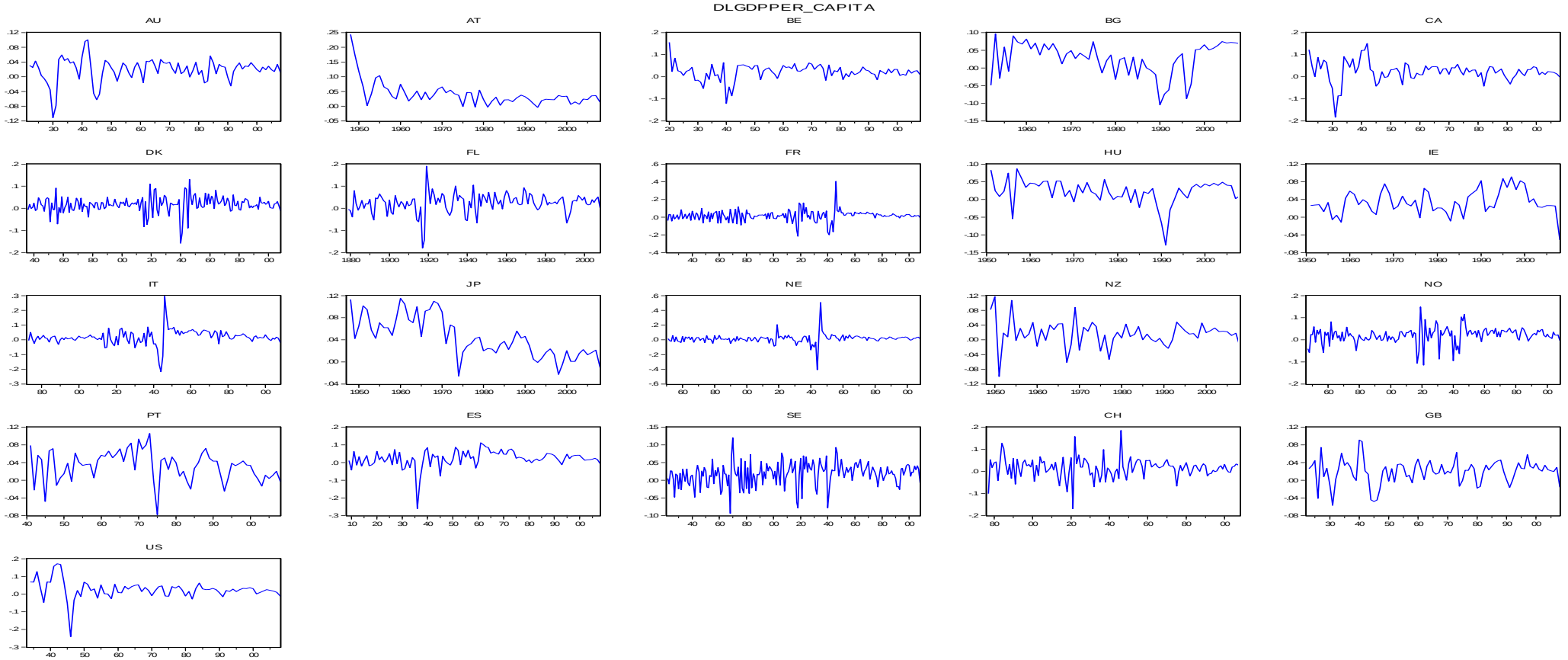
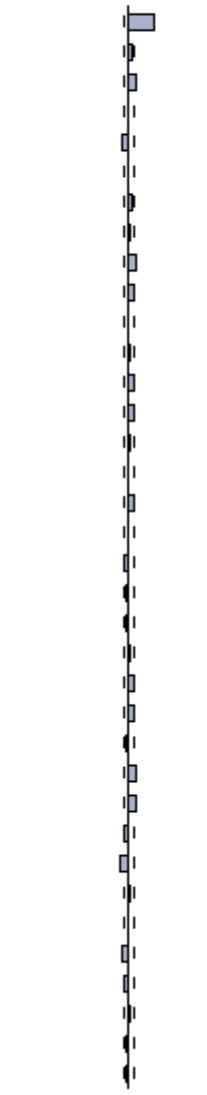


Figure 2: 1st difference of log GDP per capita

As we observe from the graphs above, the variable seems to be stationary for each of the 21 countries we concern. Furthermore, from the sample autocorrelation function below yields that the series is probably stationary. As we can see, even up to a lag of 36 quarters, the autocorrelation coefficients are very small. Also, the autocorrelation coefficient starts at a value and declines rapidly toward zero as lag lengths.

Sample: 1821 2008
Included observations: 2212



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.232	0.232	119.08	0.000
		2	0.036	-0.018	122.03	0.000
		3	0.067	0.067	132.08	0.000
		4	0.006	-0.025	132.17	0.000
		5	-0.056	-0.055	139.01	0.000
		6	-0.007	0.015	139.13	0.000
		7	0.037	0.038	142.18	0.000
		8	0.021	0.012	143.20	0.000
		9	0.076	0.072	155.97	0.000
		10	0.043	0.001	160.04	0.000
		11	0.005	-0.008	160.09	0.000
		12	0.014	0.011	160.52	0.000
		13	0.048	0.044	165.72	0.000
		14	0.047	0.036	170.70	0.000
		15	0.011	-0.008	170.95	0.000
		16	0.003	-0.010	170.97	0.000
		17	0.043	0.040	175.08	0.000
		18	-0.008	-0.028	175.21	0.000
		19	-0.026	-0.017	176.77	0.000
		20	-0.022	-0.020	177.82	0.000
		21	-0.024	-0.019	179.09	0.000
		22	0.020	0.033	179.98	0.000
		23	0.047	0.031	184.90	0.000
		24	0.060	0.041	192.98	0.000
		25	-0.022	-0.053	194.10	0.000
		26	0.066	0.075	203.78	0.000
		27	0.075	0.042	216.50	0.000
		28	-0.036	-0.053	219.43	0.000
		29	-0.076	-0.061	232.33	0.000
		30	0.023	0.045	233.51	0.000
		31	-0.007	-0.020	233.63	0.000
		32	-0.064	-0.048	242.97	0.000
		33	-0.027	-0.020	244.66	0.000
		34	0.010	0.016	244.87	0.000
		35	-0.012	-0.013	245.20	0.000
		36	-0.018	-0.024	245.96	0.000

However, this is not enough. So, we will employ the IPS unit root test as previously. The results that we obtain from the specific test are given in tables 4 and 5. The number of the observations in the case of the inclusion of individual intercept

is 2129 and when we include both individual intercept and trend is 2128. We, also use AIC for the selection of the number of lags.

Table 4: IPS unit root test

Difference of Log of GDP per capita		
H_0: unit root	t-stat.	Prob.[+]
Individual effects	-28.0914	0.0000*
Individual effects & trend	-27.5432	0.0000*

[+]Probabilities are computed assuming asymptotic normality.
Note: * denotes rejection at 1% level.

Table 5: IPS unit root test

Difference of Log of GDP per capita								
	country-by-country ADF t-statistics							
	Individual effects				Individual effects and trends			
Cross section	**t-stat.**	**Prob.[+]**	**Lags**	**Obs.**	**t-stat.**	**Prob.[+]**	**Lags**	**Obs.**
AU	-5.4208	0.0000*	11	75	-5.3142	0.0002*	11	75
AT	-5.5356	0.0000*	2	58	-6.8101	0.0000*	0	60
BE	-4.4368	0.0005*	2	86	-4.5146	0.0026*	2	86
BG	-4.8594	0.0002*	0	56	-4.9291	0.0010*	0	56
CA	-5.7719	0.0000*	10	76	-6.2184	0.0000*	10	76
DK	-10.859	0.0000*	1	171	-11.045	0.0000*	1	171
FL	-4.5748	0.0003*	6	123	-5.8916	0.0000*	5	124
FR	-6.7729	0.0000*	6	180	-6.9226	0.0000*	6	180
HU	-5.5494	0.0000*	0	57	-5.5817	0.0001*	0	57
IE	-3.9616	0.0031*	0	57	-3.8436	0.0212**	0	57
IT	-7.1081	0.0000*	1	134	-7.2158	0.0000*	1	134
JP	-0.8647	0.7914	9	51	-3.3151	0.0753***	9	51
NE	-9.4325	0.0000*	1	156	-9.5278	0.0000*	1	156
NZ	-9.0425	0.0000*	0	59	-9.0030	0.0000*	0	59
NO	-11.869	0.0000*	0	161	-6.4457	0.0000*	4	157
PT	-3.8223	0.0044*	3	64	-4.0928	0.0104**	3	64
ES	-7.1653	0.0000*	0	99	-7.3369	0.0000*	0	99
SE	-12.700	0.0000*	0	186	-13.123	0.0000*	0	186
CH	-12.916	0.0000*	0	131	-12.902	0.0000*	0	131
GB	-5.5077	0.0000*	1	84	-5.5290	0.0001*	1	84
US	-6.9795	0.0000*	9	65	-6.6847	0.0000*	9	65

[+]Probabilities are computed assuming asymptotic normality.
Note: *, **, and *** denote rejection at 1%, 5%, and 10% level, respectively.

Table 4 shows that in both cases the null hypothesis is rejected even at the 1% confidence interval (probability=0<1%), that is, there is not a unit root. As a result, the first difference of the logarithm of GDP per capita is a stationary process. In other words, the series is integrated of order one, I(1). Moreover, according to table 5, that reports the country-by-country ADF t-statistics, only 1 (Japan) of the 21 countries does not reject the null hypothesis (in the case that we include only individual effect). In the case where both individual effects and linear trends are assumed, for all of the countries the hypothesis of unit root is reject in most of them at even 1% confidence interval. The only exceptions are for Portugal and Ireland where the null hypothesis is rejected at 5%, and Japan at 10% level .

Continuing, we will do the same analysis for life expectancy at birth. First of all, in the table 6, we present the descriptive statistics, mean and standard deviation, of the level value of life expectancy at birth.

Table 6: Descriptive statistics

Countries	**Mean**	**Std. Dev.**	**Obs.**
AT	72.49468	4.701315	62
AU	71.45557	5.605171	88
BE	68.22567	7.992439	90
BG	70.21345	2.776577	58
CA	70.55455	7.030294	88
CH	63.42654	12.56141	133
DK	59.60356	12.75716	174
ES	63.02297	14.14195	101
FL	59.59672	13.15746	131
FR	54.54218	14.77888	188
GB	70.14126	6.423729	87
HU	69.29475	2.441992	59
IE	72.88017	3.590838	59
IT	57.59664	16.13531	137
JP	73.70532	7.411541	62
NE	59.71969	15.14936	159
NO	62.81552	11.41726	163
NZ	73.79607	3.420987	61
PT	67.74101	8.340848	69
SE	59.31739	13.79510	188
US	71.08382	4.954583	76
All	63.97339	12.86251	2233

Then, we plot the graph of the logarithm of life expectancy for each country separately.

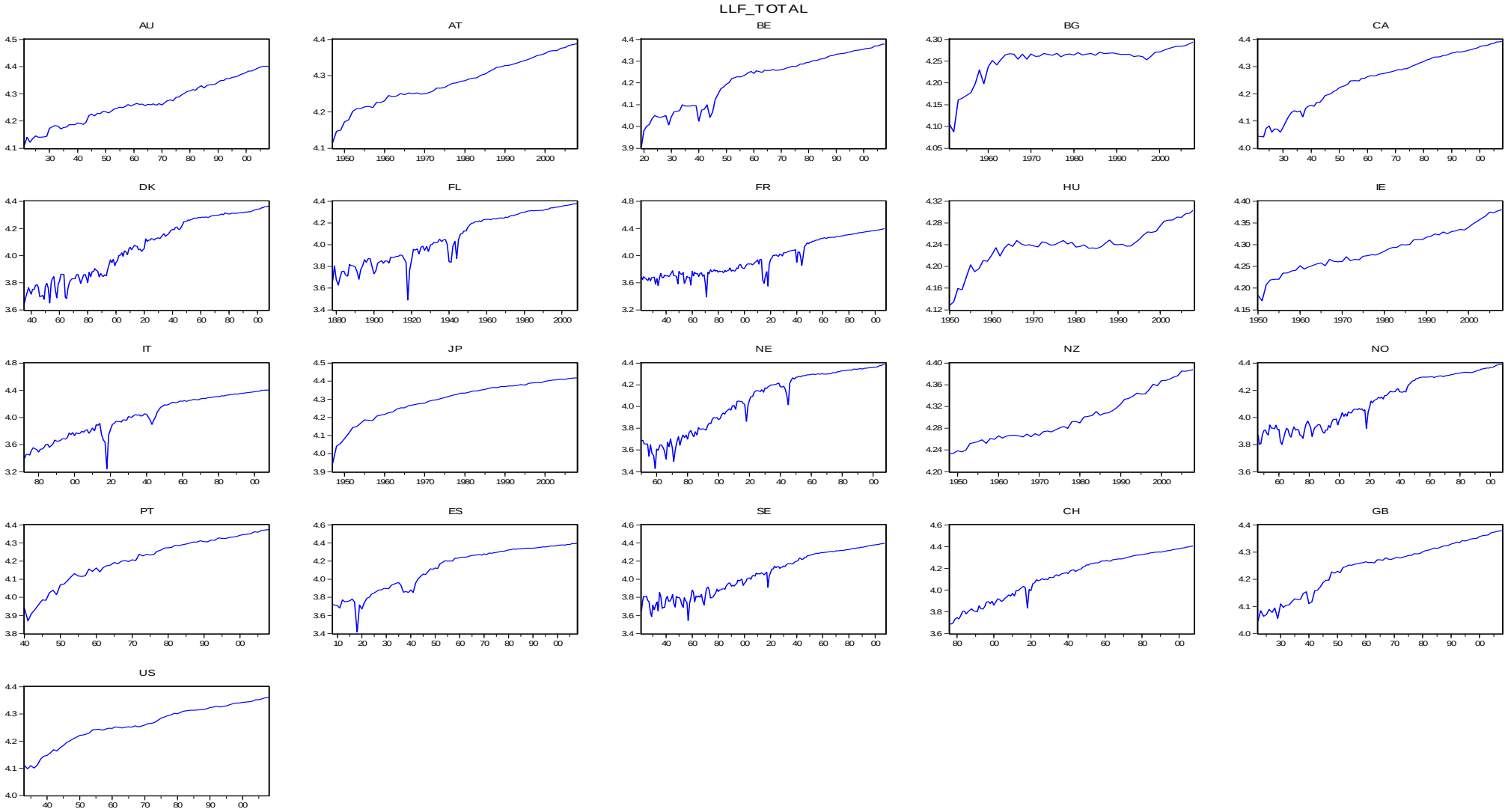


Figure 3: log of life expectancy at birth

As we observe the variable is non-stationary in each case, as in all cases, life expectancy is increasing. In other words, it has an upward trend. Also, taking a look at the sample autocorrelation function below, we see that even up to a lag of 36 quarters the autocorrelation coefficients are very high and they decline slowly toward zero as lag lengths. This is a typical correlogram of a non-stationary process (Gujarati, 2004).

Sample: 1821 2008
Included observations: 2233

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.970	0.970	2101.8	0.000
		2	0.948	0.126	4110.4	0.000
		3	0.927	0.036	6034.4	0.000
		4	0.909	0.036	7884.3	0.000
		5	0.892	0.027	9667.0	0.000
		6	0.875	-0.005	11382.	0.000
		7	0.860	0.032	13039.	0.000
		8	0.842	-0.038	14630.	0.000
		9	0.825	-0.000	16158.	0.000
		10	0.809	-0.001	17628.	0.000
		11	0.791	-0.029	19034.	0.000
		12	0.774	-0.013	20380.	0.000
		13	0.757	-0.000	21667.	0.000
		14	0.739	-0.029	22895.	0.000
		15	0.722	0.008	24068.	0.000
		16	0.706	0.001	25189.	0.000
		17	0.689	-0.020	26257.	0.000
		18	0.672	0.003	27276.	0.000
		19	0.655	-0.020	28244.	0.000
		20	0.639	0.000	29164.	0.000
		21	0.623	0.009	30041.	0.000
		22	0.609	0.007	30877.	0.000
		23	0.592	-0.036	31668.	0.000
		24	0.575	-0.014	32415.	0.000
		25	0.561	0.026	33125.	0.000
		26	0.545	-0.026	33796.	0.000
		27	0.527	-0.043	34425.	0.000
		28	0.510	-0.013	35013.	0.000
		29	0.492	-0.031	35560.	0.000
		30	0.473	-0.029	36066.	0.000
		31	0.454	-0.020	36533.	0.000
		32	0.436	-0.007	36963.	0.000
		33	0.419	0.020	37362.	0.000
		34	0.402	-0.021	37729.	0.000
		35	0.386	0.004	38067.	0.000
		36	0.370	0.012	38379.	0.000

After the presentation of the descriptive statistics, graphs and sample autocorrelation function, we proceed to the IPS unit root test for the logarithm of life expectancy. Again we use the AIC for the selection of the lags. Also, the total number of observations is 2107 in the case of inclusion of individual intercept and 2109 in the case of both individual intercept and trend. Tables 7 and 8 report the results.

Table 7: IPS unit root test

Log of life expectancy		
H_0: unit root	t-stat.	Prob.[+]
Individual effects	0.88614	0.8122
Individual effects & trend	-2.76371	0.0029*

[+]Probabilities are computed assuming asymptotic normality.
Note: * denotes rejection at 1% level.

Table 8: IPS unit root test

Log of life expectancy								
	country-by-country ADF t-statistics							
	Individual effects				Individual effects and trends			
Cross section	**t-stat.**	**Prob.[+]**	**Lags**	**Obs.**	**t-stat.**	**Prob.[+]**	**Lags**	**Obs.**
AU	-0.8317	0.8047	2	85	-3.9188	0.0152**	0	87
AT	-0.4529	0.8924	3	58	-3.2811	0.0810***	10	51
BE	-1.2458	0.6507	11	78	-1.6230	0.7749	11	78
BG	-0.3351	0.9115	10	47	-1.5086	0.8126	10	47
CA	-4.4239	0.0006*	5	82	-1.8453	0.6735	5	82
DK	-0.9579	0.7673	11	162	-0.6889	0.9717	11	162
FL	-1.2142	0.6670	3	127	-5.5301	0.0000*	0	130
FR	-0.6612	0.8524	2	185	-3.8471	0.0162**	2	185
HU	0.7150	0.9913	9	49	-1.6361	0.7639	9	49
IE	0.6660	0.9903	3	55	-5.0170	0.0007*	1	57
IT	-1.2778	0.6386	6	130	-4.8543	0.0006*	0	136
JP	-2.7755	0.0684***	6	55	-2.0982	0.5354	5	56
NE	-1.0885	0.7196	6	152	-0.9995	0.9401	6	152
NZ	1.3410	0.9986	1	59	-0.8188	0.9577	1	59
NO	-0.3847	0.9077	4	158	-2.3359	0.4118	4	158
PT	-4.8500	0.0002*	1	67	-4.6566	0.0020*	4	64
ES	-1.2019	0.6712	4	96	-1.7030	0.7426	4	96
SE	-0.5774	0.8713	8	179	-3.8193	0.0176**	4	183
CH	-3.0803	0.0306**	8	124	-0.4841	0.9831	8	124
GB	-1.9415	0.3121	2	84	-1.4183	0.8486	2	84
US	-2.7218	0.0751***	0	75	-2.5865	0.2877	6	69

[+]Probabilities are computed assuming asymptotic normality.
Note: *, **, and *** denote rejection at 1%, 5%, and 10% level, respectively.

As we can see from table 7 the null hypothesis, i.e. the series has a unit root, is accepted at even 10% confidence interval (probability=0.8122>10%) in the case that we assume individual effect, but rejected at 1% confidence interval

(probability=0.0029<1%) in the case of both individual effect and trend. As for the table 8, in the case of inclusion of individual intercept, only 5 countries (Canada, Portugal, Switzerland, Japan and United States) of all 21 reject the null hypothesis at 1%, 5% and 10% confidence interval. But in the case of inclusion of both individual intercept and linear trend, the null hypothesis is rejected at different confidence intervals for 8 countries (Australia, Austria, Finland, France, Ireland, Italy, Portugal, and Sweden).

As in both cases the results are driven by a small number of countries, we conclude that there is a unit root in the panel. We therefore proceed to consider the first difference of the series.

First, we quote the graphs of the first difference of the logarithm of life expectancy at birth.

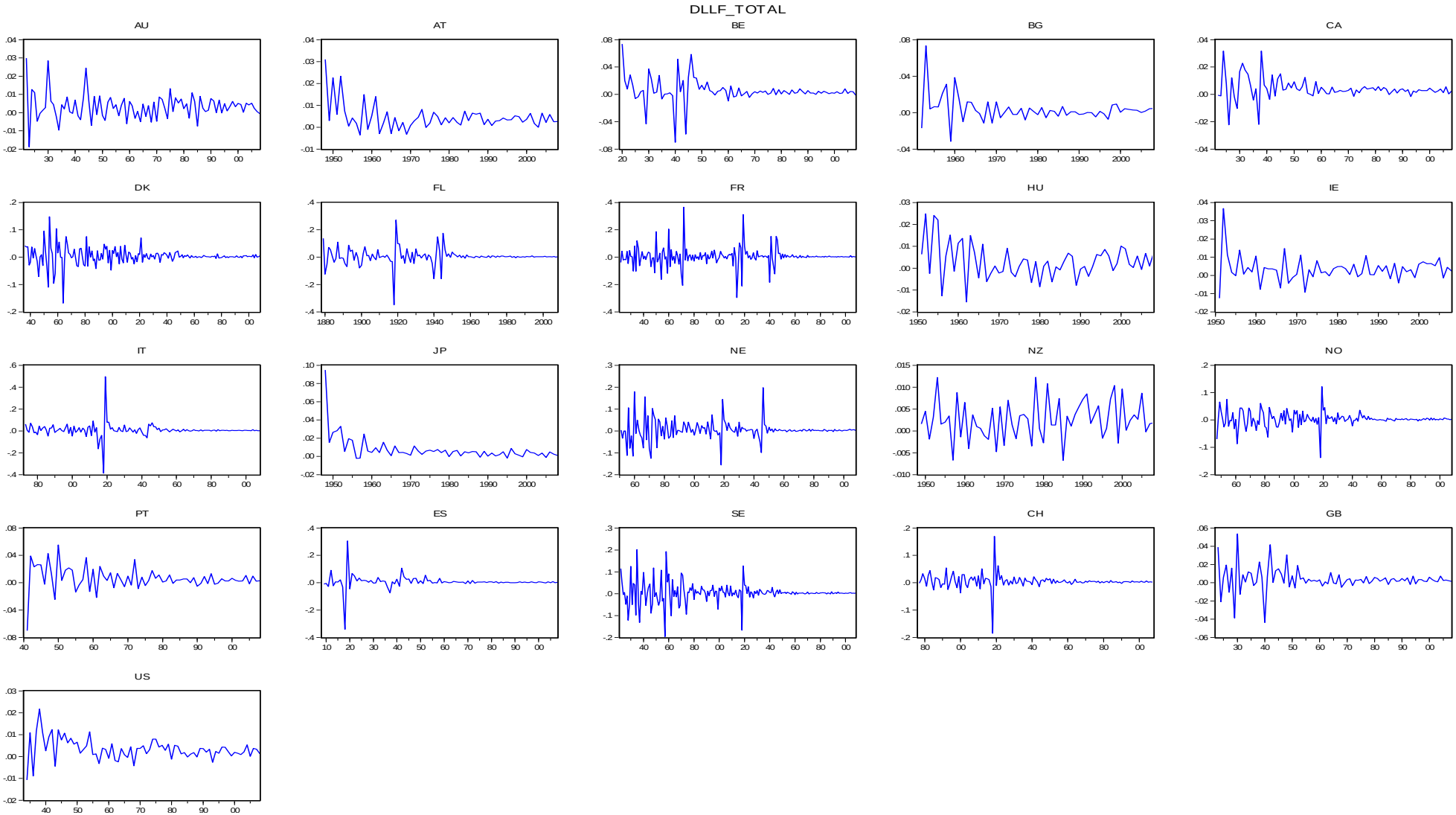


Figure 4: 1st difference of log life expectancy at birth

As we can observe from the above graphs the first difference of the logarithm of life expectancy seems to be stationary for all the countries mentioned. Also, taking a look at the sample autocorrelation function below, we see that even up to a lag of 36 quarters the autocorrelation coefficients are very small and they decline very quickly toward zero as lag lengths. This is a typical correlogram of a stationary process.

Sample: 1821 2008
Included observations: 2212

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.250	-0.250	138.68	0.000
		2	-0.063	-0.134	147.51	0.000
		3	-0.078	-0.140	160.87	0.000
		4	-0.015	-0.093	161.34	0.000
		5	-0.001	-0.060	161.34	0.000
		6	-0.061	-0.113	169.66	0.000
		7	0.042	-0.030	173.53	0.000
		8	-0.035	-0.068	176.25	0.000
		9	0.004	-0.050	176.29	0.000
		10	0.009	-0.027	176.45	0.000
		11	0.017	-0.007	177.09	0.000
		12	0.010	-0.001	177.30	0.000
		13	0.002	0.006	177.31	0.000
		14	-0.028	-0.031	179.10	0.000
		15	0.009	-0.006	179.27	0.000
		16	-0.001	-0.006	179.27	0.000
		17	0.008	0.002	179.40	0.000
		18	0.006	0.009	179.48	0.000
		19	0.019	0.029	180.25	0.000
		20	-0.023	-0.008	181.46	0.000
		21	-0.073	-0.082	193.40	0.000
		22	0.054	0.006	200.03	0.000
		23	0.018	0.015	200.75	0.000
		24	-0.038	-0.044	204.05	0.000
		25	0.036	0.020	206.88	0.000
		26	0.061	0.078	215.32	0.000
		27	0.013	0.060	215.72	0.000
		28	-0.008	0.052	215.88	0.000
		29	0.021	0.071	216.85	0.000
		30	-0.020	0.035	217.78	0.000
		31	-0.012	0.033	218.09	0.000
		32	-0.036	-0.004	221.02	0.000
		33	0.022	0.027	222.10	0.000
		34	-0.025	-0.011	223.55	0.000
		35	-0.019	-0.033	224.36	0.000
		36	0.026	0.004	225.84	0.000

Then we employ the IPS test first with individual intercept and second with individual intercept and linear trend. In both cases the number of observations is 2103. Moreover, we use the AIC for the lag selection.

Table 9: IPS unit root test

Difference of log of life expectancy		
H_0: unit root	t-stat.	Prob.[+]
Individual effects	-29.4866	0.0000*
Individual effects & trend	-31.3264	0.0000*

[+]Probabilities are computed assuming asymptotic normality.
Note: * denotes rejection at 1% level.

Table 10: IPS unit root test

Difference of log of life expectancy								
	country-by-country ADF t-statistics							
	Individual effects				Individual effects and trends			
Cross section	**t-stat.**	**Prob.[+]**	**Lags**	**Obs.**	**t-stat.**	**Prob.[+]**	**Lags**	**Obs.**
AU	-12.884	0.0001*	0	86	-12.790	0.0000*	0	86
AT	-4.1988	0.0015*	2	58	-3.9212	0.0172**	2	58
BE	-2.6607	0.0856***	10	78	-2.7933	0.2042	10	78
BG	-10.087	0.0000*	0	56	-2.9460	0.1581	9	47
CA	-1.7918	0.3819	10	76	-7.8037	0.0000*	4	82
DK	-4.4177	0.0004*	11	161	-5.3986	0.0001*	10	162
FL	-9.5206	0.0000*	2	127	-9.4951	0.0000*	2	127
FR	-13.461	0.0000*	1	185	-13.440	0.0000*	1	185
HU	-2.0856	0.2512	8	49	-2.0142	0.5791	8	49
IE	-10.853	0.0000*	0	57	-10.923	0.0000*	0	57
IT	-7.3209	0.0000*	5	130	-7.3534	0.0000*	5	130
JP	-5.4038	0.0000*	4	56	-5.7498	0.0001*	4	56
NE	-7.3060	0.0000*	5	152	-7.3495	0.0000*	5	152
NZ	-11.414	0.0000*	0	59	-11.667	0.0000*	0	59
NO	-9.4433	0.0000*	3	158	-9.4102	0.0000*	3	158
PT	-2.8500	0.0577***	9	58	-1.9931	0.5927	9	58
ES	-6.5947	0.0000*	2	97	-15.356	0.0000*	0	99
SE	-8.6468	0.0000*	7	179	-8.5888	0.0000*	7	179
CH	-6.3599	0.0000*	7	124	-7.2383	0.0000*	7	124
GB	-9.5676	0.0000*	1	84	-9.8009	0.0000*	1	84
US	-4.6980	0.0002*	1	73	-5.4340	0.0001*	1	73

[+]Probabilities are computed assuming asymptotic normality.
Note: *, **, and *** denote rejection at 1%, 5%, and 10% level, respectively.

From table 9 yields that the first difference of the logarithm of life expectancy is stationary, as at even 1% confidence interval we reject the null hypothesis that the

series has unit root (probability=0<1%) in both cases. This means that the level of this variable, that is the logarithm of life expectancy is integrated of order one, I(1).

According to table 10, in the case of individual effect, only for 2 countries (Canada and Hungary) the null hypothesis, that the series has a unit root, is accepted at 10% confidence interval. As for the second case of inclusion of both intercept and trend, the null hypothesis is accepted for 4 countries (Belgium, Bulgaria, Hungary and Portugal) at 10% confidence interval. As a result, the logarithm of life expectancy is integrated of degree one, I(1). Consequently, due to the fact that the logarithms of the two variables (GDP per capita and life expectancy) are integrated of degree one, we proceed to find out if there is a cointegration relation between the two variables.

5.1.2. Cointegration and error correction

We, first quote graphs with the two variables together for each country, and then employ the Pedroni, Kao and Johansen cointegration tests.

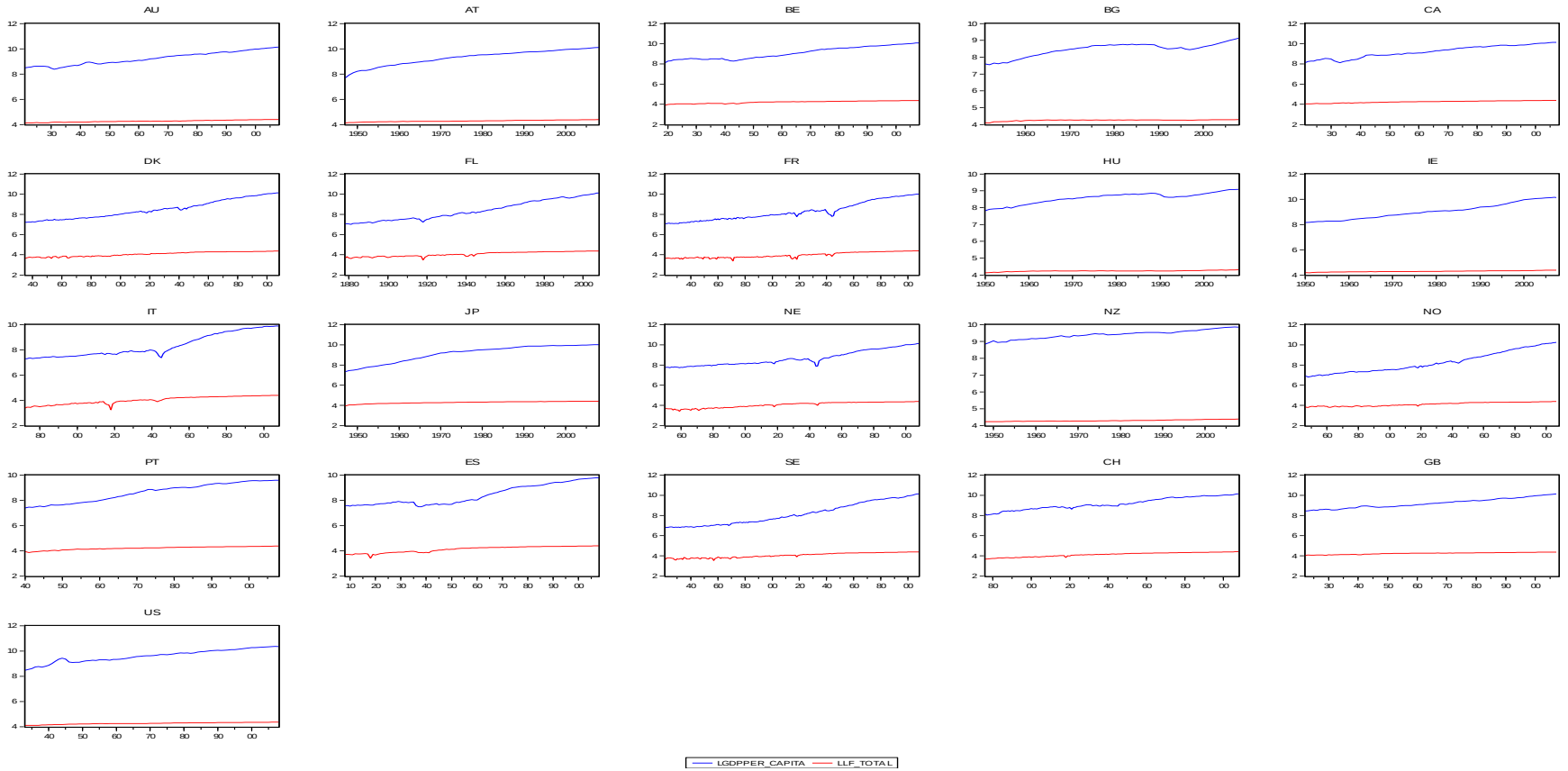


Figure 5: log GDP per capita & life expectancy

According to the above graphs and generally speaking, we can say that the two variables follow the same path.

Table 11 reports the results of the Kao cointegration test and the Pedroni cointegration test in three cases, when we (i) do not include deterministic trend, (ii) include both deterministic intercept and trend, and (iii) exclude deterministic intercept and trend. The number of observations is 2233 and the number of lags is chosen based on the AIC.

Table 11: Pedroni & Kao cointegration tests

		H_0: no cointegration					
Pedroni		**no deterministic trend**		**deterministic intercept and trend**		**no deterministic intercept and trend**	
		Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
H_1: common AR coef.	Panel v-Statistic	2.509791	0.0060*	5.157380	0.0000*	-2.670064	0.9962
	Panel rho-Statistic	-10.62732	0.0000*	-26.73420	0.0000*	1.507624	0.9342
	Panel PP-Statistic	-7.327314	0.0000*	-16.44078	0.0000*	1.203506	0.8856
	Panel ADF-Statistic	-2.693328	0.0035*	-10.02692	0.0000*	2.849715	0.9978
H_1: indivi dual coef.	Group rho-Statistic	-6.958833	0.0000*	-9.610040	0.0000*	4.492625	1.0000
	Group PP-Statistic	-6.754298	0.0000*	-9.585957	0.0000*	2.603408	0.9954
	Group ADF-Statistic	-4.134394	0.0000*	-3.747698	0.0001*	4.175615	1.0000
Kao							
	ADF-Statistic	1.246919	0.1062				

Note: * denotes rejection at 1% level.

The null hypothesis of the test is that there is no cointegrating relation between the two variables. We, first, consider that there is not deterministic trend. Table consists of two panels. In the first one the AR coefficients are common for all the countries (rows 3-6). In this case, as we can see from table 11, the null hypothesis is rejected at even 1% confidence interval for each one of the panel tests (Panel v-Statistic, rho-Statistic, PP-Statistic and ADF-Statistic), as the probability is smaller than 0.01. In the second panel the AR coefficients are not common (rows 7-9). In this case, the null hypothesis is rejected at 1% confidence interval for all of the Group Statistics (rho, PP and ADF), again, as the probability is smaller than 0.01. As a result, there is a cointegration relationship between the logs of GDP per capita and life expectancy.

If we include deterministic intercept and trend, we observe that both in the case of common and individual AR coefficients the null hypothesis is rejected at even

1% confidence interval (probability=0<1%). Consequently, there is cointegration relation between the logarithms of GDP per capita and life expectancy.

Finally, we run the Pedroni cointegration test by including neither deterministic trend nor intercept, and conclude that either with common AR coefficients or individual coefficients, the null hypothesis, (no cointegration relation between the two variables) is accepted at even 10% confidence interval.

Moreover, based on the Kao cointegration test we weakly accept (at 10% confidence interval) the null hypothesis that there is not cointegration relation between log of GDP per capita and life expectancy. Note that again the number of the observations is 2233 and the number of lags is selected by AIC.

Finally, we employ the Johansen cointegration test taking into account two cases. In the first one we exclude intercept and trend from cointegrating equation and VAR. In the second case we include intercept and trend in cointegration regression and only intercept in VAR. In both cases the selected lags are two and the observations are 2233. As a result, we get the tables below.

Table 12 and 14 present the unrestricted cointegration rank test based on Trace and Maximum Eigenvalue tests. The null hypotheses are; a) there is not cointegrating regression between the variables (3rd row), b) there is at most one cointegrating regressions (4th row). Both tests reject the first null hypothesis that there is not cointegrating relation between logarithm of GDP per capita and logarithm of life expectancy at 1% confidence interval, in both two cases that we consider. On the other hand, they do not reject the second null hypothesis that there is at most one equilibrium relation between the two variables at even 10% confidence interval (see table 12 and 14). As a result, the series are cointegrated.

Table 12: Johansen cointegration test

Johansen Fisher Panel Cointegration Test Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)				
Null Hypothesis	**Trace**	**Prob.**$^{+}$	**Max-Eigen**	**Prob.**$^{+}$
None (r=0)	336.2	0.0000*	346.8	0.0000*
At most 1 (r<=1)	21.86	0.9956	21.86	0.9956

$^{+}$Probabilities are computed using asymptotic Chi-square distribution.

Note: * denotes rejection at 1% level. Intercept and trend are exclude from cointegrating equation and VAR.

Table 13: Johansen cointegration test

Johansen Fisher Panel Cointegration Test Individual cross section results								
	Hypothesis of no cointegration				Hypothesis of at most 1 cointegration relationship			
Countries	**Trace**	**Prob.**[+]	**Max-Eign**	**Prob.**[+]	**Trace Test**	**Prob.**[+]	**Max-Eign**	**Prob.**[+]
AU	39.4201	0.0000*	39.4196	0.0000*	0.0005	0.9893	0.0005	0.9893
AT	27.8894	0.0001*	25.7592	0.0001*	2.1302	0.1703	2.1302	0.1703
BE	8.5491	0.1972	7.8681	0.1830	0.6810	0.4688	0.6810	0.4688
BG	16.6369	0.0089*	15.8184	0.0073*	0.8186	0.4215	0.8186	0.4215
CA	37.8774	0.0000*	37.6114	0.0000*	0.2660	0.6661	0.2660	0.6661
DK	35.9900	0.0000*	35.9627	0.0000*	0.0273	0.8926	0.0273	0.8926
FL	22.4212	0.0008*	22.4140	0.0004*	0.0072	0.9446	0.0072	0.9446
FR	12.4109	0.0483**	11.2552	0.0494**	1.1557	0.3290	1.1557	0.3290
HU	15.2119	0.0159**	15.2113	0.0095*	0.0006	0.9883	0.0006	0.9883
IE	16.6974	0.0087*	16.3805	0.0057*	0.3169	0.6355	0.3169	0.6355
IT	11.7953	0.0611***	10.8252	0.0587***	0.9701	0.3764	0.9701	0.3764
JP	20.2261	0.0020*	20.1773	0.0011*	0.0488	0.8564	0.0488	0.8564
NE	8.3609	0.2100	8.3464	0.1535	0.0145	0.9216	0.0145	0.9216
NZ	31.2211	0.0000*	29.9450	0.0000*	1.2761	0.3020	1.2761	0.3020
NO	40.4700	0.0000*	40.3778	0.0000*	0.0922	0.8029	0.0922	0.8029
PT	44.9999	0.0000*	44.5440	0.0000*	0.4559	0.5629	0.4559	0.5629
ES	11.0360	0.0813***	10.9731	0.0553***	0.0628	0.8372	0.0628	0.8372
SE	37.8528	0.0000*	37.8171	0.0000*	0.0357	0.8772	0.0357	0.8772
CH	33.0005	0.0000*	31.8542	0.0000*	1.1464	0.3312	1.1464	0.3312
GB	33.5843	0.0000*	33.4506	0.0000*	0.1337	0.7630	0.1337	0.7630
US	14.7101	0.0195**	14.3581	0.0136**	0.3520	0.6158	0.3520	0.6158

[+]MacKinnon-Haug-Michelis (1999) p-values.
Note: *, **, and *** denote rejection at 1%, 5%, and 10% level, respectively. Intercept and trend are exclude from cointegrating equation and VAR.

Table 14: Johansen cointegration test

Johansen Fisher Panel Cointegration Test Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)				
Null Hypothesis	**Trace**	**Prob.**[+]	**Max-Eigen**	**Prob.**[+]
None (r=0)	238.0	0.0000*	208.5	0.0000*
At most 1 (r<=1)	54.06	0.1004	54.06	0.1004

[+]Probabilities are computed using asymptotic Chi-square distribution.
Note: * denotes rejection at 1% level. Intercept and trend are included in cointegration regression and only intercept in VAR.

In tables 13 and 15 Trace and Maximum Eigenvalue tests are presented for each country separately. We, also, have two null hypotheses. In the first one there is not

cointegration relationship between the logarithm of total GDP and the one of life expectancy. In the second there is at most 1 cointegrating relationship between them.

Table 15: Johansen cointegration test

Johansen Fisher Panel Cointegration Test Individual cross section results								
	Hypothesis of no cointegration				Hypothesis of at most 1 cointegration relationship			
Countries	**Trace**	**Prob.**[+]	**Max-Eign**	**Prob.**[+]	**Trace Test**	**Prob.**[+]	**Max-Eign**	**Prob.**[+]
AU	20.6263	0.1958	15.1970	0.1832	5.4293	0.5359	5.4293	0.5359
AT	45.4447	0.0001*	33.7812	0.0002*	11.6635	0.0692***	11.6635	0.0692***
BE	22.1570	0.1354	13.9732	0.2560	8.1838	0.2370	8.1838	0.2370
BG	43.9770	0.0001*	37.8347	0.0000*	6.1423	0.4424	6.1423	0.4424
CA	34.1203	0.0037*	21.3115	0.0260**	12.8088	0.0447**	12.8088	0.0447**
DK	27.2688	0.0333**	21.2072	0.0269**	6.0616	0.4525	6.0616	0.4525
FL	30.3892	0.0128**	24.3163	0.0088*	6.0729	0.4511	6.0729	0.4511
FR	27.4301	0.0318**	21.5091	0.0242**	5.9210	0.4704	5.9210	0.4704
HU	37.7186	0.0011*	28.1077	0.0021*	9.6109	0.1459	9.6109	0.1459
IE	24.2308	0.0789***	19.7366	0.0445**	4.4942	0.6699	4.4942	0.6699
IT	29.2577	0.0182**	24.7756	0.0074*	4.4821	0.6717	4.4821	0.6717
JP	64.3538	0.0000*	54.0706	0.0000*	10.2832	0.1149	10.2832	0.1149
NE	27.6476	0.0298**	24.4961	0.0083*	3.1515	0.8580	3.1515	0.8580
NZ	17.8565	0.3536	14.3789	0.2297	3.4776	0.8156	3.4776	0.8156
NO	23.5305	0.0952***	18.9344	0.0581****	4.5961	0.6550	4.5961	0.6550
PT	48.6809	0.0000*	41.7090	0.0000*	6.9719	0.3475	6.9719	0.3475
ES	15.4606	0.5364	11.6516	0.4483	3.8089	0.7696	3.8089	0.7696
SE	43.5769	0.0001*	31.1478	0.0006*	12.4291	0.0517***	12.4291	0.0517***
CH	18.3531	0.3207	13.2866	0.3054	5.0665	0.5869	5.0665	0.5869
GB	22.7047	0.1180	18.2114	0.0734***	4.4933	0.6700	4.4933	0.6700
US	41.3389	0.0003*	23.4707	0.0120**	17.8683	0.0058*	17.8683	0.0058*

[+]MacKinnon-Haug-Michelis (1999) p-values.
Note: *, **, and *** denote rejection at 1%, 5%, and 10% level, respectively. Intercept and trend are included in cointegration regression and only intercept in VAR.

Table 13 shows us the case when we exclude intercept and trend from cointegrating equation and VAR. Table 15 shows us the case when we include intercept and trend in cointegration regression and only intercept in VAR. According to the Trace test the null hypothesis that there is not cointegration relationship between the two variables is not rejected at 10% confidence interval only for 2 countries (Belgium and New Zealand) in table 13 and 6 (Australia, Belgium, New Zealand, Spain, Switzerland and Great Britain) of the 21 countries in table 15. As for

the Maximum Eigenvalue cointegration test the null hypothesis is not rejected at 10% for 2 (Belgium and New Zealand) in table 13 and 5 (Australia, Belgium, New Zealand, Spain and Switzerland) of the 21 economies in table 15. Furthermore, based on Trace and Maximum Eigenvalue cointegration tests, the null hypothesis that there is at most one cointegrating relation between logarithm of GDP per capita and logarithm of life expectancy is rejected at 10% confidence interval in the case of none and 4 countries (Austria, Canada, Sweden and United States) according to tables 13 and 15, respectively.

Taking into account the first two cases of the Pedroni (no deterministic trend, deterministic intercept and trend) and the Johansen cointegration tests, we can conclude that there is a long run relation between the variables in question. As a result, in order to describe both short-run dynamics and long-run equilibrium simultaneously we proceed by running a simple vector error correction model (VECM) first with none and then with one lag, as described in section 4.5, with OLS. As we have said before we follow the Engle-Granger two-step method. Table 16 gives us the results of this analysis. We have three regressions presented in table 16.

The first one is the cointegrating equation. As we can see the number of the observations by employing FMOLS and DOLS is 2212 and 2187, respectively. Moreover, in both cases the long-run coefficient of the logarithm of life expectancy at birth is statistically significant even at 1% confidence interval. Also, the R-square is in the two cases around 85% or 87%, respectively. This means that the independent variable (life expectancy) interpret 85% or 87% of the model. The coefficient of life expectancy is 3.63 in the case that we run the cointegrating equation by FMOLS and 3.57 by DOLS. These mean that a 1% increase in life expectancy in the long-run leads to a 3.63% or 3.57% increase in GDP per capita, depending on the model considered.

The second equation is the ECM without including any lag. The number of the observations is 2191 in the case we run the ECM taking into account the residuals of the cointegrated equation estimated by FMOLS and 2177 by DOLS. Furthermore, the R-square is around 0.31 in both cases. Note that it is not that small, although the dimension of our data is panel. In both estimations (with FMOLS and DOLS), all variables, that is the first difference of logarithm of life expectancy (β_1), the error correction term (γ_1) and the constant term C are statistically significant at even 1% confidence interval. The coefficient β_1 is 0.19 and 0.16 running the ECM based on FMOLS and DOLS estimation of residuals of cointegrating equation, respectively.

So, if the change of life expectancy rises by 1%, the change of GDP per capita will rise by 0.19% in the first case and by 0.16% in the second. As for the adjustment parameter, it is negative in both cases. This is very important as it is consistent with the hypothesis that the error correction corrects the deviation from the long-run equilibrium relationship. Moreover, it equals to -0.019 in the case of using FMOLS method and -0.014 using DOLS method. In other words, 1.9% or 1.4% of the discrepancy between the two rates in the previous year is eliminated this year.

Finally, the third equation of the table 16 is the ECM with one lag. The number of observations is 2191 when we use the FMOLS method to get the residuals and 2177 if we use the DOLS method. The R-square is 34.2% and 33.8%, respectively. Moreover, all variables are statistically significant at even 1% confidence interval except for β_4, which is statistically significant at 10% level in the case of DOLS and insignificant in the case of FMOLS. Analytically, if DLLF increase by 1%, the DLGDP will increase by about 0.18% (FMOLS approach) or 0.16% (DOLS approach). If the lag value of the change of GDP per capita rise by 1%, the change of this year GDP per capita will increase by about 0.20% in both cases. Additionally, if the growth rate of life expectancy of last period increases by 1%, the growth rate of GDP per capita will rise by about 0.014% and 0.06%. Finally, the error correction is again consistent with the hypothesis that the error correction corrects the deviation from the long-run equilibrium relationship, as it is negative. About 1.6% or 1.9% of the gap between the two variables in the previous year doesn't exist this year.

Table 16: Cointegrating Equations & ECMs

	Fully Modified OLS				**Dynamic OLS**			
1.LGDPC=βLLF								
	Observations 2212				Observations 2187			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
LLF	3.633606*	49.23673	0.0000	0.847380	3.567934*	50.24468	0.0000	0.872028
2.DLGDPC=α_1+β_1DLLF+γ_1ECT(-1)								
	Observations 2191				Observations 2177			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
DLLF	0.192039*	6.377520	0.0000	0.311734	0.162657*	5.446414	0.0000	0.306297
ECT(-1)	-0.019563*	-5.628261	0.0000		-0.014273*	-4.023934	0.0001	
C	0.019649*	23.59875	0.0000		0.020170*	24.37258	0.0000	
3.DLGDPC=α_2+β_2DLLF+β_3DLGDPC(-1)+ β_4DLLF(-1)+γ_2ECT(-1)								
	Observations 2191				Observations 2177			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**

DLLF	0.181414*	6.074402	0.0000	0.342473	0.161433*	5.417092	0.0000	0.338393
DLGDPC(-1)	0.204190*	9.457984	0.0000		0.202242*	9.266134	0.0000	
DLLF(-1)	0.014806	0.498529	0.6182		0.056442***	1.908051	0.0565	
ECT(-1)	-0.019065*	-5.52037	0.0000		-0.016096*	-4.634462	0.0000	
C	0.015272*	16.34472	0.0000		0.015605*	16.70779	0.0000	

Note: * and *** denote significance at 1% and 10% level, respectively. ECMs are estimated by OLS using the residuals from both FMOLS and DOLS cointegrating regressions.

To conclude, according to the above analysis, life expectancy at birth (as an indicator of health standard) has a significant, positive, sizeable effect on GDP per capita not only in the short-run, but also in the long-run.

Finally, we employ panel Granger causality test, in order to find out if there is any causation relation between the first difference of logarithm of life expectancy at birth and the first difference of the logarithm of per capita GDP. Note that we include two lags. Table 17 show us the results.

Table 17: Panel Granger causality test

Null Hypothesis:	**W-Stat**	**Zbar-Stat.**	**Prob.**
DLLF does not Granger Cause DLGDPC	3.02555	2.12090	0.0339**
DLGDPC does not Granger Cause DLLF	6.97307	10.7135	0.0000*

Note: * and ** denote rejection at 1% and 5% level, respectively. The test is based on Dumitrescu-Hurlin (2012) technique.

Table 17 presents two null hypotheses. The first one is that first difference of the log of life expectancy does not cause the first difference of the log of per capita GDP and the second that the first difference of the log of per capita GDP does not cause the first difference of the log of life expectancy. In both cases, the p-values are smaller than 0.05, so the null hypotheses are rejected at 5% confidence interval. Consequently, lagged values of the growth rate of life expectancy explain the current value the growth rate of per capita GDP. Conversely, lagged values of the growth rate of per capita GDP explain the current value of the growth rate of life expectancy. In other words, there is a two-way causality between the two variables. Note that the first result (that life expectancy causes growth) is similar with the result that we obtain from ECMs, as the short-run parameters are statistically significant and positive.

5.2. The relationship between total GDP and life expectancy at birth

In this section, we are going to investigate the relationship between total GDP and life expectancy at birth. We should not forget the analysis of life expectancy that had been done in the previous section. Remember that life expectancy is an I(1) process.

5.2.1. Descriptive statistics and stationarity

Now we are going to do the same analysis for total GDP. First, we present a table with descriptive statistics of the level value of total income for each country, respectively.

Table 18: Descriptive statistics

Countries	Mean	Std. Dev.	Obs.
AT	97624518	53205132	62
AU	1.67E+08	1.42E+08	88
BE	1.01E+08	67234392	90
BG	41437750	14461862	58
CA	2.89E+08	2.42E+08	88
CH	64642664	53653541	133
DK	32430103	38361350	174
ES	2.22E+08	2.15E+08	101
FL	31690092	34948861	131
FR	3.12E+08	3.78E+08	188
GB	6.29E+08	3.67E+08	87
HU	57058618	17350264	59
IE	36974893	28536471	59
IT	3.33E+08	3.63E+08	137
JP	1.43E+09	9.47E+08	62
NE	90980032	1.10E+08	159
NO	26427000	35292669	163
NZ	40564212	18239492	61
PT	68791226	47471259	69
SE	46613310	59404665	188
US	3.84E+09	2.62E+09	76
All	3.04E+08	8.90E+08	2233

Then, in order to get a clue about the nature of the series in question, we plot the graphs for each country of the logarithm of total GDP.

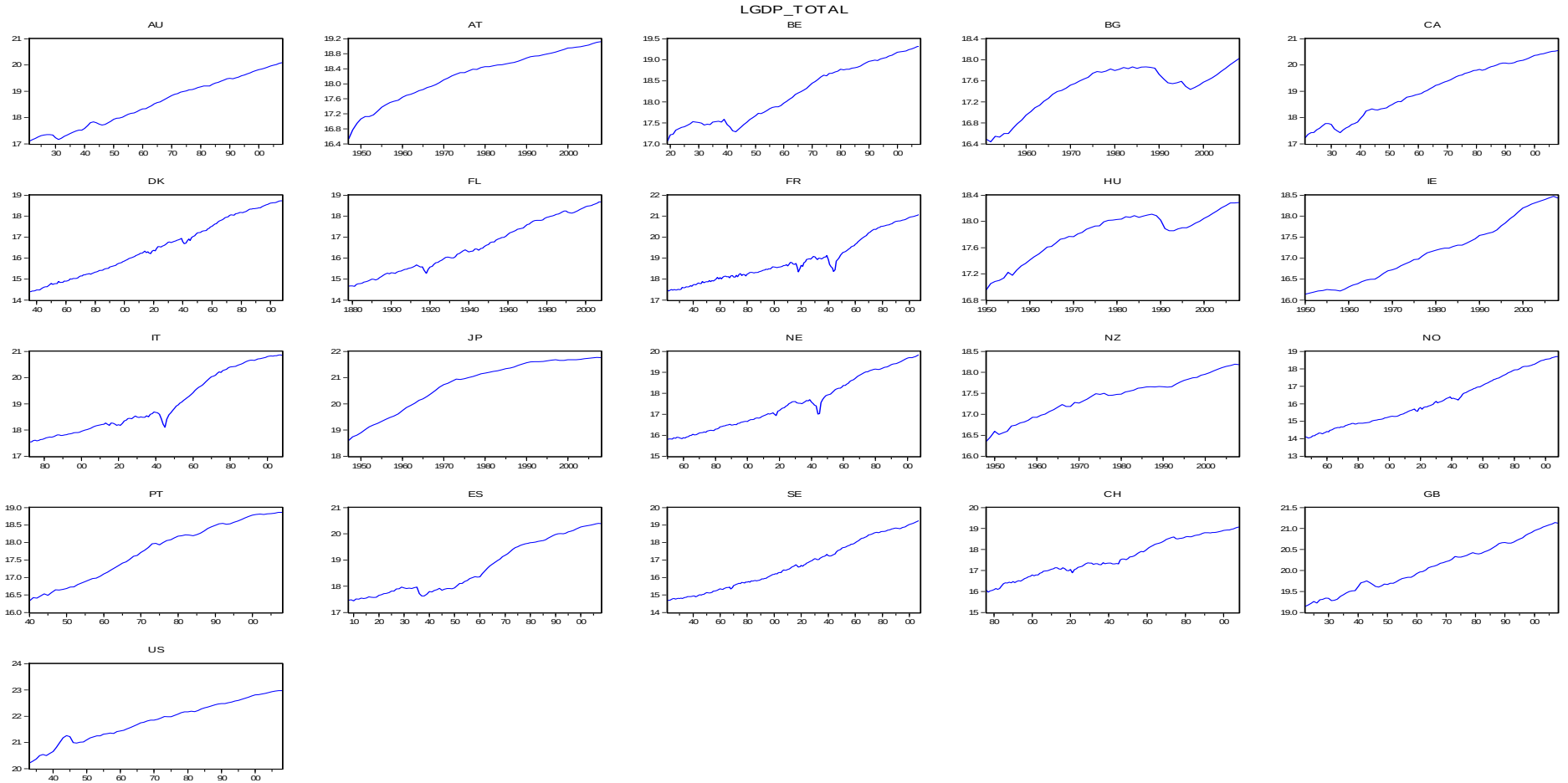
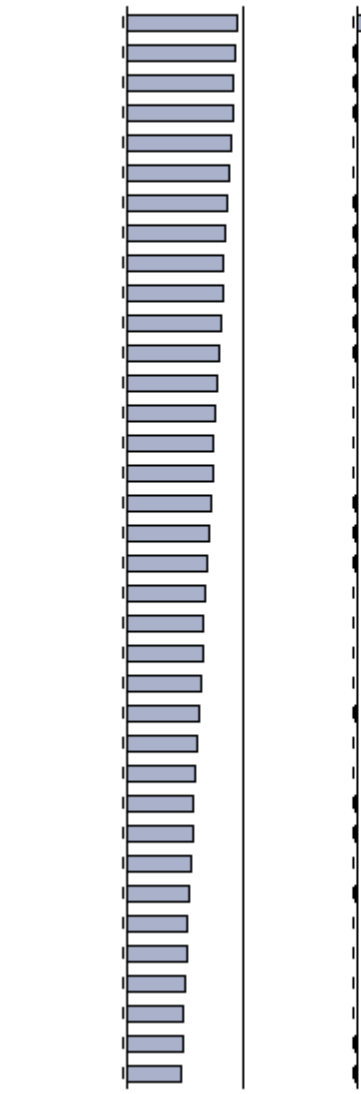


Figure 6: log of total GDP

According to the graphs above, the logarithm of total GDP is increasing, showing an upward trend. This suggests that the series is probably not stationary. Moreover, from the sample autocorrelation function below we see that the autocorrelation coefficients are very high at various lags and decline very slowly toward zero. As a result, total GDP is probably a non-stationary series.

Sample: 1821 2008
Included observations: 2233



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.986	0.986	2174.0	0.000
		2	0.972	-0.020	4286.2	0.000
		3	0.957	-0.010	6337.2	0.000
		4	0.943	-0.013	8327.2	0.000
		5	0.928	-0.006	10257.	0.000
		6	0.914	-0.006	12128.	0.000
		7	0.899	-0.012	13941.	0.000
		8	0.885	-0.010	15696.	0.000
		9	0.870	-0.010	17394.	0.000
		10	0.855	-0.008	19035.	0.000
		11	0.840	-0.010	20621.	0.000
		12	0.825	-0.010	22152.	0.000
		13	0.811	-0.006	23630.	0.000
		14	0.796	-0.005	25055.	0.000
		15	0.781	-0.007	26428.	0.000
		16	0.767	-0.008	27751.	0.000
		17	0.752	-0.009	29024.	0.000
		18	0.737	-0.012	30249.	0.000
		19	0.722	-0.012	31425.	0.000
		20	0.708	-0.006	32554.	0.000
		21	0.693	-0.003	33637.	0.000
		22	0.678	-0.006	34676.	0.000
		23	0.664	-0.007	35671.	0.000
		24	0.649	-0.008	36624.	0.000
		25	0.635	-0.008	37535.	0.000
		26	0.621	-0.005	38406.	0.000
		27	0.606	-0.009	39238.	0.000
		28	0.592	-0.013	40031.	0.000
		29	0.578	-0.007	40786.	0.000
		30	0.563	-0.009	41505.	0.000
		31	0.549	-0.005	42188.	0.000
		32	0.535	-0.007	42836.	0.000
		33	0.521	-0.007	43451.	0.000
		34	0.507	-0.004	44034.	0.000
		35	0.493	-0.009	44585.	0.000
		36	0.479	-0.008	45106.	0.000

Continuing, we will employ the IPS unit root test, in order to examine if the series is stationary or not. We do the test considering the AIC. The number of the observations is 2145 in the case that we include individual effects and 2162 when we include individual effect and linear trend. Tables 19 and 20 report the results of the IPS test.

Table 19: IPS unit root test

Log of total GDP		
H_0: unit root	t-stat.	Prob.[+]
Individual effects	3.3816	0.9996
Individual effects & trend	-1.61707	0.0529***

[+]Probabilities are computed assuming asymptotic normality.
Note: *** denotes rejection at 10% level.

Table 20: IPS unit root test

Log of total GDP								
	country-by-country ADF t-statistics							
	Individual effects				Individual effects and trends			
Cross section	**t-stat.**	**Prob.[+]**	**Lags**	**Obs.**	**t-stat.**	**Prob.[+]**	**Lags**	**Obs.**
AU	-0.6871	0.8432	10	77	-1.3089	0.8784	10	77
AT	-6.9758	0.0000*	0	61	-6.8856	0.0000*	0	61
BE	0.1733	0.9694	3	86	-2.5408	0.3083	2	87
BG	-2.7108	0.0785***	1	56	-3.4575	0.0549**	5	52
CA	-3.0287	0.0367**	11	76	-2.5313	0.3127	1	86
DK	0.2630	0.9757	0	173	-2.6623	0.2537	0	173
FL	0.3837	0.9816	4	126	-2.1511	0.5122	4	126
FR	0.7695	0.9933	5	182	-1.4297	0.8492	5	182
HU	-1.9458	0.3096	1	57	-1.6630	0.7547	1	57
IE	0.3690	0.9799	1	57	-2.5656	0.2971	1	57
IT	0.3642	0.9807	2	134	-1.8680	0.6655	2	134
JP	-3.5779	0.0097*	10	51	-1.3093	0.8744	10	51
NE	0.6156	0.9898	2	156	-2.4021	0.3770	2	156
NZ	-2.2551	0.1897	0	60	-3.0114	0.1378	0	60
NO	1.5625	0.9994	0	162	-1.6574	0.7655	0	162
PT	-1.7740	0.3900	4	64	0.1043	0.9967	4	64
ES	0.5695	0.9882	1	99	-1.7515	0.7206	1	99
SE	1.4859	0.9993	0	187	-2.3625	0.3980	0	187
CH	-0.5728	0.8716	0	132	-1.9318	0.6323	0	132
GB	0.2006	0.9712	2	84	-3.1350	0.1050	1	85
US	-0.9000	0.7823	10	65	-4.5081	0.0028*	1	74

[+]Probabilities are computed assuming asymptotic normality.
Note: *, **, and *** denote rejection at 1%, 5%, and 10% level, respectively.

As previously, the null hypothesis is that total GDP has a unit root, in other words, it is a non-stationary series. From table 19 yields that the total GPD is not stationary, as the t-statistic p-values (0.9996 and 0.0529 respectively) are greater than

5%. So, the null hypothesis is not rejected at 5% confidence interval. However, the null hypothesis is not rejected at 1% level in the case of inclusion of both individual effects and trend, according to table 20, only for four (Austria at 1% level, Bulgaria at 10%, Canada at 5%, and Japan at 1%) out of the 21 countrie. And only for three countries (Austria at 1% level, Bulgaria at 10%, and United States at 1%), in the case of inclusion of both intercept and trend.

As in both cases the results are driven by a small number of countries, we conclude that there is a unit root in the panel. We therefore proceed to consider the first difference of the series.

In order to find the number of integration of the logarithm of total GDP we test for stationarity the first difference of the variable. Before we do the formal tests, we plot the graphs of the first difference of the logarithm of total GDP for each of the 21 countries separately.

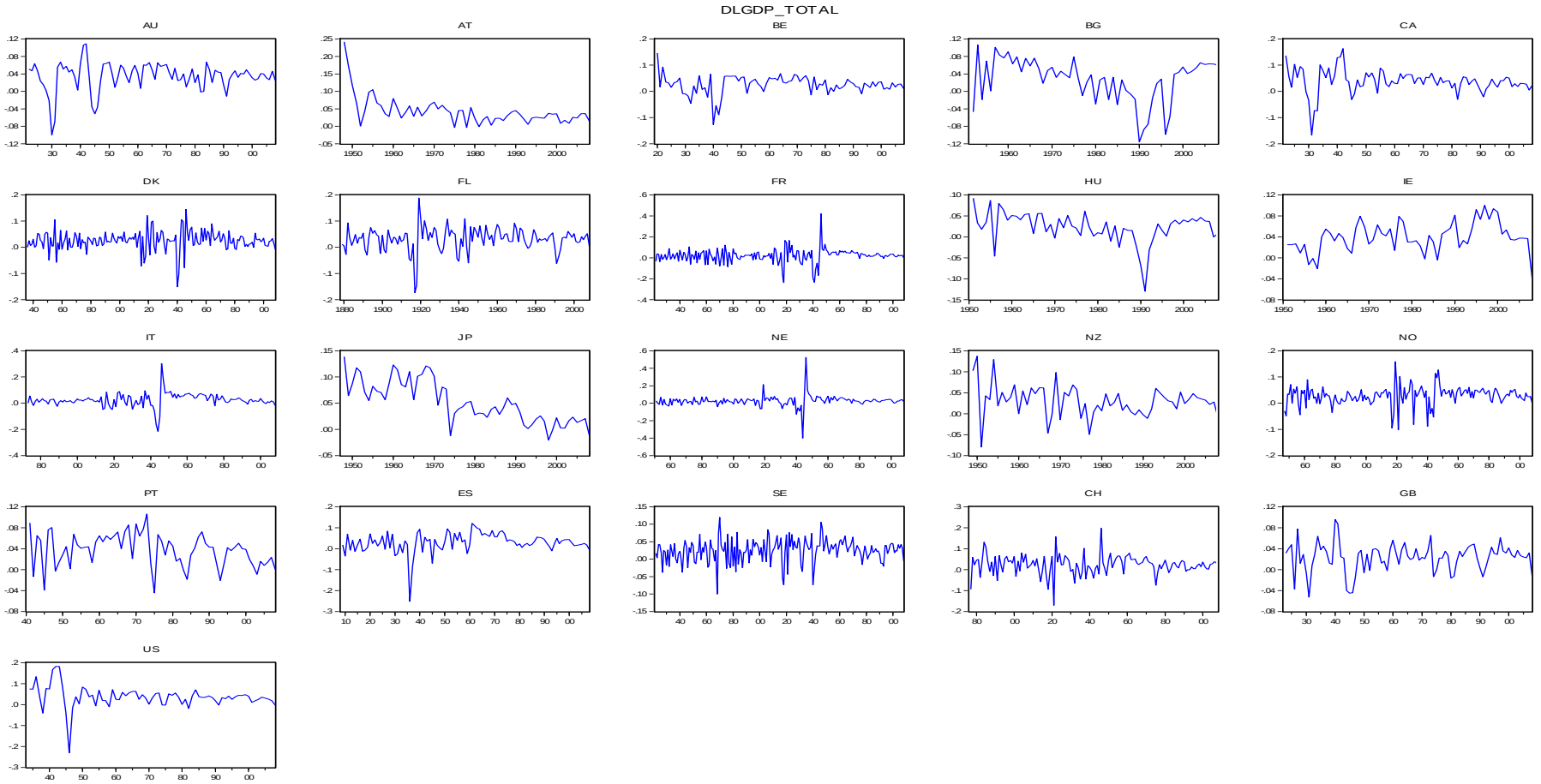


Figure 7: 1st difference of log total GDP

As we can see from the graphs above, the first differences of the variable in question seem to be stationary. Furthermore, the autocorrelation function below indicates that there is probably not presence of a unit root, as autocorrelation coefficients tend to be zero. That is, the first difference of the logarithm of total GDP is probably stationary.

Sample: 1821 2008
Included observations: 2212

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.254	0.254	143.39	0.000
		2	0.058	-0.007	150.85	0.000
		3	0.083	0.075	166.29	0.000
		4	0.019	-0.022	167.10	0.000
		5	-0.049	-0.055	172.52	0.000
		6	-0.002	0.020	172.53	0.000
		7	0.041	0.041	176.21	0.000
		8	0.029	0.018	178.06	0.000
		9	0.083	0.075	193.27	0.000
		10	0.052	0.003	199.26	0.000
		11	0.017	-0.003	199.87	0.000
		12	0.028	0.019	201.60	0.000
		13	0.059	0.048	209.31	0.000
		14	0.056	0.039	216.33	0.000
		15	0.017	-0.009	217.01	0.000
		16	0.009	-0.008	217.20	0.000
		17	0.043	0.036	221.24	0.000
		18	-0.011	-0.035	221.53	0.000
		19	-0.032	-0.023	223.87	0.000
		20	-0.026	-0.023	225.37	0.000
		21	-0.031	-0.025	227.45	0.000
		22	0.018	0.035	228.21	0.000
		23	0.048	0.031	233.38	0.000
		24	0.057	0.035	240.75	0.000
		25	-0.018	-0.053	241.51	0.000
		26	0.062	0.068	250.20	0.000
		27	0.065	0.033	259.69	0.000
		28	-0.048	-0.064	264.79	0.000
		29	-0.089	-0.070	282.69	0.000
		30	0.006	0.038	282.78	0.000
		31	-0.023	-0.027	283.96	0.000
		32	-0.078	-0.055	297.66	0.000
		33	-0.040	-0.025	301.34	0.000
		34	-0.001	0.012	301.34	0.000
		35	-0.024	-0.020	302.66	0.000
		36	-0.029	-0.027	304.49	0.000

Then we employ the IPS unit root test, first with individual intercept, and then with individual intercept and linear trend. The number of observations is 2135 and 2137, respectively. Furthermore, we choose the AIC for the lag selection. Tables 21 and 22 report the results.

Table 21: IPS unit root test

Difference of log of total GDP		
H_0: unit root	t-stat.	Prob.[+]
Individual effects	-27.2304	0.0000*
Individual effects & trend	-28.2389	0.0000*

[+]Probabilities are computed assuming asymptotic normality.
Note: * denotes rejection at 1% level.

Table 22: IPS unit root test

Difference of log of total GDP								
	country-by-country ADF t-statistics							
	Individual effects				Individual effects and trends			
Cross section	**t-stat.**	**Prob.[+]**	**Lags**	**Obs.**	**t-stat.**	**Prob.[+]**	**Lags**	**Obs.**
AU	-5.1469	0.0000*	9	77	-4.8379	0.0010*	9	77
AT	-5.4014	0.0000*	2	58	-6.8184	0.0000*	0	60
BE	-4.3159	0.0008*	2	86	-4.3350	0.0045*	2	86
BG	-4.5018	0.0006*	0	56	-4.8316	0.0013*	0	56
CA	-3.6881	0.0062*	11	75	-5.3564	0.0002*	11	75
DK	-10.820	0.0000*	1	171	-10.806	0.0000*	1	171
FL	-6.6729	0.0000*	3	126	-6.6833	0.0000*	3	126
FR	-6.7025	0.0000*	4	182	-6.8206	0.0000*	4	182
HU	-5.2350	0.0001*	0	57	-5.3995	0.0002*	0	57
IE	-3.8033	0.0049*	0	57	-3.7608	0.0261**	0	57
IT	-7.0515	0.0000*	1	134	-7.0973	0.0000*	1	134
JP	-0.6112	0.8588	9	51	-3.4028	0.0622***	9	51
NE	-9.3156	0.0000*	1	156	-9.3705	0.0000*	1	156
NZ	-8.1716	0.0000*	0	59	-8.3768	0.0000*	0	59
NO	-11.866	0.0000*	0	161	-11.997	0.0000*	0	161
PT	-3.5470	0.0097*	3	64	-4.0184	0.0128**	3	64
ES	-7.1038	0.0000*	0	99	-7.1853	0.0000*	0	99
SE	-12.904	0.0000*	0	186	-13.071	0.0000*	0	186
CH	-12.287	0.0000*	0	131	-12.277	0.0000*	0	131
GB	-5.4497	0.0000*	1	84	-5.4468	0.0001*	1	84
US	-6.9248	0.0000*	9	65	-6.7399	0.0000*	9	65

[+]Probabilities are computed assuming asymptotic normality.
Note: *, **, and *** denote rejection at 1%, 5%, and 10% level, respectively.

According to table 21, the first difference of the logarithm of total GDP does not have a unit root in both cases (individual effects, individual effects and linear trend), as the t-statistic p-value equals to 0, that is it is smaller than even 1%. In other

words, the null hypothesis is rejected at 1% confidence interval (as 0<0.01) and so the series is stationary. This implies that the logarithm of total GDP is integrated of order one, or I(1) process. Moreover, from table 22, which shows the country-by-country ADF t-statistics, we conclude that the null hypothesis is not rejected even at 10% confidence interval only for Japan, in the case of inclusion of individual effects, as t-statistic p-value is 0.8588>0.1. In the case of inclusion of both intercept and trend, the null hypothesis is rejected at 10% for all economies. Consequently, due to the fact that the logarithms of total GDP and life expectancy at birth are both integrated of degree one, we proceed to find out if there is an equilibrium relation between the two variables.

5.2.2. Cointegration and error correction

First, it would be useful to plot a graph of the logarithm of the two variables together for each country.

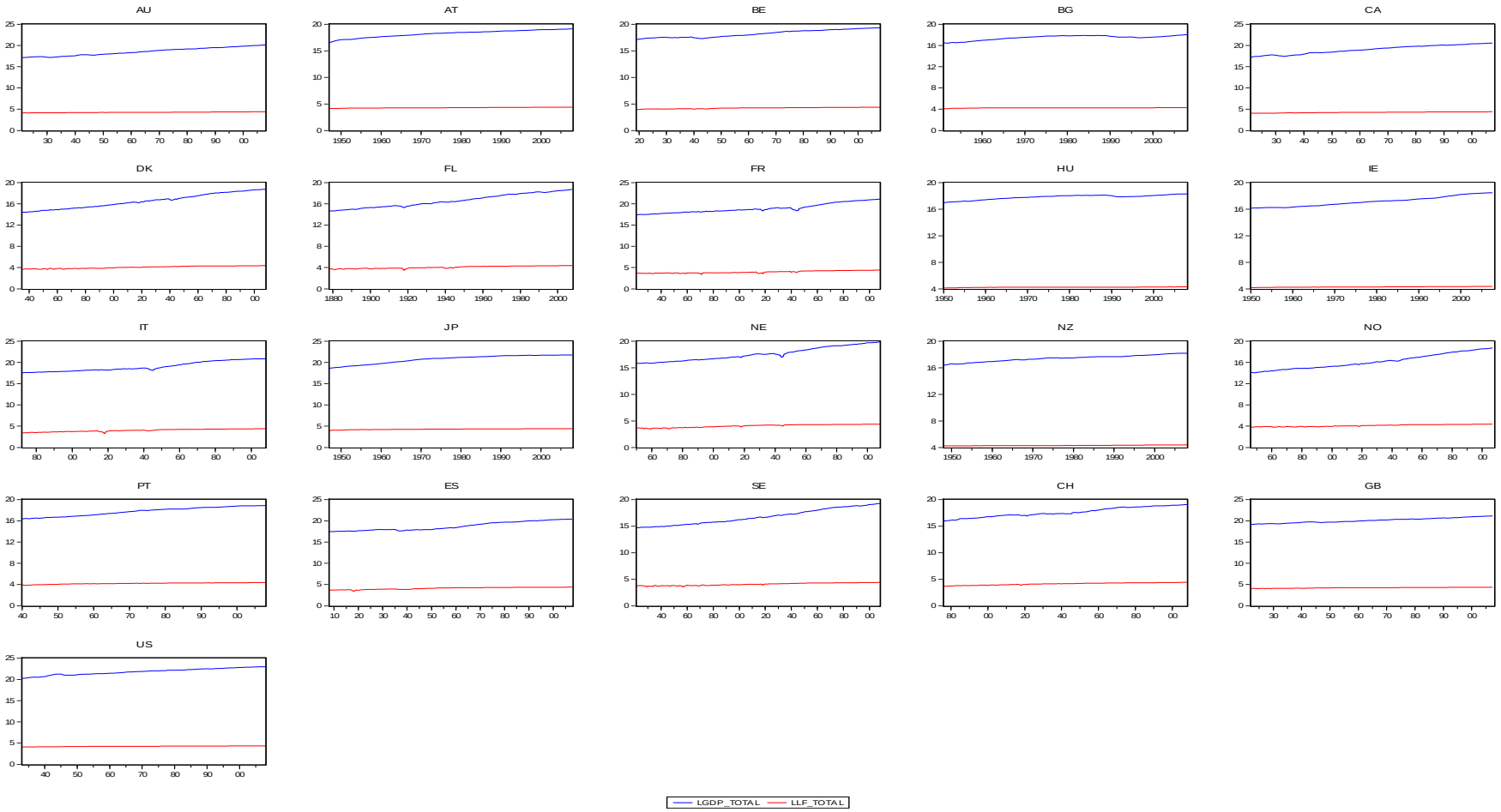


Figure 8: log total GDP & life expectancy

From the above graphs we observe that the two variables tend to move generally together.

Then we will employ the Pedroni, Kao and Johansen cointegration tests. Table 23 below reports the results of the Kao cointegration test and the Pedroni cointegration, tests taking into account three cases. The first case of the Pedroni cointegration test is that there is not deterministic trend, the second that there is deterministic intercept and trend and the third that there is neither deterministic intercept nor trend. The number of observations in all cases is 2233. The number of lags is, also, chosen based on the AIC. Moreover, the null hypothesis of both tests is that there is no cointegration relation between total GDP and life expectancy. Remember that the Pedroni cointegration test consists of two parts. In the first one we assume the same AR coefficients for each country and in the second one different.

Table 23: Pedroni & Kao cointegration tests

		H_0: no cointegration					
Pedroni		**no deterministic trend**		**deterministic intercept and trend**		**no deterministic intercept and trend**	
		Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
H_1: common AR coef.	Panel v-Statistic	3.91846	0.0000*	3.68471	0.0001*	-0.51011	0.6950
	Panel rho-Statistic	-15.1049	0.0000*	-25.1689	0.0000*	-4.38807	0.0000*
	Panel PP-Statistic	-9.49926	0.0000*	-15.6572	0.0000*	-3.40569	0.0003*
	Panel ADF-Statistic	-4.38078	0.0000*	-9.72467	0.0000*	-0.77788	0.2183
H_1: individual coef.	Group rho-Statistic	-8.17517	0.0000*	-10.0223	0.0000*	0.16578	0.5658
	Group PP-Statistic	-7.28740	0.0000*	-9.95763	0.0000*	-1.35306	0.0880***
	Group ADF-Statistic	-4.67989	0.0000*	-4.85237	0.0000*	0.86087	0.8053
Kao							
ADF-Statistic		1.63839	0.0507***				

Note: * and *** denote rejection at 1% and 10% level, respectively.

Looking at table 23 we observe that in the first two cases (no deterministic trend, deterministic intercept and trend) all of the 7 tests reject the null hypothesis at even 1% confidence interval, as the p-values are smaller than 0.01. So, according to these two cases there is an equilibrium relation between the two variables.

In the third case (columns 7, and 8) neither deterministic intercept nor trend are included. Based on this test there is equilibrium relation between the two

variables, only in the cases of panel rho-statistic and panel PP-statistic at 1% confidence interval (p-values are 0 and 0.0003 <0.01, respectively) and group PP-statistic at 10% (p-value=0.088<0.1). In other words, only 3 of seven tests reject the null hypothesis of no cointegration at 10% confidence interval.

Furthermore, based on the Kao cointegration test, with again 2233 observations and using AIC for lags selection, the t-statistic is 1.638 and the p-value 0.0507. The p-value is smaller than 0.1, so the null hypothesis that there is not cointegration is weakly rejected at 10% confidence interval. As a result, there is (a weaker compared to the most of the Pedroni cointegration results) equilibrium relationship between total GDP and life expectancy, according to the Kao test at 10% confidence interval.

Finally, we employ the Johansen cointegration test taking into account two cases. In the first one we exclude intercept and trend from cointegrating equation and VAR. In the second case we include intercept and trend in cointegration regression and only intercept in VAR. In both cases the selected lags are two and the observations are 2233. As a result, we get the following tables.

Table 24 and 26 present the unrestricted cointegration rank test based on Trace and Maximum Eigenvalue tests. Note again that the null hypotheses are; a) there is not cointegrating regression between the variables (3rd row), b) there is at most one cointegrating regressions (4th row). Both tests reject the first null hypothesis that there is not cointegrating relation between logarithm of total GDP and logarithm of life expectancy at 1% confidence interval. On the other hand, in both cases (table 24 and 26) the second null hypothesis is not rejected at 10% and 5% confidence interval, respectively. As a result, the series are cointegrated.

Table 24: Johansen cointegration test

Johansen Fisher Panel Cointegration Test Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)				
Null Hypothesis	**Trace**	**Prob.+**	**Max-Eigen**	**Prob.+**
None (r=0)	401.8	0.0000*	391.6	0.0000*
At most 1 (r<=1)	50.55	0.1715	50.55	0.1715

+ Probabilities are computed using asymptotic Chi-square distribution.
Note: * and *** denote rejection at 1% and 10% level, respectively. Intercept and trend are excluded from cointegration regression and VAR.

Table 25: Johansen cointegration test

Johansen Fisher Panel Cointegration Test Individual cross section results								
	Hypothesis of no cointegration				Hypothesis of at most 1 cointegration relationship			
Countries	**Trace**	**Prob.**[+]	**Max-Eign**	**Prob.**[+]	**Trace Test**	**Prob.**[+]	**Max-Eign**	**Prob.**[+]
AU	43.2067	0.0000*	43.2019	0.0000*	0.0048	0.9546	0.0048	0.9546
AT	30.5014	0.0000*	28.6674	0.0000*	1.8339	0.2067	1.8339	0.2067
BE	7.9404	0.2413	7.8833	0.1820	0.0571	0.8447	0.0571	0.8447
BG	16.4240	0.0097*	16.3508	0.0058*	0.0732	0.8243	0.0732	0.8243
CA	39.5695	0.0000*	39.5608	0.0000*	0.0088	0.9390	0.0088	0.9390
DK	53.0709	0.0000*	52.5016	0.0000*	0.5693	0.5125	0.5693	0.5125
FL	33.6099	0.0000*	31.4821	0.0000*	2.1278	0.1706	2.1278	0.1706
FR	27.5735	0.0001*	22.0560	0.0005*	5.5175	0.0224**	5.5175	0.0224**
HU	18.3244	0.0044*	18.1641	0.0026*	0.1603	0.7406	0.1603	0.7406
IE	18.1418	0.0048*	17.8061	0.0031*	0.3356	0.6249	0.3356	0.6249
IT	26.1872	0.0001*	18.0810	0.0027*	8.1061	0.0052*	8.1061	0.0052*
JP	14.0848	0.0251**	14.0101	0.0158**	0.0748	0.8224	0.0748	0.8224
NE	18.6744	0.0038*	17.7411	0.0032*	0.9333	0.3868	0.9333	0.3868
NZ	36.5533	0.0000*	33.3819	0.0000*	3.1715	0.0888***	3.1715	0.0888***
NO	49.4922	0.0000*	49.4252	0.0000*	0.0670	0.8319	0.0670	0.8319
PT	37.4274	0.0000*	37.4271	0.0000*	0.0002	0.9915	0.0002	0.9915
ES	16.8488	0.0082*	14.8222	0.0112**	2.0266	0.1822	2.0266	0.1822
SE	51.6950	0.0000*	49.5025	0.0000*	2.1925	0.1636	2.1925	0.1636
CH	35.6828	0.0000*	31.5148	0.0000*	4.1680	0.0489**	4.1680	0.0489**
GB	33.3932	0.0000*	32.8909	0.0000*	0.5023	0.5414	0.5023	0.5414
US	14.5490	0.0208**	14.5405	0.0126**	0.0085	0.9399	0.0085	0.9399

[+]MacKinnon-Haug-Michelis (1999) p-values.

Note: *, **, and *** denote rejection at 1%, 5%, and 10% level, respectively. Intercept and trend are excluded from cointegration regression and VAR.

Table 26: Johansen cointegration test

Johansen Fisher Panel Cointegration Test Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)				
Null Hypothesis	**Trace**	**Prob.**[+]	**Max-Eigen**	**Prob.**[+]
None (r=0)	244.1	0.0000*	209.4	0.0000*
At most 1 (r<=1)	57.70	0.0540***	57.70	0.0540***

[+] Probabilities are computed using asymptotic Chi-square distribution.

Note: * and *** denote rejection at 1% and 10% level, respectively. Intercept and trend are included in cointegration regression and only intercept in VAR.

In tables 25 and 27 Trace and Maximum Eigenvalue tests are presented again, but this time for each country separately. We, also, have two null hypotheses. The first is that there is not cointegration relationship between the logarithm of total GDP and the one of life expectancy. The second is that there is at most 1 cointegrating relationship between them.

Table 27: Johansen cointegration test

Johansen Fisher Panel Cointegration Test Individual cross section results								
	Hypothesis of no cointegration				Hypothesis of at most 1 cointegration relationship			
Countries	**Trace**	**Prob.**[+]	**Max-Eign**	**Prob.**[+]	**Trace Test**	**Prob.**[+]	**Max-Eign**	**Prob.**[+]
AU	22.2283	0.1331	15.4510	0.1704	6.7773	0.3683	6.7773	0.3683
AT	46.9564	0.0000*	33.9914	0.0002*	12.9650	0.0421**	12.9650	0.0421**
BE	21.7546	0.1496	14.6050	0.2160	7.1496	0.3292	7.1496	0.3292
BG	44.2930	0.0001*	36.8061	0.0001*	7.4869	0.2965	7.4869	0.2965
CA	31.0400	0.0104**	16.1605	0.1385	14.8796	0.0198**	14.8796	0.0198**
DK	23.6066	0.0933***	17.3841	0.0954***	6.2225	0.4326	6.2225	0.4326
FL	32.9109	0.0056*	27.0324	0.0032*	5.8785	0.4759	5.8785	0.4759
FR	27.8881	0.0277**	22.8917	0.0148**	4.9963	0.5969	4.9963	0.5969
HU	39.9529	0.0005*	30.8887	0.0007*	9.0642	0.1764	9.0642	0.1764
IE	33.0733	0.0053*	26.9199	0.0033*	6.1535	0.4410	6.1535	0.4410
IT	29.4465	0.0172**	25.3720	0.0060*	4.0745	0.7313	4.0745	0.7313
JP	64.9036	0.0000*	53.9717	0.0000*	10.9319	0.0907***	10.9319	0.0907***
NE	24.9336	0.0651***	21.3655	0.0255**	3.5681	0.8033	3.5681	0.8033
NZ	21.3085	0.1667	14.1567	0.2438	7.1518	0.3290	7.1518	0.3290
NO	22.5471	0.1228	19.2465	0.0524***	3.3006	0.8390	3.3006	0.8390
PT	51.2713	0.0000*	42.9859	0.0000*	8.2853	0.2293	8.2853	0.2293
ES	14.9822	0.5760	11.4572	0.4673	3.5250	0.8092	3.5250	0.8092
SE	41.1028	0.0003*	31.9618	0.0005*	9.1410	0.1719	9.1410	0.1719
CH	15.5953	0.5254	10.9133	0.5223	4.6820	0.6425	4.6820	0.6425
GB	21.6870	0.1521	17.0610	0.1055	4.6260	0.6506	4.6260	0.6506
US	39.5682	0.0006*	21.4624	0.0246**	18.1057	0.0053*	18.1057	0.0053*

[+]MacKinnon-Haug-Michelis (1999) p-values.
Note: *, **, and *** denote rejection at 1%, 5%, and 10% level, respectively. Intercept and trend are included in cointegration regression and only intercept in VAR.

According to the Trace test, the null hypothesis that there is not cointegration relationship between the variables in question is not rejected at 10% confidence interval only in the case of 1 (Belgium) and 7 of the 21 countries mentioned (Australia, Belgium, New Zealand, Norway, Spain, Switzerland and Great Britain),

based on tables 25 and 27 ,respectively. Moreover, the Maximum Eigenvalue test shows that only for 1 (Belgium) and 7 countries (Australia, Belgium, Canada, New Zealand, Spain, Switzerland and Great Britain) the null hypothesis is rejected at 10% confidence interval. Moreover, the null hypothesis that there is at most one cointegration regression between logarithm of total GDP and logarithm of life expectancy is not rejected at 10% confidence interval only for 4 (France, Italy, New Zealand and Switzerland) and 4 (Austria, Canada, Japan and United States) countries, based on tables 25 and 27, respectively.

Consequently, taking into account the Pedroni cointegration test with individual intercept, and individual intercept and trend at 1% level, the Kao at 10% level and the Johansen cointegration tests 10% and 5% level, respectively, we conclude that there is equilibrium relationship between total GDP and life expectancy. So, we proceed presenting this relation running first a cointegrating regression and then an ECM.

First, we run the cointegrating equation of the two variables, as shown in table 28, with both FMOLS and DOLS method. The number of the observations is 2212 and 2182, respectively. The R-square is also 93.6% and 94.7% in the two cases. Moreover, the long-run parameter β is statistically significant at even 1% confidence interval as the t-statistic p-values are 0. Also, it equals 5.03 and 4.96, which means that if life expectancy increase by 1% in the long-run, total GDP will rise by 5.03% and 4.96%, respectively.

Then, we run the ECM without including any lag taking into account the residuals estimated by the cointegrating regression with both FMOLS and DOLS. The number of the observations in the first case is 2191 and in the second 2173. The R-square is also around 32% in both cases. Note that, despite the panel data dimension, they are not that small. Furthermore, all coefficients are statistically significant at 1% confidence interval. As we can see, β_1s are 0.20 and 0.16, that is, if the growth rate of life expectancy rise by 1%, the growth rate of total GDP will rise by 0.20% and 0.16%, respectively. Moreover, the error correction is consistent with the hypothesis that the error correction corrects the deviation from the long-run equilibrium relationship, as it is negative. About 1.6% or 1.1% of the gap between the two variables in the previous year doesn't exist this year.

Finally, we run the ECM including one lag in the equation. Again the number of the observations is 2191 and 2173 and the R-square is 35.6% and 35.2%,

respectively. As we can see from table 28, all variables apart from β_4, in the case we run the model with FMOLS, are statistically significant at 5% confidence interval and most of them even at 1%. Analytically, if the growth rate of life expectancy increases by 1%, the growth rate of total GDP will increase by about 0.19% employing FMOLS or 0.17% employing DOLS. If the lag value of the growth rate of total GDP rise by 1%, the growth rate of this year total GDP will increase by about 0.21% in both cases. Additionally, if the growth rate of life expectancy of last period increases by 1%, the growth rate of GDP per capita will rise by 0.03% and 0.07%, respectively. Finally, the error correction is negative again, that is, it is consistent with the hypothesis that the error correction corrects the deviation from the long-run equilibrium relationship. As a result, 1.4% and 1.1% of the discrepancy between the two rates in the previous year is eliminated this year. In other words, 1.4% and 1.1% of the last period's equilibrium error is corrected. As a consequence, health standard has a statistically significant, positive, and sizeable impact on total GDP.

Table 28: Cointegrating Equations & ECMs

	Fully Modified OLS				**Dynamic OLS**			
1.LGDPT=βLLF								
	Observations 2212				Observations 2182			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
LLF	5.028513*	55.77501	0.0000	0.936004	4.960490*	56.58223	0.0000	0.947207
2.DLGDPT=β_1DLLF+γ_1ECT(-1)								
	Observations 2191				Observations 2173			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
DLLF	0.199752*	6.538076	0.0000	0.322560	0.164163*	5.434258	0.0000	0.316555
ECT(-1)	-0.015828*	-5.776866	0.0000		-0.011067*	-3.911651	0.0001	
C	0.026921*	32.03410	0.0000		0.027416*	32.69995	0.0000	
3.DLGDPT=α_2+β_2DLLF+β_3DLGDPT(-1)+ β_4DLLF(-1)+γ_2ECT(-1)								
	Observations 2191				Observations 2173			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
DLLF	0.191715*	6.351147	0.0000	0.355963	0.167092*	5.565374	0.0000	0.352057
DLGDPT(-1)	0.212287*	9.864745	0.0000		0.211485*	9.708583	0.0000	
DLLF(-1)	0.032043	1.068125	0.2856		0.071820**	2.406410	0.0162	
ECT(-1)	-0.014203*	-5.213784	0.0000		-0.011651*	-4.223552	0.0000	
C	0.020763*	20.34937	0.0000		0.021042*	20.54657	0.0000	

Note: * and ** denote significance at 1% and 5% level, respectively. ECMs are estimated by OLS using the residuals from both FMOLS and DOLS cointegrating regressions.

Comparing the effect of health on per capita GDP with the effect on total GDP we observe that: (i) the short run impact is similar, (i) but the long-run impact of life expectancy on total GDP is greater than the impact of life expectancy on per capita GDP. The last one is due to the fact that the rise of life expectancy leads to the increase of population, too.

Finally, in table 29 we present panel Granger causality tests which test whether there is any causation relation between life expectancy at birth and total GDP. Note that we include two lags.

Table 29: Panel Granger causality test

Null Hypothesis:	W-Stat	Zbar-Stat.	Prob.
DLLF does not Granger Cause DLGDPT	3.06294	2.20228	0.0276**
DLGDPT does not Granger Cause DLLF	7.27770	11.3766	0.0000*

Note: * and **denote rejection at 1% and 5% level, respectively. The test is based on Dumitrescu-Hurlin (2012) technique.

In table 29 two null hypotheses are considered. The first one is that the first difference of the log of life expectancy does not cause the first difference of log of total GDP and the second that the first difference of log of total GDP does not cause the first difference of log of life expectancy. In both cases, the p-values are smaller than 0.05 (in the second case is 0), so the null hypotheses are rejected at 5% confidence interval (at even 1% in the second case). Consequently, lagged values of the growth rate of life expectancy explain the current value of the growth rate of total GDP. Conversely, lagged values of the growth rate of total GDP explain the current value of the growth rate of life expectancy. In other words, there is a two way causality between the two variables.

5.3. The relationship between GDP per capita and life expectancy of males and females

In this section we are going to investigate the link between growth using GDP per capita as its indicator and health status of the two sexes. We will present both short run and long run effects of life expectancy at birth of males and females on GDP per capita.

5.3.1. Stationarity

In this subsection we are going to test male life expectancy and female life expectancy for stationarity. First of all, we plot the graphs of life expectancy of male and female together for each of the 21 countries. Blue lines show the log of life expectancy at birth of the women, and the red ones depict the log of life expectancy of men. As we observe, in most of the countries we consider life expectancy of female is higher than that of male. Furthermore, in the case of Denmark, France, Italy, Netherlands, Sweden and Switzerland the health parameter of women is very close to that of men. Moreover, the lines are parallel in all cases, which means that the life expectancy of the two sexes increase analogically. Finally, we observe that life expectancy of both genders has an increasing trend, that is the series seem to be non-stationary.

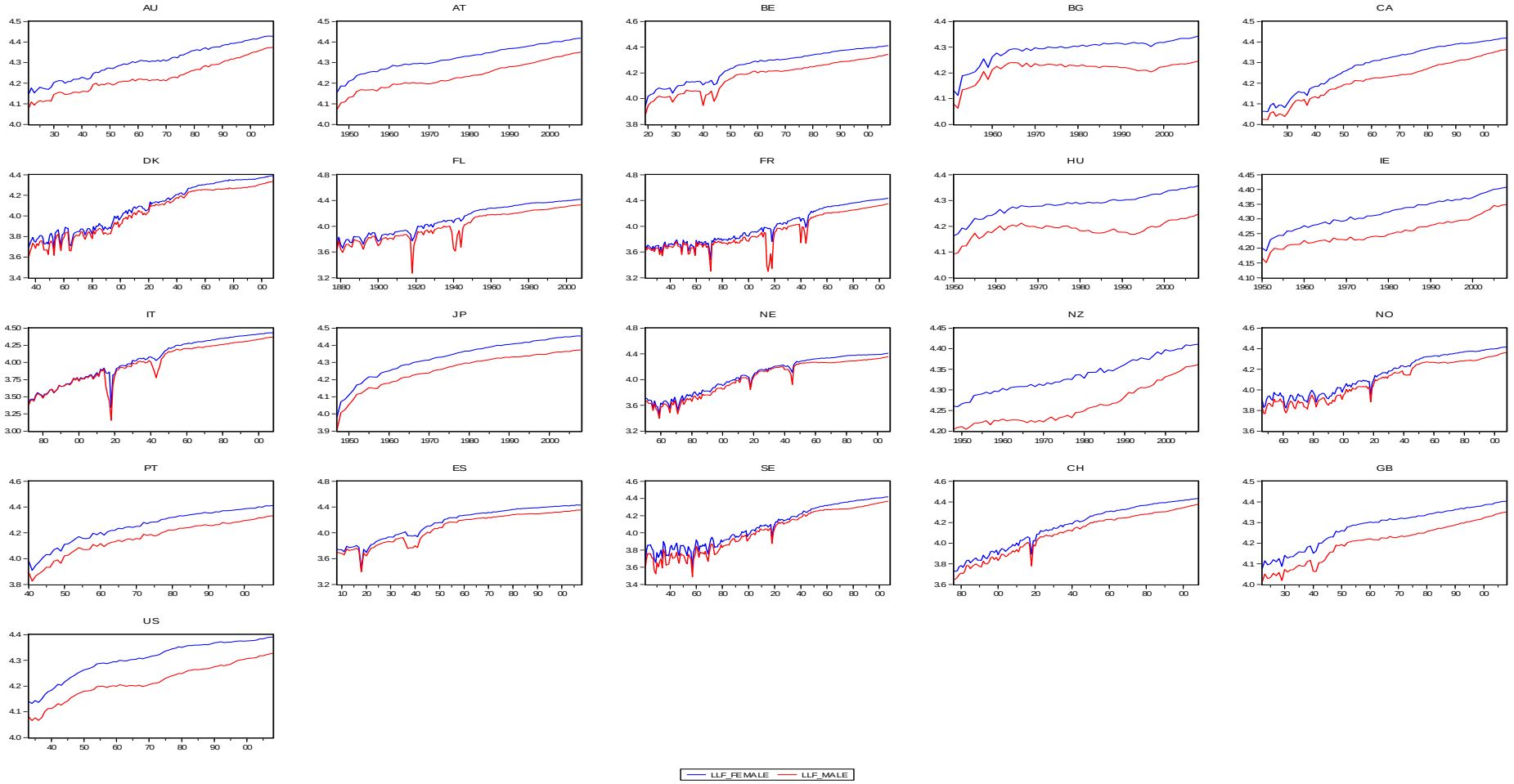


Figure 9: Log of life expectancy of male and female

Now we are going to employ the IPS unit root tests, in order to examine if the series are stationary or not. We do the test considering the AIC. Table 32 presents two cases, the result of the test after including only individual intercepts and both individual intercepts and linear trends. The number of the observations for life expectancy of male in the two cases is 2116 and 2112, respectively. As for the life expectancy of female it is 2110 and 2116.

Table 32: IPS unit root test

Log of life expectancy of:	**Male**		**Female**	
H_0: unit root	**t-stat.**	**Prob.+**	**t-stat.**	**Prob.+**
Individual effects	1.95266	0.9746	-2.29262	0.0109**
Individual effects & trend	-2.53622	0.0056*	-1.23747	0.1080

+Probabilities are computed assuming asymptotic normality.
Note: * and ** denote rejection at 1% and 5% level, respectively.

As we can see from table 32, life expectancy of males is non-stationary at even 10% confidence interval according to the first case (only individual effect), but stationary at even 1% confidence interval based on second case (individual effect and trend). The last result, however, is driven by only 5 of the 21 countries. Furthermore, life expectancy of females is non-stationary at 1% confidence interval in the first case and at even 10% in the second case. As a result, taking into account the IPS unit root test, and the graphs we conclude that the two series are not stationary.

In order to find the number of integration of the logarithm of life expectancy of both males and females, we test for stationarity the first difference of the variable. Before we do the formal tests, we plot the graphs of the first difference of them for each of the 21 countries separately. Again the blue line accounts for males and the red one for females.

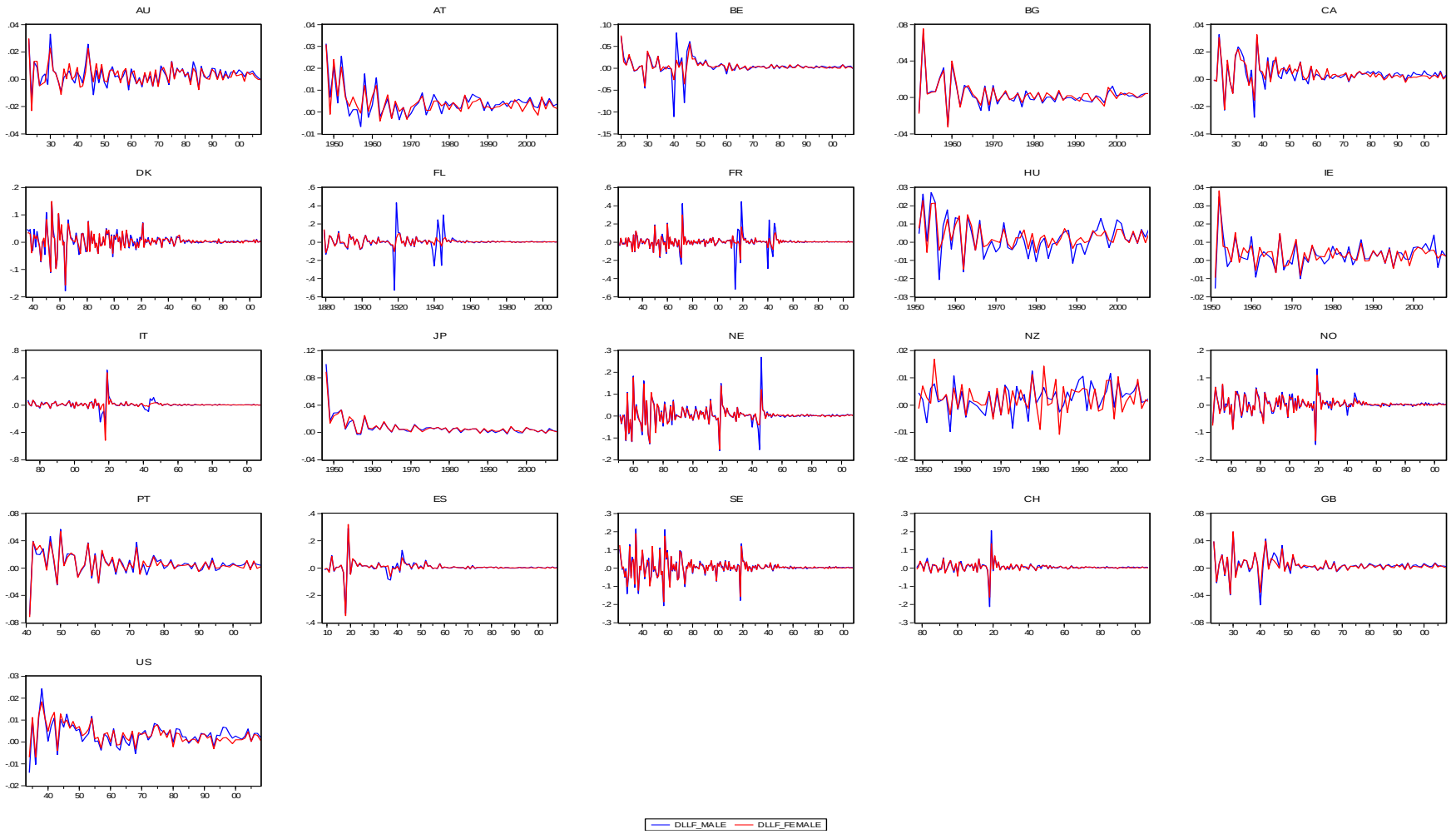


Figure 10: 1st difference of life expectancy of male & female

As we can see from figure 10, both variables are probably stationary. So, we employ the IPS unit root tests including individual intercept and both individual intercept and linear trend in order to prove it. The results are presented in table 33. We again choose AIC. The number of observations in the case of male life expectancy variable is 2102 and 2100. However, the number of observations in the case of female life expectancy is 2099 and 2100, respectively.

Table 33: IPS unit root test

Log of life expectancy of:	**Male**		**Female**	
H_0: unit root	**t-stat.**	**Prob.**[+]	**t-stat.**	**Prob.**[+]
Individual effects	-28.1212	0.0000*	-25.7684	0.0000*
Individual effects & trend	-28.2857	0.0000*	-32.4150	0.0000*

[+]Probabilities are computed assuming asymptotic normality.
Note: * denotes rejection at 1% level.

From table 33 we conclude that the null hypothesis that there is a unit root is rejected at even 1% confidence interval for both variables in both cases, as the t-statistic p-values equal to zero, that is they are smaller than 0.01. As a result, the first difference of life expectancy of male and female is a stationary process. In other words, the levels of the series are integrated of one degree, I(1). We remind that in section 5.1.1 we have shown that GDP per capita is, also, I(1). Consequently, we will test for cointegration the two variables.

5.3.2. Cointegration and error correction

The tests we employ to investigate if there is an equilibrium relation between GDP per capita and both life expectancy of males and females are the Pedroni, Kao and Johansen cointegration tests. Table 34 below report the results of the Kao (deterministic trend is excluded) and Pedroni cointegration tests taking into account three cases. The first case is that there is not deterministic trend, the second that there is deterministic intercept and trend and the third that there is neither deterministic intercept nor trend. The number of observations in all cases in both combinations (life expectancy of male- GDP per capita and life expectancy of female- GDP per capita) is 2233. The number of lags is, also, chosen based on the AIC. Moreover, the null hypothesis of the Pedroni and Kao cointegration test is that there is no cointegration relation between per capita GDP and life expectancy of male and life expectancy of

female. Remember that the Pedroni cointegration test consists of two parts. In the first one we assume the same AR coefficients for each country and in the second one different coefficients.

Table 34: Pedroni & Kao cointegration tests

Male								**Female**					
		H_0: no cointegration between LGDC and male LLF						**H_0: no cointegration between LGDC and female LLF**					
Pedroni		**no deterministic trend**		**deterministic intercept and trend**		**no deterministic intercept and trend**		**no deterministic trend**		**deterministic intercept and trend**		**no deterministic intercept and trend**	
		Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
H_1: common AR coef.	Panel v-Statistic	4.329	0.0000*	5.669	0.0000*	-2.389	0.9916	0.962	0.1679	4.509	0.0000*	-2.847	0.9978
	Panel rho-Statistic	-14.158	0.0000*	-25.847	0.0000*	0.539	0.7050	-6.411	0.0000*	-26.788	0.0000*	1.856	0.9683
	Panel PP-Statistic	-9.151	0.0000*	-16.235	0.0000*	0.160	0.5636	-5.162	0.0000*	-16.510	0.0000*	1.729	0.9581
	Panel ADF-Statistic	-6.609	0.0000*	-14.062	0.0000*	1.996	0.9770	-0.273	0.3925	-2.379	0.0087*	3.152	0.9992
H_1: individual coef.	Group rho-Statistic	-7.304	0.0000*	-8.749	0.0000*	3.878	0.9999	-5.076	0.0000*	-10.873	0.0000*	4.787	1.0000
	Group PP-Statistic	-6.634	0.0000*	-8.763	0.0000*	1.640	0.9495	-5.704	0.0000*	-10.491	0.0000*	3.382	0.9996
	Group ADF-Statistic	-4.528	0.0000*	-4.479	0.0000*	3.432	0.9997	-2.885	0.0020*	-1.424	0.0773***	4.337	1.0000
Kao													
	ADF-Statistic	-1.815	0.0348**					-1.532	0.0628***				

Note: * and *** denote rejection at 1% and 10% level, respectively.

Furthermore, the columns 3-8 show the results for the case of males and the columns 9-14 for the case of females. In the case of males, as we can see from table 34, the null hypothesis is rejected at even 1% confidence interval for each one of the panel and group tests, as the probability is smaller than 0.01, both including individual effects and individual effects and trends (in the case of females only two tests do not reject). However, in the case of exclusion of individual effects and trends, the null hypothesis is not rejected even at 10% confidence interval. In the case of female life expectancy, when we include only constant, 5 out of 7 tests reject the null hypothesis at even 1% level. Including both constant and trend, yields that 6 out of 7 tests reject at 1% level and the last one at 10%. In the case of exclusion of both intercept and trend the null hypothesis is not rejected. Consequently, based on the first two cases, we can say that there is equilibrium relationship between male life expectancy and per capita GDP, and female life expectancy and per capita GDP.

Moreover, based on the Kao cointegration test there is (a weaker compared to the first two cases of the Pedroni tests) cointegration relation between log of GDP per capita and life expectancy of males and females at 5% and 10% confidence interval, respectively. Note, also, that the number of the observations is again 2233 and the number of lags is selected by AIC.

Finally, we are going to present the results of the Johansen unrestricted cointegration rank test. Table 35 below shows the results of Trace and Maximum-Eigenvalue tests. The null hypotheses are; a) there is not cointegrating regression between log of GDP per capita and life expectancy of males and females(4rd and 6th rows), b) there is at most one cointegrating regressions between them(5th and 7th rows). The results for males can be seen at 3-6 columns and that of females at 7-10. Furthermore, we assume two cases, that there is no intercept or trend in cointegrating equation and Var (rows 4 and 5) , and that there is both intercept and trend in cointegrating regression and only intercept in Var (rows 6 and 7). Note, also, that the number of the lags is two.

Table 35: Johansen Cointegration Test

Johansen Fisher Panel Cointegration Test Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)									
		Male				**Female**			
	Null Hypothesis	**Trace**	**Prob.+**	**Max-Eigen**	**Prob.+**	**Trace**	**Prob.+**	**Max-Eigen**	**Prob.+**
No intercept or trend in CE or Var	**None (r=0)**	320.1	0.000*	323.9	0.000*	362.9	0.000*	375.9	0.000*
	At most 1 (r<=1)	34.51	0.787	34.51	0.788	16.58	0.999	16.58	0.999
Intercept & trend in CE & no trend in Var	**None (r=0)**	207.7	0.000*	195.6	0.000*	265.1	0.000*	221.9	0.000*
	At most 1 (r<=1)	48.48	0.228	48.48	0.228	64.48	0.014**	64.48	0.014**

+ Probabilities are computed using asymptotic Chi-square distribution.
Note: * and ** denote rejection at 1% and 5% level, respectively.

Based on table 35, in case of male life expectancy, the null hypothesis that there is no cointegrating equation between the variables in question, is rejected at even 1% confidence interval, in both cases we consider. On the other hand, the null hypothesis that there is at most one cointegrating equation between the variables is not rejected even at 10% confidence interval. As for female life expectancy, we get the same results in the case of exclusion of constant and trend. However, in the case of inclusion both constant and trend in cointegrating equation and only constant in Var, we obtain the same results but at 1% confidence interval. In other words, there is evidence of equilibrium relation between log of GDP per capita and log of life expectancy of males and females in weaker way.

All in all, we can say that there exists equilibrium relationship between both the health status of males, and females and GDP per capita. As a result, we are going to examine these links by running both cointegrating regressions with FMOLS and DOLS methods and ECMs with OLS.

First of all, table 36 presents the cointegrating equations of logarithm of life expectancy at birth of male and female (LLF for both of them) and logarithm of GDP per capita. Columns 3-6 account for the case of male and 7-10 of female employed both with FMOLS and DOLS methods,. The number of observations when we take into account life expectancy of male is 2212 and 2186 in the case of FMOLS and

DOLS method, respectively. However, taking into account life expectancy of female, it is 2212 and 2185, respectively.

Table 36: Cointegrating Equations

		Male				Female			
	1.LGDPC=βLLF								
Method	**Variable**	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
FMOLS	**LLF**	3.656789*	47.58540	0.0000	0.832157	3.585546*	49.54862	0.0000	0.852556
DOLS	**LLF**	3.588567*	48.15502	0.0000	0.862019	3.530321*	50.97144	0.0000	0.876175

Note: * denotes significance at 1% level.

As we can see from table 36 the log of life expectancy of both male and female is statistically significant either we employ FMOLS or DOLS at even 1% confidence interval. We observe, also, that the R-squares are too large. When we employ FMOLS, R-square is around 83% for the case of male and 85% for the case of female. This suggest that health standard of males (females) explain the model by 83% (85%). Furthermore, the coefficient in interest, that shows us the long run relationship between GDP per capita and life expectancy of males or females is around 3.66 or 3.58, in the case we estimate the model by FMOLS. This means that if life expectancy at birth of male or female increase by 1%, GDP per capita will rise by 3.66% and 3.58%, respectively. Additionally, if we estimate the model using DOLS method, these coefficients will be 3.59 and 3.53, respectively. That is, if life expectancy of male or female rise by 1%, per capita GDP will rise by 3.59% and 3.53%. We observe, from the above analysis, that the coefficient of life expectancy at birth of male and that of female are too close in both cases (FMOLS,DOLS). Consequently, the health level of males and females has positive, statistically significant, and of similar size impact on per capita GDP. However, this doesn't surprise us, as we know that women entered the labor force in 1850. (Note that, although our data dates back to 1821, only 4 of the 21 countries' data is before 1850).

The above was the first step of the Engle-Granger two-step method (Brooks, 2008). Below we analyze the second one. In this step we get the residuals from the first step estimations (with FMOLS and DOLS) in the case of male life expectancy and female life expectancy. We consider two regressions. In the first one we do not include any lags, but in the second one we add one lag in both variables. Note that including more lags the results are very similar. These results are presented in table 37 and 38. In table 37 we show the results of the two ECMs for both male and female life

expectancy taking into account the residuals that yielded from FMOLS estimation of cointegrating equations and in table 38 from DOLS.

Table 37: ECMs

		Male				Female			
	2.DLGDPC=$\alpha_1+\beta_1$DLLF+γ_1ECT(-1)								
Method	**Variable**	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
OLS	**DLLF**	0.18945*	7.70162	0.0000	0.3175	0.12072*	3.531001	0.0004	0.3022
	ECT(-1)	-0.01939*	-5.91722	0.0000		-0.01811*	-5.06915	0.0000	
	C	0.01976*	24.0220	0.0000		0.01989*	23.54453	0.0000	
	3.DLGDPC=$\alpha_2+\beta_2$DLLF+β_3DLGDPC(-1)+ β_4DLLF(-1)+γ_2ECT(-1)								
Method	**Variable**	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
OLS	**DLLF**	0.17729*	7.32793	0.0000	0.3471	0.12725*	3.64569	0.0003	0.3359
	DLGDPC(-1)	0.20372*	9.44609	0.0000		0.20894*	9.68064	0.0000	
	DLLF(-1)	-0.01453	-0.59830	0.5497		0.0621***	1.81035	0.0704	
	ECT(-1)	-0.01884*	-5.73241	0.0000		-0.01813*	-5.14999	0.0000	
	C	0.01554*	16.8399	0.0000		0.01511*	15.8228	0.0000	

Note: * and *** denote significance at 1% and 10% level, respectively. ECMs are estimated by OLS using the residuals from FMOLS cointegrating regressions.

As we said before table 37 presents two models for each sex, the one without lags and the one with one lag in first difference of log of life expectancy of male or female and per capita GDP. The coefficients of the first differences give us the short-run relation between the variables in question. They are all positive and statistically significant at even 1% confidence interval, except for DLLF(-1), the one last periods growth rate of life expectancy, which in the case of male life expectancy is insignificant at even 10% level and in the case of female life expectancy is significant at 10% level. Moreover, we care, also, about the error correction term (ECT). As we can see from table 37, this parameter is statistically significant at even 1% confidence interval in both two models and for both sexes. We, also, observe that it is negative, which ensures that it corrects the deviation from the long-run equilibrium relationship. Moreover, when we consider male life expectancy at birth as a explanatory variable, the ECT is around -0.019, but when we consider female life expectancy it is -0.018. That is, 1.9% or 1.8% of the discrepancy between GDP per capita and male or female life expectancy in the previous year is eliminated this year. In other words, 1.9% or 1.8% of the last period's equilibrium error is corrected.

Table 38: ECMs

		Male				Female			
	2.DLGDPC=β_1DLLF+γ_1ECT(-1)								
Method	**Variable**	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
OLS	**DLLF**	0.15784*	6.5226	0.0000	0.311	0.09281*	2.7311	0.0064	0.298
	ECT(-1)	-0.0128*	-3.7237	0.0002		-0.0132*	-3.6714	0.0002	
	C	0.02025*	24.6335	0.0000		0.02051*	24.5081	0.0000	
	3.DLGDPC=α_2+β_2DLLF+β_3DLGDPC(-1)+ β_4DLLF(-1)+γ_2ECT(-1)								
Method	**Variable**	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
OLS	**DLLF**	0.15141*	6.3282	0.0000	0.342	0.11507*	3.2841	0.0010	0.333
	DLGDPC(-1)	0.20237*	9.2529	0.0000		0.20582*	9.4279	0.0000	
	DLLF(-1)	0.02175	0.9087	0.3636		0.10471*	3.0281	0.0025	
	ECT(-1)	-0.0139*	-4.1644	0.0000		-0.0159*	-4.5417	0.0000	
	C	0.01587*	17.1311	0.0000		0.01556*	16.3356	0.0000	

Note: * denotes significance at 1% level. ECMs are estimated by OLS using the residuals from DOLS cointegrating regressions.

According to table 38, The short run coefficients are again positive and statistically significant at even 1% level, apart from DLLF(-1) which is statistically insignificant, only in the case of male life expectancy. Furthermore, the ECT is again statistically significant at even 1% confidence interval in both two models and for both sexes. It is, also, negative and again this ensures that it corrects the deviation from the long-run equilibrium relationship. When we consider male life expectancy at birth as an explanatory variable, the adjustment term is around -0.013 and -0.014 in two models, respectively. When we consider female life expectancy as an explanatory variable, it is around -0.013 and -0.016, respectively. That is, 1.3% or 1.4% of the discrepancy between GDP per capita and male life expectancy in the previous year is eliminated this year. Also, 1.3% or 1.6% of the discrepancy between per capita GDP and female life expectancy in previous year doesn't exists this year. Consequently, both male and female health standard affect economic growth not only in the short-run but also in the long-run.

Finally, in table 39 panel Granger causality tests are presented. As we said in previous sections, they reveal if there is any causation relation between male and female life expectancy at birth and per capita GDP. Note that we include two lags.

Table 39: Panel Granger causality test

	Male			Female		
Null Hypothesis:	**W-Stat**	**Zbar-Stat.**	**Prob.**	**W-Stat**	**Zbar-Stat.**	**Prob.**
DLLF does not Granger Cause DLGDPC	3.26353	2.63891	0.0083*	2.85705	1.75411	0.0794***
DLGDPC does not Granger Cause DLLF	7.52886	11.9234	0.0000*	6.22737	9.09036	0.0000*

Note: * and *** denote rejection at 1% and 10% level. The test is based on Dumitrescu-Hurlin (2012) technique.

In table 39 the null hypotheses considered are: (i) the growth rate of life expectancy of either male (columns 2-4) or female (columns 5-7) does not cause the growth rate of per capita GDP and (ii) the growth rate of per capita GDP does not cause the growth rate of life expectancy of either male or female. In the case of male, both null hypotheses are rejected at even 1% confidence interval. Consequently, lagged values growth rate of male life expectancy explain the current value of the growth rate of per capita GDP and conversely. On the other hand, in the case of female life expectancy, the first null hypothesis is rejected at 5% level. As a result, there is a weak causation running from the growth rate of life expectancy to the growth rate of per capita GDP. The second null hypothesis, though, is rejected at even 1% level. Thus, lagged values of the growth rate of per capita GDP explain the current value of the growth rate of female life expectancy. Generally speaking, there is a two way causality between the two pairs of variables. Finally, the causation running from life expectancy to per capita GDP is consistent with the results of the statistically significant and positive short-run coefficients that we obtain from tables 37 and 38.

Consequently, we find a positive and statistically significant impact of both genders' health standard on per capita GDP in the short-run and in the long-run.

5.4. The relationship between total GDP and life expectancy of males and females

In this section we examine the link between growth using total GDP as its indicator and health status of the two sexes. We will present both short run and long run effects of life expectancy at birth of males and females on total GDP.

5.4.1. Stationarity

We have shown in sections 5.2.1 and 5.3.1 that total GDP and both male and female life expectancy at birth are integrated of degree one, respectively.

Proceeding we are going to examine if there is both a short-run and an equilibrium relationship between total GDP and health standard of male and female, too.

5.4.2. Cointegration and error correction

We employ the Pedroni, Kao and Johansen cointegration tests in order to investigate if there is an equilibrium relation between total GDP and life expectancy of both males and females. Table 40 below show the results of the Kao (deterministic trend is excluded) and Pedroni cointegration tests taking into account three cases. The first case is that there is not deterministic trend, the second that there is deterministic intercept and trend and the third that there is neither deterministic intercept nor trend. The number of observations in all cases in both combinations (life expectancy of male- GDP per capita and life expectancy of female- GDP per capita) is 2233. The number of lags is, also, chosen based on the AIC. Moreover, the null hypothesis of the Pedroni and Kao cointegration test is that there is no cointegration relation between total GDP and life expectancy of male and female, separately. Remember that the Pedroni cointegration test consists of two parts. In the first one we assume the same AR coefficients for each country and in the second one different coefficients.

Table 40: Pedroni & Kao cointegration tests

Male								**Female**					
	H_0: no cointegration between LGDT and male LLF							**H_0: no cointegration between LGDT and female LLF**					
Pedroni		**no deterministic trend**		**deterministic intercept and trend**		**no deterministic intercept and trend**		**no deterministic trend**		**deterministic intercept and trend**		**no deterministic intercept and trend**	
		Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
H_1: common AR coef.	Panel v-Statistic	0.2267	0.4103	6.25417	0.0000*	-0.3386	0.6326	1.5942	0.0554***	6.69663	0.0000*	-0.2199	0.5870
	Panel rho-Statistic	-14.378	0.0000*	0.69111	0.7553	-7.9651	0.0000*	-10.449	0.0000*	0.84124	0.7999	-2.5594	0.0052*
	Panel PP-Statistic	-8.5636	0.0000*	0.42896	0.6660	-5.3231	0.0000*	-6.3282	0.0000*	0.85450	0.8036	-2.2423	0.0125**
	Panel ADF-Statistic	-5.4162	0.0000*	-0.56245	0.2869	-3.4444	0.0003*	0.8372	0.7988	0.96142	0.8318	0.0329	0.5131
H_1: individual coef.	Group rho-Statistic	-5.8829	0.0000*	1.75140	0.9601	-1.3202	0.0934***	-4.9202	0.0000*	1.80454	0.9644	2.0754	0.9810
	Group PP-Statistic	-4.8631	0.0000*	0.14119	0.5561	-2.3969	0.0083*	-4.2493	0.0000*	0.60637	0.7279	0.3439	0.6345
	Group ADF-Statistic	-2.7693	0.0028*	-1.01593	0.1548	-0.0569	0.4773	-0.3133	0.3770	0.46388	0.6786	2.5769	0.9950
Kao													
	ADF-Statistic	-2.0687	0.0193**					-1.6164	0.0530***				

Note: *, *, and *** denote rejection at 1%, 5%, and 10% level, respectively.

Furthermore, the columns 3-8 show the results for the case of males and the columns 9-14 for the case of females. In the case of males, as we can see from table 40, the null hypothesis is rejected at even 1% confidence interval for each one of the panel and group tests (except for one), as the probability is smaller than 0.01, in the case that we include individual effects. In the case that we include both individual effects and trends only one tests shows that there is cointegrating relation. Finally, in the case of exclusion of individual effects and trends, the null hypothesis is rejected even at 1% confidence interval for 4 of 7 tests and at 10% for 1% level. Consequently, we conclude that there is a weak equilibrium relationship between total GDP and male life expectancy.

As for the case of female, there is an evidence of cointegration relation only when we exclude deterministic trends. According to other two cases, most of the tests do not reject the null. As a result, based on the Pedroni cointegration tests, there is no equilibrium relationship between female life expectancy and total GDP.

Moreover, based on the Kao cointegration test there is (a weaker compared to the first and third cases of the Pedroni tests) weak cointegration relations between log of GDP total and life expectancy of males and females at 5% and 10% confidence interval, respectively. Note, also, that the number of the observations is again 2233 and the number of lags is selected by AIC.

Finally, we are going to present the results of the Johansen unrestricted cointegration rank test. Table 41 below shows the results of Trace and Maximum-Eigenvalue tests. The null hypotheses are; a) there is not cointegrating regression between log of total GDP and life expectancy of males and females(3rd and 5th rows), b) there is at most one cointegrating regressions between them (4th and 6th rows). The results for males can be seen at 3-6 columns and that of females at 7-10. Furthermore, we assume two cases, that there is no intercept or trend in cointegrating equation and Var (rows 3 and 4) , and that there is both intercept and trend in cointegrating regression and only intercept in Var (rows 5 and 6). Note, also, that the number of the lags is two.

Table 41: Johansen Cointegration Test

Johansen Fisher Panel Cointegration Test Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)									
		Male				**Female**			
	Null Hypothesis	**Trace**	**Prob.**[+]	**Max-Eigen**	**Prob.**[+]	**Trace**	**Prob.**[+]	**Max-Eigen**	**Prob.**[+]
No intercept or trend in CE or Var	**None (r=0)**	405.4	0.000*	385.7	0.000*	405.2	0.000*	401.5	0.000*
	At most 1 (r<=1)	70.21	0.004*	70.21	0.004*	37.50	0.669	37.50	0.669
Intercept & trend in CE & no trend in Var	**None (r=0)**	210.9	0.000*	196.8	0.000*	270.6	0.000*	222.0	0.000*
	At most 1 (r<=1)	47.80	0.249	47.80	0.249	62.84	0.020**	62.84	0.020**

[+] Probabilities are computed using asymptotic Chi-square distribution.
Note: * and ** denote rejection at 1% and 5% level, respectively.

Based on table 41, in case of males, the null hypothesis that there is no cointegrating equation between the variables in question, is rejected at even 1% confidence interval, in both cases we consider. On the other hand, the null hypothesis that there is at most one cointegrating equation between the variables is rejected at 1% confidence interval in the case of no intercept or trend in cointegrating equation and Var. However, in the case that there is both intercept and trend in cointegrating regression and only intercept in Var, it is not rejected at even 10% level. Consequently, we cannot draw conclusions, based on the Johansen cointegration tests.

As for the females, we get the reverse results in the two cases considered. In the case of inclusion of both intercept and trend in cointegrating regression and only intercept in Var the null hypothesis is not rejected at 1% level. However, in the case of inclusion both constant and trend in cointegrating equation and only constant in Var, we obtain the same results but at 1% confidence interval. In other words, there is a weak evidence of equilibrium relation between log of total GDP and log of life expectancy of females.

All in all, we can say that there exists a weak equilibrium relationship between health status of males and total GDP, based on the Pedroni and Kao tests. Moreover, based on the Kao and Johansen cointegration tests, yields that there is a weak cointegration relation between female health standard and total GDP. As a result, we are going to examine these links by running both cointegrating regressions with FMOLS and DOLS methods and ECMs with OLS.

Below we present the cointegrating regressions and error correction models of total GDP and both male and female life expectancy. They are presented in the tables 42, 43 and 44 below. They have the same structure as the tables 36, 37 and 38 with one difference, the dependent variable here is log or first difference of log total GDP instead of log (table 42) and first difference of log per capita GDP (tables 43 and 44).

Table 42**:** Cointegrating Equations

		Male				Female			
	1.LGDPT=βLLF								
Method	**Variable**	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
FMOLS	**LLF**	5.062653*	53.66053	0.0000	0.92846	4.962163*	56.08740	0.0000	0.93849
DOLS	**LLF**	4.982789*	54.14161	0.0000	0.94255	4.889880*	57.64963	0.0000	0.94873

Note: * denotes significance at 1% level.

Table 42 presents the results of cointegrating equations for the two sexes with both FMOLS and DOLS methods. As we can see the coefficient of both male and female life expectancy is statistically significant at even 1% confidence interval in each case. Furthermore, the R-squares are too large (about 0.90), which means that male or female life expectancy explain more than 90% of the model. Finally, the cointegrating coefficient is around 5 in each case for both two sexes. This implies that the increase of either male or female life expectancy at 1% will lead to an increase of total GDP by around 5%.

Table 43: ECMs

		Male				Female			
	2.DLGDPT=α_1+β_1DLLF+γ_1ECT(-1)								
Method	**Variable**	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
OLS	**DLLF**	0.197147*	7.89626	0.0000	0.3291	0.128164*	3.69421	0.0002	0.3119
	ECT(-1)	-0.01630*	-6.3281	0.0000		-0.013584*	-4.8446	0.0000	
	C	0.027004*	32.5217	0.0000		0.027224*	31.9243	0.0000	
	3.DLGDPT=α_2+β_2DLLF+β_3DLGDPT(-1)+ β_4DLLF(-1)+γ_2ECT(-1)								
Method	**Variable**	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
OLS	**DLLF**	0.185980*	7.59657	0.0000	0.3609	0.138836*	3.93621	0.0001	0.3488
	DLGDPT(-1)	0.211331*	9.82818	0.0000		0.217588*	10.1088	0.0000	
	DLLF(-1)	-0.00113	-0.0464	0.9630		0.079590**	2.29736	0.0217	
	ECT(-1)	-0.01458*	-5.6222	0.0000		-0.012623*	-4.5766	0.0000	
	C	0.021035*	20.8235	0.0000		0.020597*	19.8117	0.0000	

Note: * and ** denote significance at 1% and 5% level, respectively. ECMs are estimated by OLS using the residuals from FMOLS cointegrating regressions.

Table 43 presents the ECMs with none or one lag taking into account the residuals of cointegrating regressions estimated by FMOLS. The R-square is around 31-36% in all four models. All coefficients are statistically significant at even 1% confidence interval, except for the DLLF(-1), which is statistically significant at 5% level in the case of female life expectancy and insignificant in the case of male. Short-run coefficient β_1s and β_2s, that show the impact of growth male and female life expectancy on growth total GDP, are statistically significant at 1% level. The adjustment parameter $\gamma_1$or γ_2 that we care about, equals to around -0.016 or -0.015 in the case that we consider male life expectancy in the model and -0.014 or -0.013 in the case that we consider female life expectancy. We observe that it is negative in all cases, and it implies that 1.6% (first case) of the discrepancy between male life expectancy and total GDP the previous year is eliminated this year. In other words, 1.6% of the last period's equilibrium error is corrected this year.

Table 44: ECMs

		Male				**Female**			
	2.DLGDPT=β_1DLLF+γ_1ECT(-1)								
Method	**Variable**	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
OLS	**DLLF**	0.160327*	6.54755	0.0000	0.3217	0.097093*	2.81748	0.0049	0.3076
	ECT(-1)	-0.01126*	-4.1228	0.0000		-0.00990*	-3.4901	0.0005	
	C	0.027487*	33.0383	0.0000		0.027717*	32.7415	0.0000	
	3.DLGDPT=α_2+β_2DLLF+β_3DLGDPT(-1)+ β_4DLLF(-1)+γ_2ECT(-1)								
Method	**Variable**	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
OLS	**DLLF**	0.157838*	6.54498	0.0000	0.3559	0.123722*	3.49561	0.0005	0.3466
	DLGDPT(-1)	0.212368*	9.74973	0.0000		0.217156*	9.98548	0.0000	
	DLLF(-1)	0.037181	1.54065	0.1236		0.119993*	3.44315	0.0006	
	ECT(-1)	-0.01120*	-4.2055	0.0000		-0.01134*	-4.1031	0.0000	
	C	0.021262*	20.9041	0.0000		0.020841*	20.0358	0.0000	

Note: * denotes significance at 1% level. ECMs are estimated by OLS using the residuals from DOLS cointegrating regressions.

Table 44 presents relative results with table 41, but this time we use residuals of cointegrated equation estimating it by DOLS. Again all coefficients are statistically significant at even 1% confidence interval, apart from DLLF (first difference of life expectancy) in the case of male only. The R-square is, also around 31-36%, which is high enough for the long time period we consider. Short-run coefficients are all statistically significant even at 1% level, apart from DLLF(-1) in the case of male life

expectancy. The adjustment parameter is negative in all cases, that is it is consistent with the hypothesis that the error correction corrects the deviation from the long-run equilibrium relationship. Moreover, the speed of adjustment back to equilibrium equals to around 0.01 in all four models. Consequently the difference between either male or female life expectancy and total GDP in last period will reduce by 1% this year. Or 1% of the last period's equilibrium error is corrected this year. Consequently, there is a short-run and a long-run relation between total GDP growth and male and female life expectancy growth, based on tables 42 and 43.

Finally, in table 45 panel Granger causality tests are presented. As The specific tests reveal if there is any causation relation between male and female life expectancy at birth and total GDP. Note that we include two lags.

Table 45: Panel Granger causality test

	Male			**Female**		
Null Hypothesis:	**W-Stat**	**Zbar-Stat.**	**Prob.**	**W-Stat**	**Zbar-Stat.**	**Prob.**
DLLF does not Granger Cause DLGDPT	3.27729	2.66885	0.0076*	2.91259	1.87502	0.0608***
DLGDPT does not Granger Cause DLLF	7.88622	12.7012	0.0000*	6.44191	9.55737	0.0000*

Note: * and *** denote rejection at 1% and 10% level, respectively. The test is based on Dumitrescu-Hurlin (2012) technique.

In table 45 the null hypotheses considered are: (i) the growth rate of life expectancy of either male (columns 2-4) or female (columns 5-7) does not cause the growth of total GDP and (ii) the growth rate of total GDP does not cause the growth rate of life expectancy of either male or female. In the case of male, both null hypotheses are rejected at even 1% confidence interval. Consequently, lagged values of growth rate of male life expectancy explain the current value of the growth rate of total GDP. On the other hand, in the case of female life expectancy, the first null hypothesis is rejected at 5% level. As a result, there is a weaker causation running from the growth rate of life expectancy to the growth rate of total GDP. The second null hypothesis, though, is rejected at even 1% level. Thus, lagged values of the growth rate of total GDP explain the current value of the growth rate of female life expectancy. Generally speaking, there is a two way causality between the two pairs of variables. Finally, the causation running from life expectancy to total GDP is

consistent with the results of the short-run coefficients that we got from tables 43 and 44.

To sun up, we find a positive and statistically significant impact of both genders' health standard on total GDP in the short-run and in the long-run.

5.5. Comparisons with other studies

In the rest of the chapter 5 we showed that total life expectancy, male life expectancy, and female life expectancy, have all a positive impact on total GDP and per capita GDP both in the short-run and in the long-run. We used an unbalanced panel cointegration and causality analyses for 21 countries (20 of which are OECD members) for a very long period of time ranging from 1821 to 2008.

In this section we are going to compare our results with some of the papers referred in the "literature review" (chapter 2). We are not able to compare our work with all of the studies due to the fact that each study has its characteristics. For instance, they do not use the same data dimension (time period and number of cross-sections). Some of them use panel data, and others time series or rarer (one) cross-sectional analysis. Another case is that each empirical study uses different methodology (2SLS, 3SLS, GLS, SUR, cointegrating analysis etc.). Finally, they do not use the same indicator of either health status or growth.

Additionally, none of the studies discussed investigates the relationship between health and each gender's health status separately. As a consequence, we cannot compare the results of the specific relations with other works. So, we are going to compare our results, related to the link between the aggregate population's health standard and the total and per capita GDP in the short-run and in the long-run, with Swift (2011), Ecevit (2013), and Akram et al. (2008), which are the most comparable studies.

Specifically, Swift (2011) is the most comparable study of the literature presented in chapter 2 with ours. He uses time series analysis (we use panel data analysis) ranging from 1821 to 2001 or from 1921 to 2001 (to 2008 in our study) including 13 OECD economies (21 in our case, 20 of which are, also, OECD members). Moreover, he follows cointegration analysis in order to investigate the link between life expectancy at birth and both total and per capita GDP. Additionally, he uses the same health and growth proxies with us, that is life expectancy at birth, and total and per capita GDP, respectively. In the case that GDP per capita is dependent variable, he concludes that: first, there is not short run link between the variables in

question, as the short run coefficients are statistically insignificant. In contrast, we find a positive and statistically significant relationship between life expectancy and both total and per capita GDP. Second, there is long-run equilibrium between health and both total and per capita GDP. The long run coefficients in the case of per capita GDP are 2%-7% depending on the country, and 4. 995% on average. A 1% increase of life expectancy will lead to an average increase of all 13 economies of 4.995%. This result is similar with ours, as we find that an 1% increase of life expectancy enchases per capita GDP by 3.63% or 3.57%, depending on the method we employ (FMOLS or DOLS, respectively). Finally, he finds that the speed of adjustment is -0.035 on average, that is, 3.5% of previous year's discrepancy will not exist this year. Our estimated ECT is ranging from -0.0143 to -0.0196, depending on the model. This means that 1.43%-1.96% of the long-run increase of per capita GDP, which is due to the increase of life expectancy, will take place each year.

Considering the link between health and total GDP, Swift (2011) found again that there is not short-run relation. On the other hand, we found again that there is a positive and statistically significant link. Moreover, the long run coefficients in Swift's (2011) study are ranging from 3% to 9%. On average, though, the long-run parameter is 6.124%. It is close to ours, which is 5.03% or 4.96%, depending again on the methodology used (FMOLS or DOLS, respectively). Finally, the second coefficient of equilibrium relationship or the adjustment parameter is -0.025. Comparing it with ours, it is quite close, as in our case it is ranging from -0.011 to -0.0158.

Ecevit (2013) uses a panel data cointegration and Granger causality analyses for the time period 1970-2010 and for 21 OECD members, in order to investigate the link between health and economic growth. He uses life expectancy at birth as indicator of health and real per capita GDP as growth proxy. The main differences of this study with ours are that we consider a larger period of time (1821-2008) and that we run not only cointegrating equations, but also ECMs. Ecevit (2013) assumes three models and employ them by OLS, FMOLS, and DOLS methods. The estimated long-run coefficients are ranging from 1.69 to 4.321 and they are similar with ours (3.63 with FMOLS, and 3.57 with DOLS). Finally, Ecevit (2013), taking into account all three models, concludes that the growth rate of life expectancy causes the growth rate of per capita GDP. We, also, rejected the null hypothesis, that growth

rate of life expectancy does not cause growth rate of per capita GDP. As a consequence, the panel Granger causality results that we obtained are consistent with the positive and statistically significant short-run coefficient that we found in the ECM.

Finally, Akram et al. (2008) use time series analysis for the case of Pakistan for the time period 1972-2006. They, also, use cointegration analysis and consider life expectancy and infant mortality as health indices and per capita GDP as growth index. The main difference with our analysis is that we use panel data approach consisting of much more economies (21, 20 of which are OECD members) and much longer time period (1821-2008). They examine the relationship of the level values of the variables in question, but we use the logarithm of them. As a result, we cannot make direct comparisons. Generally, they found no link between health and economic growth in the short-run, and a positive and statistically significant in the long-run. The first result differs with ours, but the second one is the same.

As for the rest of the literature discussed in chapter 2, and generally speaking, most of them support that heath standard affects growth positively either in the short-run or in the long-run, depending on the econometric analysis that they use, except for Acemoglu and Johnson (2007) and Ashraf et al. (2009). Acemoglu and Johnson (2007) state that health status has a small positive impact on total GDP at the first 30-40 years and a little bit larger over time. They, also, support that due to the increase of population, GDP per capita and GDP per worker decrease a bit more at first and less after 40 years. In other words, they believe that the increase of total GDP does not compensate the increase of population and as a result per capita/worker GDP declines. Moreover, Ashraf et al. (2009) using two criterions for the improvement of health , they conclude that: first, per capita GDP rises in the long-run, but decreases in the short-run due to the increase of life expectancy from 40 to 60. Second, the eradication of both malaria and tuberculosis leads to an unimportant effect on per capita GDP both in the short-run and the long-run.

6. Conclusion

Health improvements can cause a rise in total GDP through both the increase of population, but mainly, through the gains in human and physical capital which have as a result the increase in productivity and GDP per capita. In this study we used an unbalanced panel of 21 economies, 20 of which are members OECD members, for the time period 1821-2008. This period of time includes not only the medical improvements that started in the 1940s, but also the earlier ones (second half of 19th century) for some of the economies considered in our study. We considered life expectancy at birth as an indicator of health and total and per capita GDP as indicators of growth. Moreover, we tested if there is not only short-run, but also long-run relationship between health and growth. We, also, examined the link between growth and each gender's life expectancy.

First of all, we tested for unit root all variables and yielded that they are all non-stationary, or integrated of degree one, I(1). Then we showed that there are equilibrium relations between life expectancy (total, male, and female) and both total and per capita GDP. Cointegrating equations, that were employed through FMOLS and DOLS methodologies, showed that health standard of the citizens of a country have a positive and statistically significant effect on total and per capita income in the long-run. A 1% increase in life expectancy at birth leads to about 5% and 3.6% increase of total and per capita GDP, respectively. The same result yielded after the discrimination of the two sexes. Both health level of males and females have positive and statistically significant impact of the same size with each other and total life expectancy on the total and per capita GDP in the long-run. Furthermore, error correction models implied that there is both short-run and long-run relationship between total, male and female life expectancy and total and per capita GDP. All parameters, short-run and long-run, considered in the two ECMs, proved to be statistically significant at even 1% confidence interval, except for the lagged growth rate of life expectancy, which was in most of the cases statistically insignificant. Again the results considering life expectancy of a citizen and the ones of the two genders have the same influence of the same size on both total and per capita GDP. Taking into account the residuals from the FMOLS estimated cointegrating regression we found that about 1.8-1.9% of the previous year's discrepancy between life expectancy (total or male or female) and per capita GDP will not exist this year. Based, however, on DOLS estimation of the residuals, the respective percentage

interval is 1.4-1.6%. Also, around 1.3-1.6% of the last year's deviation between life expectancy (total or male or female) and total GDP will be corrected this year. Moreover, we can observe from the analyses of the sections 5.1.2 and 5.2.2 that health status has similar effect on both total and per capita GDP in the short-run, but greater impact on total GDP than on per capita GDP in the long-run. Finally, we found that there is reverse causality in the six pair of variables, growth rate of total life expectancy and both growth rate of total and per capita income, growth rate of male life expectancy and both growth rate of total and per capita GDP, and growth rate of female life expectancy and both growth rate of total and per capita income.

Consequently, there is a strong evidence that health status of the aggregate population or separately of the aggregate males and females has a positive, sizable and statistically significant impact on economic performance of the country. These relationships are very important for policy purposes. It would be useful if policy makers took into account health improvements as a way to accelerate the economic growth. Especially, in the case of the economies that do not perform that well, some changes in economic policy regarding health could enhance their economic performance. Specifically, as suggested by Bloom and Canning (2008), cheap and easy health policies could lead to a dramatic improvement in health even in the poorest economies. Moreover, higher priority can be given to disease that do not have large burden on mortality, but do affect productivity in a great deal.

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