THE IMPACT OF HEALTH ON GDP:

A PANEL DATA INVESTIGATION

Aliona Neofytidou
Department of Economics
University of Macedonia
GREECE
alionanf@gmail.com

Stilianos Fountas
Department of Economics
University of Macedonia
156 Egnatia Street
Thessaloniki 540 06
GREECE
Phone: +30-2310-891774
Fax: +30-2310-891292
sfountas@uom.gr

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Abstract

Using a balanced panel of 19 industrial economies and a long time series ranging from 1950 to 2013, we investigate the short-run and long-run relationship between health, proxied by life expectancy, and income using panel cointegrating analysis and panel Granger causality. We find that total life expectancy, male life expectancy, and female life expectancy have all a positive and statistically significant short-run and the long-run effect on both total and per capita income. As a consequence, we conclude that health should be considered an important ingredient of the economic performance of an economy. We examine the robustness of our results using data from Scandinavian and non-Scandinavian countries.

1. Introduction

"Understanding *why some countries are so rich while some others are so poor* is one of the most important, perhaps the most important, challenges facing social science."

(Acemoglu, 2009, p. 8)

Economists have long been interested in explaining cross-country income differences by focusing on the determinants of growth. One of the most important contributors to growth is human capital. 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 argue that health is a better predictor of economic growth than education (Barro, 2013; Knowles and Owen, 1995).

The literature argues that a higher income makes easier the access to goods and services that contribute to improved 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 prospects. Hence, in this paper we examine the bidirectional short-run and long-run relation between income and health. Our methodology includes panel cointegration analysis and panel Granger causality.

The paper contributes to the relevant literature along the following lines. First, we use a long time period ranging from 1950 to 2013, which includes the medical improvements that started in the 1940s and mentioned in Acemoglu and Johnson (2007) study. 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 over 2,000. Third, we apply modern macroeconometric techniques, such as panel cointegration analysis and panel Granger causality. Finally, we consider the differential effects of gender on the relation between life expectancy and income.

Swift (2011) is the closest study to our analysis. We differ from Swift (2011) in three ways. First, we use a panel, as opposed to a time series approach. Our sample is much larger as (i) more countries are included and (ii) the cross section and time series information is combined in the panel. Hence, the reliability of our results is enhanced. Second, and in continuation of the first point above, we employ panel cointegration and panel Granger-causality analysis to test for the short-run and long-run effects of health on income. Third, we consider the impact of the gender on the relation between health and income by examining separately the effect of male and female life expectancy on income.

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- and long-run. Also, the impact of male and female life expectancy on total and per capita GDP is statistically significant and of similar size, which implies that both the male and female health status affects income of a country to the same extent. Our results are, in general, robust to the use of two groups of countries, Scandinavian and non-Scandinavian countries.

The structure of the paper is as follows. Section 2 provides a literature review. Sections 3 and 4 describe the data and the methodology, respectively. Section 5 presents the results of the analysis. Finally, Section 6 concludes and offers some policy implications.

2. Theory and literature Review

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 impact of health on labor supply is 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.

The theoretical literature on the relation between life expectancy and growth is rather limited. A recent study by Kunze (2014) uses an overlapping generations model with family altruism and shows that the effect on growth depends on the existence of operative bequests. If these bequests are available, the effect of life expectancy on

growth is unambiguously negative. This result obtains because an increase in life expectancy reduces the size of bequests and capital accumulation, thus reducing output growth. However, if the bequests are inoperative the relationship between life expectancy and growth is inverted U-shaped.

The empirical literature on the health-economic growth nexus is quite large and employs mostly the panel-data methodology. Barro and Lee (1994) use data for 85 countries for the period 1965-1975 and 95 countries for the period 1975-1985. Life expectancy at birth proves to be a positive and highly significant determinant of growth, in particular for poorer countries. Bloom et al. (2004) estimate a panel of 104 countries for the period 1960-1990 (every 10 years) with nonlinear two stage least squares. Considering efficiency as the total factor productivity (TFP), they conclude that health has a positive and statistically significant effect on economic growth. Barro (1996, 2013) using a panel of around 100 countries from 1960 to 1990, concludes that the growth rate is positively influenced by higher life expectancy which is an indicator of health status. This result is robust to various estimation techniques such as OLS, SUR and three-stage least squares (3SLS).

Acemoglu and Johnson (2007) use a panel dataset consisting of 75 countries for the time periods 1940-1980 and 1940-2000 and employ two stage least squares (2SLS). They conclude that there is a small positive impact of life expectancy on total GDP over the first 40 years, and a somewhat greater impact over the next 20 years. However, this positive impact is not enough to compensate for the increase in population. As a consequence, there is no evidence of a significant positive impact of health on per capita GDP. Ashraf et al. (2009) using a simulation model and assuming that life expectancy rises from 40 to 60, find that per capita output may increase in the long-run, however, 30-40 years after the shock, income might decrease. This result is in line with the findings of Acemoglu and Johnson (2007). Caselli et al. (1996) use a panel of 97 countries including 5-year periods from 1960 to 1985. They conclude that there is a positive statistically significant impact of health on economic growth, even though the use of generalized method of moments (GMM) indicates a negative but statistically insignificant effect of life expectancy on real per capita GDP. Bhargava et al. (2001) using a panel data set for the period 1965-90 find a significant impact of adult surviving rates (a proxy for health) on GDP growth in low income countries. Aguayo-Rico et al. (2005) build a health index based on four determinants of health lifestyles, environment, health services and socioeconomic

conditions and find a positive and statistically significant impact of health on economic growth. Knowles and Owen (1995), also, considering a sample of 84 non-oil economies for the time period 1960-1985 and using OLS and 2SLS show that there is a strong and robust relationship between health and income per capita.

Recent empirical studies make use of modern econometric techniques. Swift (2011) performs a time-series analysis on 13 OECD countries for the last two centuries. Using the Johansen multivariate cointegration analysis he finds that there is a stable long-run relationship between life expectancy and both total and per capita GDP for each country in the sample. However, in the short-run, there is no effect of life expectancy on growth. This may explain the finding of Acemoglu and Johnson (2007) that the full effects of better health on growth may appear some decades later.

3. Data

In this study we attempt to investigate both the short-run and the long-run relationship between health and economic growth. We use life expectancy at birth as an indicator of health. Specifically, we examine the relationship between health and a measure of income (GDP per capita and total GDP). Furthermore, in addition to the aggregate measure of life expectancy (LET), we consider separate life expectancy measures for males (LEM) and females (LEF), in order to investigate the effect of life expectancy of each gender on GDP per capita (GDPC) and total GDP (GDPT). Hence, our analysis includes five variables in total. The first variable is GDPC taken from Maddison[1]. The second variable is total GDP constructed as the product of GDP per capita and national population, where national population is taken from Maddison. Both GDPC and GDPT 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]. All variables are expressed in logarithms.

The choice of the variables selected for this study is based on data availability for the time period 1950-2013 that we consider. A look at the growth regressions reported in the literature shows that, in addition to the health proxy, other variables, such as education and investment are often included. Nevertheless, we do not take into account any of them as they are not available for our sample time period. This

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

does not seem to cause a problem in our estimations as, according to Juselius (2006, p. 11), the cointegrating relation does not depend on the size of the information set. In other words, the inclusion or not of additional variables in the model will not affect the long-run equilibrium relationship, if such a relationship exists.

Furthermore, we use data for 19 OECD countries. The time span covers the period 1950-2013 and hence we have a balanced panel dataset. The countries included are Australia, Austria, Belgium, Denmark, Finland, France, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and United States. For robustness, we also repeat the analysis for two subgroups of countries: The Scandinavian countries (Denmark, Iceland, Norway, Finland and Sweden) and the non Scandinavian countries.

Finally, the choice of a panel study is due to the associated advantages of this type of data which include "more informative data, more variability, less collinearity among variables, more degrees of freedom and more efficiency" (Gujarati, 2004 p.637). Also, using a panel data structure is more appropriate for analyzing growth dynamics (Durlauf and Quah, 1998).

4. Methodology

4.1. Stationarity and cointegration tests

We first test for stationarity of all variables. As a starting point we use the Im, Pesaran, and Shin (2003) unit root test, henceforth denoted by IPS. We also test for evidence of cross-sectional dependence (CSD) in the error terms of the panel using three tests, namely the Breusch-Pagan LM test, the Pesaran scaled LM test and Pesaran's CD test (Pesaran, 2004). Having established evidence for CSD, we apply the Pesaran CIPS unit root test (Pesaran, 2007) which allows for CSD. Following the establishment of non-stationary processes, we apply panel data cointegration analysis. Specifically, we employ the Pedroni (1999, 2004) panel cointegration tests, which are based on the Engle-Granger (1987) cointegration test. The last one is based on the examination of the residuals of a spurious regression, with I(1) variables. 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.

4.2. FMOLS and DOLS

In order to estimate the cointegrating vectors, we employ Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) methodology. The FMOLS estimator proposed by Phillips and Hansen (1990) 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, thus permitting us to apply standard Wald tests using asymptotic chi-square distribution. On the other hand, in order to eliminate the feedback in the cointegrating equation, Saikkonen (1992) and Stock and Watson (1993) proposed DOLS as an asymptotically efficient estimator.

4.3. Engle-Granger two-step methodology

We follow the Engle-Granger two-step method (Brooks, 2008). In the first step, we examine the order of integration of the variables. Provided all variables are I(1) and cointegrated, we run the cointegrating regression with FMOLS and DOLS and take the residuals u_t. In the second step, we run the error-correction models (ECMs) with OLS using the residuals from the first step. Analytically, the cointegrating equation takes the form:

$$LGDP_t=\beta LLF_t+u_t \quad (1)$$

where β is estimated by the FMOLS or DOLS estimator depending on the estimation method. LGDP and LLF denote the logs of GDP and LF, respectively. The estimated cointegrating vector is (1, –b). ECMs using no lags and one lag, respectively are estimated:

$$\Delta LGDP_t = \beta_1 \Delta LLF_t + \gamma_1 u_{t-1} + \varepsilon_t \quad (2)$$

$$\Delta LGDP_t = \beta_2 \Delta LLF_t + \beta_3 \Delta LGDP_{t-1} + \beta_4 \Delta LLF_{t-1} + \gamma_2 u_{t-1} + \varepsilon_t \quad (3)$$

where ΔLGDP is the first difference operator, u_{t-1} is the error-correction term (ECT), and ε_t is iid.

5. Results

In this section we analyze the effect of health on economic performance. As mentioned above, we use life expectancy at birth as a proxy of health, and per capita GDP and total GDP as proxies of growth. Following unit root and cointegration tests, we run panel cointegrating regressions and error-correction models in order to investigate the short-run and long-run link between health and economic growth.

5.1. Stationarity and cross-sectional dependence

First, we test for panel stationarity. We employ the IPS unit root test for the logarithms of all variables. We consider individual effects and a time trend. Table 1 consists of three panels. In panel A we report the unit root tests for levels and first differences in our two income proxies. We conclude that income is stationary in first differences. In Panel B we report the unit roots test on all three life expectancy variables. Finally, Panel C reports the test on the first differences of the life expectancy variables. There is some ambiguity regarding the stationarity properties of the life expectancy proxies as the unit root test results at the levels are not uniform. However, on the basis of the results of Panel C, we conclude that life expectancy is I(1). The number of lags is selected based on the Akaike Information Criterion (AIC)[3].

We next test for CSD. Using three different tests, including Pesaran's CD test, we find evidence for CSD in the error term. The results are reported in Table 2. We consider all possible permutations of models using the two definitions of income (per capita and total income) and the three definitions of life expectancy (total, male and female). In all six cases considered the null hypothesis of lack of CSD is rejected very strongly. Given the evidence for CSD, we proceed with the use of Pesaran's CIPS unit root test in the presence of CSD. The results are reported in Table 3. We provide the test values for two models: drift only, and drift plus trend. Based on the use of both models, we conclude that all series are I(1).

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

[3] Given the possibility of structural breaks, we have also employed the Karavias and Tzavalis (2014) unit root test which takes into consideration the possibility of a break. The unit root tests indicate that all income proxies are I(1) and all life expectancy variables are stationary. Since this test is valid for cases when the cross-section dimension exceeds the time series dimension, we believe that it is not appropriate for our case. Results are available upon request.

We employ the Pedroni cointegration tests to investigate the existence of a long-run equilibrium relationship between GDPC and total life expectancy at birth. Table 4 reports the results of the Pedroni cointegration test in three cases: (i) no deterministic trend, (ii) both deterministic intercept and trend, and (iii) no deterministic intercept and trend. The number of lags is chosen based on the AIC. In all cases, the null hypothesis is that there is no cointegrating relation between the two variables. We report the seven statistics proposed by Pedroni that refer to two cases: i) the autoregressive (AR) coefficients are common for all the countries (rows 3-6), and ii) the AR coefficients are not common (rows 7-9). The stronger evidence for cointegration obtains when no deterministic trend is included in the model. Overall, the results reported in Table 4 indicate some evidence for cointegration at the 5% significance level.

As a result, in order to describe both short-run dynamics and long-run equilibrium simultaneously, we estimate by OLS a simple vector error correction model (VECM). Table 5 reports the results of three estimated regressions. The first one (Panel A) is the cointegrating equation. Using both the FMOLS and the DOLS methods, the long-run coefficient of the logarithm of LF at birth is statistically significant at 1%. The estimated cointegrating coefficient is 8.32 and 8.36 in the FMOLS by DOLS equations, respectively, meaning that a 1% increase in LF in the long-run leads to a 8.32% or 8.36% increase in GDPC, depending on the model considered.

The second equation (Panel B) is the ECM without lags. In both estimations (with FMOLS and DOLS), all variables are highly statistically significant. The adjustment parameter is negative in both cases in agreement with the hypothesis that the error correction corrects the deviation from the long-run equilibrium relationship. According to the coefficients size, 1.4% or 0.9% of the discrepancy between the two variables in the previous year is eliminated this year. Finally, the third equation of Table 5 (Panel C) reports the ECM with one lag. The estimated ECTs imply that about 1.8% or 1.7% of the gap between the two variables in the previous year is eliminated this year. In summary, according to the above analysis, life expectancy at birth (as an indicator of health standard) has a significant, positive, and sizeable effect on GDP per capita in both the short-run and the long-run.

Finally, we employ panel Granger causality tests, in order to determine the causation relation between life expectancy at birth and per capita GDP. Table 6

presents the test statistics of two null hypotheses. Both hypotheses are rejected at 1% implying two-way causality between the growth rate of LF and the growth rate of GDPC. Note that the first result (life expectancy causes growth) is similar with the result that we obtain from ECMs, as the short-run parameters are statistically significant and positive[4].

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 in GDP per capita and the health status of the two sexes. We will present both short run and long - run effects of LLF at birth of males and females on GDPC. The results of the Pedroni cointegration tests (not reported but available on request) indicate a long-run equilibrium relationship between male LF and GDPC, and female LF and GDPC. The evidence for cointegration is stronger for the case of female life expectancy. Hence, in Tables 7 and 8 we present the cointegrating equations run with FMOLS and DOLS and the estimated ECMs with OLS[5] for males and females, respectively. According to panel A in Table 7, the cointegrating parameter of the male equation is strongly statistically significant (at 1%). An increase in male life expectancy at birth by 1% will increase GDP per capita by about 7.8%. The corresponding coefficient for the female equation in panel A of Table 8 is somewhat higher (about 8.6%). The small difference of the cointegrating parameter for males and females is a quite interesting finding. It indicates that the health level of males and females has a positive, statistically significant, and of similar size impact on GDPC. However, this finding is perhaps not surprising since we know that women were part of the labour force during the sample period.

In Panels B and C of Tables 7 and 8, we report the estimated ECMs, for male and female life expectancy, respectively. The ECT is strongly statistically significant for both sexes. The error-correction coefficients indicate that between 1.2% and 1.8% of last period's equilibrium error is corrected. Finally, in Table 9 panel Granger causality tests are presented. Generally speaking, for both sexes there is a two-way

[4] We employ the Pedroni cointegration tests using total GDP and find similar results with the case of GDPC. The major difference is that the long-run impact of LF on total GDP is greater than the impact on GDPC. This result is not surprising given that the rise of LF leads to an increase of population and hence total income. Results are available upon request.

[5] Similar results are obtained by the FMOLS method and hence are not reported but are available on request.

causality between the two pairs of variables. In summary, based on the above results, we find a positive and statistically significant impact of both genders' health standard on GDPC in both the short-run and the long-run[6].

5.4. Robustness test: Scandinavian countries

As a robustness test, we divide the countries used in the previous empirical analysis into two groups: Scandinavian and non-Scandinavian countries. The objective is to examine whether our results are unaffected by considering subsets of the countries included in the full panel. The group of Scandinavian countries includes 5 countries, namely, Denmark, Finland, Iceland, Norway and Sweden for the period 1950-2013. Our data is a balanced panel of 320 observations.

We first test for stationarity and then perform Pedroni's cointegration tests (results available upon request from the authors). Given the evidence for cointegration, we estimate the cointegration regression and the ECMs. Table 10 includes the results for the case where GDP per capital in regressed on the total life expectancy. In panel A we report evidence for a strong long-run effect of life expectancy on GDP per capita. The cointegration coefficient is equal to 10.5 implying a strong effect of life expectancy on per capita income for the Scandinavian countries. This effect is larger than the estimated effect for the total country group. In panel B and C we report the estimated ECMs. The ECT coefficients in Panel C indicate that between 2.2% and 2.5% of last period's deviation from the long-run equilibrium is corrected during the next year. These figures imply a faster return to the long-run equilibrium in comparison with the results obtained for the full country sample. Table 11 reports the results of the panel Granger-causality tests. We conclude that the GDP per capita Granger-causes life expectancy but the opposite causal effect is not statistically significant. This is in contrast with the result obtained for the full country sample.

We next repeat the above analysis using separate data for male and female life expectancy. Table 12 reports the results for male life expectancy. We find a significant long-run relationship from life expectancy on GDP per capita (panel A). This evidence is supported by the significance of the error-correction terms reported

[6] The above analysis has been repeated measuring economic activity by total GDP. The results obtained (not reported but available on request) are similar with the results obtained using per capita GDP. The major difference is that the size of the cointegrating parameter is higher indicating a larger long-run effect of life expectancy on total growth as compared with the effect on per-capita growth.

in panels B and C. Similar results obtain when we use female life expectancy instead (Table 13). The results show a significant long-run effect of life expectancy on growth which is higher in comparison to the case of male life expectancy. Finally, Table 14 reports the results of panel Granger-causality tests for males and females. For both sexes, in the short run life expectancy has no effect on per-capita growth. However, per capita growth Grangers-causes life expectancy for males but not females.

5.5. Comparison with other studies

We find that life expectancy at birth is an important short-run and long-run determinant of economic performance proxied by total GDP and per capita GDP using a long series covering more than one century and a large number of countries. This result holds irrespective of gender. Moreover, we find that the causal relationship between economic growth and life expectancy is bidirectional implying that economic growth is also a positive determinant of life expectancy.

Our empirical analysis contributes to this literature in several ways: First, it examines the impact of gender on the relationship between health and economic growth. Second, it combines a long time-series dimension with a large cross-section of countries in a panel framework using more efficient estimation methods. Third, we test for both the short-run and the long-run relationship between health and economic growth. The most relevant paper to our study is Swift (2011). However, this paper does not examine the effect of gender's health on growth.

Swift (2011) uses a smaller number of countries and performs time series cointegration analysis on 13 OECD economies using data from 1821 (or 1921 for some countries) to 2001 to investigate the link between LF at birth and both GDPT and GDPC. He finds a long-run relationship between income and life expectancy, but no short-run relationship on the basis of the estimated ECMs. His estimate of the long-run coefficient is of similar size to our results.

Regarding the rest of the literature discussed in section 2, the majority finds that the health standard affects growth positively either in the short-run or in the long-run, depending on the econometric analysis used, with the exception of Acemoglu and Johnson (2007) and Ashraf et al. (2009). Acemoglu and Johnson (2007) find that the health status has a small positive impact on total GDP at the first 30-40 years which is

getting a little larger over time. They also find that the increase in total GDP does not compensate the increase of population and as a result per capita/worker GDP declines. Finally, Ashraf et al. (2009) conclude that 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 years. They also find that 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. Conclusions and policy implications

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 use an balanced panel of 19 OECD countries, for the period 1950-2013. This period of time includes the medical improvements that started in the 1940s. We consider life expectancy at birth as an indicator of health and total GDP and per capita GDP as indicators of income. We test for a short-run and a long-run relationship between total population health and income. We, also, examine the link between income and each gender's life expectancy.

We obtain some important results. First, the health standard of a country's population proxied by life expectancy has a positive and statistically significant effect on total and per capita income in the long-run. Second, the long-run impact of total, male, and female life expectancy on income (both total and per capita) is similar in size. Furthermore, error-correction models imply that there is both short-run and long-run relationship between total, male and female LF and income (total and per capita). Finally, we find that there is bidirectional causality between income (per capita or total) and life expectancy (for the total, male, or female population). Most of the above results are robust to the choice of countries (Scandinavian versus non-Scandinavian).

On the basis of our results, there is strong evidence that the 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 a country. These findings are very important for policy purposes. Policy makers should take into account health improvements as a way to accelerate the economic growth. Especially, for economies that lack in growth, health-improving policies would be expected to 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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Table 1: IPS unit root tests (Balanced panel with 19 countries)

Panel A	**Log of GDP per capita**		**Log of total GDP**		**Difference of log of GDP per capita**		**Difference of log of total GDP**	
H_0: unit root	t-stat.	Prob.+	t-stat.	Prob.+	t-stat.	Prob.+	t-stat.	Prob.+
Individual effects & trend	5.880	1.000	6.147	1.000	-19.957	0.000***	-19.497	0.000***
Panel B	**Log of total life expectancy**		**Log of male life expectancy**		**Log of female life expectancy**			
H_0: unit root	t-stat.	Prob.+	t-stat.	Prob.+	t-stat.	Prob.+		
Individual effects & trend	-3.108	0.000***	-0.286	0.388	-1.388	0.083*		
Panel C	**Difference of log of total life expectancy**		**Difference of log of male life expectancy**		**Difference of log of female life expectancy**			
H_0: unit root	t-stat.	Prob.+	t-stat.	Prob.+	t-stat.	Prob.+		
Individual effects & trend	-23.192	0.000***	-26.148	0.000***	-19.972	0.000***		

+Probabilities are computed assuming asymptotic normality.

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

Table 2: Tests for cross-sectional dependence (balanced panel with 19 countries)

Panel Least Squares	LGDPC = α + β* LLET			LGDPC = α + β* LLEM			LGDPC = α + β* LLEF		
Test	**Statistic**	**d.f.**	**Prob.**	**Statistic**	**d.f.**	**Prob.**	**Statistic**	**d.f.**	**Prob.**
Breusch-Pagan LM	3261.908	171	0.000	4153.960	171	0.000	2848.883	171	0.000
Pesaran scaled LM	166.109		0.000	214.346		0.000	143.776		0.000
Pesaran CD	38.829		0.000	51.974		0.000	22.686		0.000

Panel Least Squares	LGDPT = α + β* LLET			LGDPT = α + β* LLEM			LGDPT = α + β* LLEF		
Test	**Statistic**	**d.f.**	**Prob.**	**Statistic**	**d.f.**	**Prob.**	**Statistic**	**d.f.**	**Prob.**
Breusch-Pagan LM	5519.406	171	0.000	7971.368	171	0.000	3866.545	171	0.000
Pesaran scaled LM	288.181		0.000	420.768		0.000	198.805		0.000
Pesaran CD	64.243		0.000	88.0898		0.000	37.667		0.000

Table 3: Pesaran's CIPS test

Variable	Drift and trend, lag=1	Drift, lag=1
LGDPC	-2.359	-1.871
DLGDPC	-5.217	-4.977
LGDPT	-2.381	-1.699
DLGDPT	-5.197	-4.953
LLET	-2.123	-2.199
DLLET	-7.375	-6.867
LLEM	-2.594	-2.370
DLLEM	-7.366	-6.664
LLEF	-2.999	-2.372
DLLEF	-7.590	-7.365

Note: The second column reports the results with a drift and trend and the third column reports the results with only a drift. The 5% critical values are -2.70 and -2.20 for the drift and trend and drift only models, respectively.

Table 4: Pedroni's cointegration tests (Per capita GDP and total life expectancy)

H_0: no cointegration between LGDPC and LLET							
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	9.447	0.000	13.083	0.000	-1.362	0.913
	Panel rho-Statistic	-2.584	0.005	-0.491	0.312	0.373	0.645
	Panel PP-Statistic	-1.860	0.031	-0.574	0.283	-2.187	0.014
	Panel ADF-Statistic	-0.828	0.204	2.246	0.988	-1.619	0.053
H_1: individual coef.	Group rho-Statistic	-0.243	0.404	1.485	0.931	3.705	0.999
	Group PP-Statistic	-0.164	0.435	1.395	0.919	-1.315	0.094
	Group ADF-Statistic	-0.415	0.339	2.226	0.987	-1.105	0.135

Table 5: Cointegration regressions and error-correction models (Per capita GDP and total life expectancy)

	Fully Modified OLS				**Dynamic OLS**			
Panel A: LGDPC=βLLET + e								
	Observations 1197				Observations 1159			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
LLET	8.322	53.342	0.000	0.924	8.358	47.748	0.000	0.929
Panel B: ΔLGDPC=α_1+$\beta_1\Delta$LLET+γ_1ECT(-1)								
	Observations 1178				Observations 1159			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
ΔLLET	0.453	3.239	0.001	0.013	0.146	0.996	0.320	0.004
ECT(-1)	-0.014	-2.782	0.006		-0.009	-1.776	0.076	
C	0.023	10.023	0.000		0.024	9.831	0.000	
Panel C: ΔLGDPC=α_2+$\beta_2\Delta$LLET+$\beta_3\Delta$LGDPC(-1)+ $\beta_4\Delta$LLET(-1)+γ_2ECT(-1)								
	Observations 1178				Observations 1159			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
ΔLLET	0.435	3.193	0.001	0.126	0.256	2.043	0.041	0.127
ΔLGDPC(-1)	0.325	12.189	0.000		0.431	12.566	0.000	
ΔLLET(-1)	0.091	0.692	0.489		0.170	0.818	0.414	
ECT(-1)	-0.018	-3.906	0.001		-0.017	-2.988	0.003	
C	0.014	7.287	0.000		0.012	7.169	0.000	

Note: Based on Omitted Random Effects, in panel B we used period and cross-section random effects specification, and in panel C, only period random effects.

Table 6: Panel Granger Causality Test

Null Hypothesis:	F-Stat.
Life expectancy does not Granger Cause Growth per capita	7.498 (0.000)
Growth per capita does not Granger Cause Life expectancy	5.187 (0.006)

Note: p-values in parentheses. Stacked test (common coefficients) with 2 lags.

Table 7: Cointegration regressions and error-correction models (Per capita GDP and male life expectancy)

	Fully Modified OLS				Dynamic OLS			
Panel A: LGDPC=βLLEM + e								
	Observations 1197				Observations 1159			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
LLEM	7.936	43.905	0.000	0.893	7.845	40.433	0.000	0.906
Panel B: ΔLGDPC=α_1+$\beta_1\Delta$LLEM+γ_1ECT(-1)								
	Observations 1178				Observations 1159			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
ΔLLEM	0.333	2.754	0.006	0.014	0.087	0.699	0.485	0.007
ECT(-1)	-0.016	-3.475	0.001		-0.013	-2.676	0.008	
C	0.023	10.294	0.000		0.024	9.934	0.000	
Panel C: ΔLGDPC=α_2+$\beta_2\Delta$LLEM+$\beta_3\Delta$LGDPC(-1)+ $\beta_4\Delta$LLEM(-1)+γ_2ECT(-1)								
	Observations 1178				Observations 1159			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
ΔLLEM	0.272	2.303	0.022	0.126	0.151	1.220	0.223	0.128
ΔLGDPC(-1)	0.325	12.246	0.000		0.343	12.621	0.000	
ΔLLEM(-1)	-0.039	-0.345	0.730		-0.034	-0.292	0.771	
ECT(-1)	-0.018	-4.256	0.000		-0.016	-3.449	0.001	
C	0.015	7.799	0.000		0.015	7.647	0.000	

Note: Based on Omitted Random Effects, in panel B we used period and cross-section random effects specification, and in panel C, only period random effects.

Table 8: Cointegration regressions and error-correction models (Per capita GDP and female life expectancy)

	Fully Modified OLS				Dynamic OLS			
Panel A: LGDPC=βLLEF + e								
	Observations 1197				Observations 1159			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
LLEF	8.617	61.332	0.000	0.940	8.811	52.801	0.000	0.946
Panel B: ΔLGDPC=α_1+$\beta_1\Delta$LLEF+γ_1ECT(-1)								
	Observations 1178				Observations 1159			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
ΔLLEF	0.478	3.363	0.001	0.011	0.194	1.300	0.194	0.002
ECT(-1)	-0.010	-1.902	0.057		-0.004	-0.734	0.463	
C	0.023	10.198	0.000		0.024	10.168	0.000	
Panel C: ΔLGDPC=α_2+$\beta_2\Delta$LLEF+$\beta_3\Delta$LGDPC(-1)+ $\beta_4\Delta$LLEF(-1)+γ_2ECT(-1)								
	Observations 1178				Observations			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
ΔLLEF	0.541	3.886	0.000	0.128	0.388	2.632	0.009	0.128
ΔLGDPC(-1)	0.324	12.108	0.000		0.341	12.459	0.000	
ΔLLEF(-1)	0.258	1.918	0.055		0.289	2.104	0.036	
ECT(-1)	-0.017	-3.398	0.001		-0.012	-2.406	0.016	
C	0.014	7.020	0.000		0.014	6.936	0.000	

Note: Based on Omitted Random Effects, in panel B we used period and cross-section random effects specification, and in panel C, only period random effects.

Table 9: Panel Granger causality test

	Male	**Female**
Null Hypothesis:	**F-Stat**	**F-Stat**
ΔLLF does not Granger Cause ΔLGDPC	5.628 (0.004)	9.353 (9.E-5)
ΔLGDPC does not Granger Cause ΔLLF	4.441 (0.012)	6.531 (0.002)

Note: p-values in parentheses. Stacked test (common coefficients) with 2 lags.

Table 10: Cointegration regressions and error-correction models using per capita GDP and total life expectancy (Scandinavian Countries)

	Fully Modified OLS				Dynamic OLS			
Panel A: LGDPC=βLLET + e								
	Observations 315				Observations 305			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
LLET	10.467	26.587	0.000	0.920	10.542	25.690	0.000	0.927
Panel B: ΔLGDPC=α_1+$\beta_1\Delta$LLET+γ_1ECT(-1)								
	Observations 310				Observations 305			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
ΔLLET	-0.137	-0.416	0.678	0.012	-0.499	-1.507	0.133	0.015
ECT(-1)	-0.019	-1.750	0.081		-0.016	-1.474	0.142	
C	0.024	9.232	0.000		0.025	9.384	0.000	
Panel C: ΔLGDPC=α_2+$\beta_2\Delta$LLET+$\beta_3\Delta$LGDPC(-1)+ $\beta_4\Delta$LLET(-1)+γ_2ECT(-1)								
	Observations 310				Observations 305			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
ΔLLET	0.114	0.332	0.740	0.075	-0.201	-0.573	0.567	0.091
ΔLGDPC(-1)	0.251	4.591	0.000		0.279	5.055	0.000	
ΔLLET(-1)	0.043	0.132	0.895		0.219	0.645	0.520	
ECT(-1)	-0.025	-2.370	0.018		-0.022	-2.044	0.042	
C	0.017	5.922	0.000		0.017	5.630	0.000	

Note: in both panel B and C period random effects are considered.

Table 11: Panel Granger Causality Tests (Scandinavian Countries)

Null Hypothesis:	F-Stat.
ΔLLET does not Granger Cause ΔLGDPC	1.906 (0.150)
ΔLGDPC does not Granger Cause ΔLLET	4.522 (0.012)

Notes: p-values are given in parentheses. Stacked test (common coefficients) with two lags.

Table 12: Cointegration regressions and error-correction models using per capita GDP and male life expectancy (Scandinavian Countries)

	Fully Modified OLS				Dynamic OLS			
Panel A: LGDPC=βLLEM + e								
	Observations 315				Observations 305			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
LLET	9.557	19.536	0.000	0.864	9.422	18.011	0.000	0.879
Panel B: ΔLGDPC=α_1+$\beta_1\Delta$LLEM+γ_1ECT(-1)								
	Observations 310				Observations 305			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
ΔLLEM	-0.142	-0.609	0.543	0.010	-0.300	-1.325	0.186	0.016
ECT(-1)	-0.013	-1.413	0.159		-0.018	-1.812	0.071	
C	0.024	9.583	0.000		0.024	9.534	0.000	
Panel C: ΔLGDPC=α_2+$\beta_2\Delta$LLEM+$\beta_3\Delta$LGDPC(-1)+ $\beta_4\Delta$LLEM(-1)+γ_2ECT(-1)								
	Observations 310				Observations			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
ΔLLEM	-0.176	-0.725	0.469	0.075	-0.360	-1.485	0.139	0.097
ΔLGDPC(-1)	0.241	4.461	0.000		0.271	4.962	0.000	
ΔLLEM(-1)	-0.269	-1.157	0.248		-0.273	-1.134	0.258	
ECT(-1)	-0.0176	-1.993	0.047		-0.021	-2.206	0.028	
C	0.019	6.995	0.000		0.019	6.682	0.000	

Note: In both panels B and C period random effects are considered.

Table 13: Cointegration regressions and error-correction models using per capita GDP and female life expectancy (Scandinavian Countries)

	Fully Modified OLS				**Dynamic OLS**			
Panel A: LGDPC=βLLEF + e								
	Observations 315				Observations 305			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
LLEF	11.043	34.518	0.000	0.948	11.340	33.135	0.000	0.956
Panel B: ΔLGDPC=α_1+$\beta_1\Delta$LLEF+γ_1ECT(-1)								
	Observations 310				Observations			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
ΔLLEF	0.092	0.290	0.772	0.018	-0.379	-1.157	0.248	0.011
ECT(-1)	-0.027	-2.356	0.019		-0.018	-1.444	0.150	
C	0.023	9.142	0.000		0.024	9.415	0.000	
Panel C: ΔLGDPC=α_2+$\beta_2\Delta$LLEF+$\beta_3\Delta$LGDPC(-1)+ $\beta_4\Delta$LLEF(-1)+γ_2ECT(-1)								
	Observations 310				Observations 305			
Variable	**Coefficient**	**t-stat.**	**p-value**	**R^2**	**Coefficient**	**t-stat.**	**p-value**	**R^2**
ΔLLEF	0.643	1.920	0.056	0.096	0.245	0.726	0.469	0.113
ΔLGDPC(-1)	0.266	4.902	0.000		0.296	5.412	0.000	
ΔLLEF(-1)	0.540	1.707	0.089		0.861	2.717	0.007	
ECT(-1)	-0.033	-2.850	0.005		-0.028	-2.317	0.021	
C	0.014	5.054	0.000		0.014	4.849	0.000	

Note: In both panels B and C period random effects are considered.

Table 14: Panel Granger Causality Tests (Scandinavian countries)

Null Hypothesis:	**F-Stat. Male**	**F-Stat. Female**
Life expectancy does not Granger Cause Growth per capita	1.974 (0.141)	2.030 (0.133)
Growth per capita does not Granger Cause Life expectancy	4.581 (0.011)	1.457 (0.235)

Notes: p-values are given in parentheses. Stacked test (common coefficients) with two lags.