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The Relationships between Human Capital Investment and Economic Growth: A Panel Error Correction Model

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Abstract. In this paper, long and short term relationships between human capital investment and economic growth for individuals and pooled cases in the OECD countries, over the period between 1975 and 2005, were examined. Health care expenditure is used as a proxy for the human capital. After the application of the panel unit root and panel cointegration tests, the long and short run income elasticities of health care expenditures are estimated using the panel error correction model. The results show that an increase in the health expenditures/investments causes an increase in the economic growths for all the countries in the short and long runs.

JEL Classification Codes: I15, O15
Keywords: Health care expenditures; panel unit root; panel cointegration; panel error correction model

1. Introduction

The insufficiency of the physical capital as an explanation of economic relationships has led to new pursuits recently; and the human capital, which has always been in the background for various reasons, has started to take its well-deserved place. The problem of measuring the human capital is an issue that is frequently discussed in the macro and micro economics. While some numerical values were attempted to be assigned for the human capital in some of the researches conducted, in some works, however, instrumental variables for the human capital were used. The most effective instrumental variables for the human capital are the ones with the purpose of increasing the life standards of the citizens; in other words, they are the investments made in humans, and therefore, generally related to the education and

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health.[1] The educational expenses, average number of education years, rate of literacy, earnings as regards to education, the size of the classes, and fees of the teachers can be presented as the instrumental variable examples related to the education whereas health costs, ratio of death, designated bed capacity in the hospitals, the number of doctors, and private health costs are among the instrumental variable examples related to health.

The relationship between the human capital and economic growth has been discussed in the economic literature since 1950s, and has been handled within the endogenous growth theories. The view that one way of increasing the growth is closely related to the extra investments in the human capital has been adopted (Lucas, 1988; Romer, 1990). The recent econometric studies on time series analysis, both for a single country and many countries, by using a panel data analysis, were conducted with the purpose of discovering this relationship (see especially for panel data case, Gerdtham et al., 1992; Hitiris and Posnett, 1992; Hansen and King, 1996; Blomqvist and Carter, 1997; McCoskey and Selden, 1998; Gerdtham and Löthgren, 2000, 2002; Jewell et al. 2003; Dregen and Reimers, 2005; Chakroun, 2009; Swift, 2010).

In this paper, the investment in citizens' health is used as an indicator of human capital. The high human capital countries have a comparative advantage at fighting different diseases, drug addict, fertility etc. The health of individuals affects economic productivity and growth. If the governments want to achieve economic growth, the health expenditures should be thought of as an investment and not as a cost.

Numerous studies exist in the literature on determining the relationship between the health expenses and GDP, conducted by using various methods, for the OECD countries. Gerdtham et al. (1992), in their study, analyzed 20 OECD countries for the time period between 1960 and 1987; they regarded the expenditures as a function of GDP and some other variables and classified the health expenditures (health care services) as luxury goods since they estimated the income elasticity as being more than 1. By using the same data, Hitiris and Posnett (1992) added the effect of the countries to the regression model to control the unobservable effects and calculated the elasticity being close to 1. Hansen and King (1996), on the other hand, conducted the ADF unit root and Engle Granger cointegration

[1] See Judson (2002) and Wößmann (2003) for more detailed information.

tests for the health expenditure and GDP variables in each country, by using the same data set with Gerdtham et al. (1992)., and, as a result, rejected the viewpoint that there exists a cointegrated relation between the two variables. Blomqvist and Carter (1997), likewise, worked on the 24 OECD countries for the period of 1960-1991; and rejected the cointegrated relation based on the Philips Peron t-statistics that they had used in their studies. McCoskey and Selden (1998) used the same data set with Gerdtham et al. (1992) and rejected the null hypothesis that there exists a unit root in both GDP and health expenditure series referring to the IPS (Im, Pesaran and Shin, 2003) test results. Gerdtham and Löthgren (2000, 2002) tested the stationarity for both the pooled individual OECD countries by using the panel method and IPS test, respectively; conducted cointegration tests to determine if there exists a long run relationship between the two variables; and, as a conclusion, identified a cointegrated relationship with a linear trend between the variables. Dregen and Reimers (2005), similarly, in their studies conducted for the time period between 1975 and 2001, examined the relationship between the health expenditures and GDP, by using instrumental variables for non-income factors and technology, and concluded that health expenditures (services) are not luxury goods. Jewell et al. (2003) considered the factors of structural breaks and cross-section dependence and stated that health expenditures and GDP with the two breaks were stationary. Chakroun (2009), then again, calculated the income elasticities of the 17 OECD countries for the time period between 1975 and 2003, by using panel threshold regression model. The results displayed that the health expenditures were not luxurious but necessary; and the relationship between the health and income was not linear but changed according to the time and country. Swift (2010) analyzed the relationship between the average life span with GDP and GDP per capita for 13 OECD countries between the time periods of 1820-2001 and 1921-2001. According to the Johansen cointegration analysis results, a 1 % increase in the life span for the long run would create an increase of 6 % and 5 % in the values for GDP and GDP per capita, respectively.

As can be inferred from the abovementioned paragraph, when the studies, conducted with the purpose of determining the long run relationship between health expenditures and income in the OECD countries, are examined by using various methods, no consensus can be observed in the literature on whether the series included unit root or not; whether a long run relationship between the two variables existed or not; and whether the health care services fall into the category of luxury goods or necessary goods. The

purpose of this study, on the other hand, is to contribute to the literature by examining the short run and long run relationships between the health expenditures and GDP by using panel cointegration and error correction model. The income elasticities will be estimated and whether health expenditures/services fall into the category of luxury or not will be examined. With this purpose, the data of GDP per capita and health expenditures per person for 20 OECD countries, belonging to the time period between 1975 and 2005, were used; and a balanced panel data set was created. Unit root tests for both of the series were first conducted; and it was concluded that both of the series were I (1). Then, panel cointegration tests were conducted with the purpose of examining the existence of a cointegrated relationship between the two series; and the results proved that there existed a long run relationship between the two series. Their long term elasticities were estimated by using FMOLS (Fully Modified OLS) (Philips and Moon, 1999; Pedroni, 2000) and DOLS (Dynamic OLS) (Stock and Watson, 1993) estimation methods. The panel error correction model was later created; and short and long run coefficients between both of the variables were obtained by PMGE (pooled mean group estimation) and MGE (mean group estimation) methods proposed by Shin and Smith (1999) and Pesaran and Smith (1995), respectively. For the method in this study, the lag length was determined by using one of Akaike, Schwarz, or Hannan Quin criteria. According to the results, the majority of the short run and long run coefficients were found to be meaningful and positive for all the panels and countries.

The outline of the paper is as follows. In section (2), we discuss the economic and econometric theory about this study. In section (3) several empirical results are discussed. Finally, section (4) concludes the paper.

2. Methods

In this paper, we consider the following model to test whether or not health care is a luxury good:

$$s_{it} = \alpha + \beta y_{it} + \mu_i + \varepsilon_{it} \qquad i=1,...N \quad t=1,...,T$$

where s_{it} : logarithm of health care expenditures and y_{it} : logarithm of real GDP in the i^{th} country at time t. μ_i is individual effect, and *it* ε is the error term. If the β coefficient, which represents income elasticity of health spending, is greater than 1, health is a luxury commodity.

Before examining the long run relationship between GDP and health expenditures, the stationarities of the series, in other words if they contain unit roots or not, should be checked. Numerous panel unit root tests exist, with various advantages over one another. The tests proposed by Breitung (2000) and Im, Pesaran and Shin (2003) were used in this study. Hlouskova and Wagner (2006) proved that Breitung (2000) panel unit test was "better" than the other tests especially for small samples with the Monte Carlo simulations they had conducted. Nonetheless, a general unit root process is used in the Breitung test; in other words, autoregressive coefficient is restricted to be same for all the individual units under the both null and alternative hypotheses. On the other hand, in contrast with the Breitung test, a root process specific for each individual unit is used in the IPS test; thus, an assumption that all the individual units converge towards the equilibrium value with the same speed under the alternative hypotheses cannot be made, and thus it is less restrictive. These two tests have been among the most commonly used tests in the literature because of the abovementioned advantages.

Pedroni (1999), with the aim of investigating the existence of the cointegration relation among variables in the panel data, suggested seven parametric and non-parametric Philips-Perron type panel cointegration tests that suggest "no cointegration" in its null hypothesis and permit heterogenity in the alternative hypothesis (four of them are panel and three of them are group test statistics). Pedroni (1999) presented critical values for the conditions with and without intercepts and deterministic trends in his paper. Kao (1999), on the other hand, suggested an ADF based panel cointegration test with a null hypothesis that similarly suggests "no cointegration".

If there exists a long run relationship between the series, according to the results of the panel cointegration tests, this long run relationship can be estimated by using FMOLS or DOLS estimation methods. FMOLS estimator is an OLS estimator that is corrected according to the endogenity and serial correlation; and the parameters can be estimated by using the equation below:

$$\hat{\beta}^{*}_{NT} - \beta = \left[\sum_{i=1}^{N} \hat{L}^{-2}_{22i} \sum_{t=1}^{T} \left(s_{it} - \overline{s}_i \right)^2 \right]^{-1} \sum_{i=1}^{N} \hat{L}^{-1}_{11i} \hat{L}^{-1}_{22i} \left[\sum_{t=1}^{T} \left(s_{it} - \overline{s}_i \right) \varepsilon^{*}_{it} - T \hat{\gamma}_i \right] \quad (1)$$

where $\hat{\beta}_{NT}$: standard panel OLS estimator, $\overline{s}_i$, on the other hand, displays the individual specific means.

$$\varepsilon_{it}^{*} = \varepsilon_{it} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}\Delta s_{it}\,,\ \hat{\gamma}_i \equiv \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^{o} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}\left(\hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^{o}\right)$$

(2)

$\hat{\Omega}_i$: long run variance of residuals, $\hat{\Omega}_i^{o}$: contemporaneous covariance, and Γ_i: weighted sum of the autocovariances. $\hat{L}_i$, on the other hand, is the lower triangular decomposition of $\hat{\Omega}_i$ [1].

The panel DOLS estimator, however, can be obtained with the help of the regression below;

$$y_{it} = \alpha_i + s_{it}'\beta + \sum_{j=-q}^{q} c_{ij}\Delta s_{it+j} + v_{it}$$

(3)

FMOLS and DOLS estimation methods only estimate the long run parameters whereas PMGE and MGE estimation methods estimate both short run and long run parameters. The MGE calculates general long run parameters by using the means of the long run parameters obtained from the ARDL model used for the estimation of the individual units. PMGE, on the other hand, is located between the MGE method, which permits the change of intercept and slope parameters, and fixed effects model that permits the change of the intercept but not the change of the slope parameters for the individual units. PMGE limits the change of the long run coefficients across the individual units but permits the short run coefficients and the error variances to change for the units. PMGE is based on the Autoregressive Distributed Lag (ARDL) model which is presented below:

$$y_{it} = \sum_{j=1}^{p-1}\lambda_{ij}\Delta y_{it-j} + \sum_{j=0}^{q-1}\delta_{ij}'\Delta s_{it-j} + \mu_i + \varepsilon_{it}$$

(4)

This model can be re-written as below:

$$\Delta y_{it} = \phi_i y_{it-1} + \beta_i' s_{it} + \sum_{j=1}^{p-1}\lambda_{ij}^{*}\Delta y_{it-j} + \sum_{j=0}^{q-1}\delta_{ij}^{*}\Delta s_{it-j} + \varepsilon_{it}$$

(5)

here,

[1] See Philips and Moon (1999) and Pedroni (2000) for further information.

$$\phi_i = -\left(1 - \sum_{j=1}^{p} \lambda_{ij}\right), \beta_i = \sum_{j=0}^{q} \delta_{ij}, \lambda_{ij}^{*} = -\sum_{m=j+1}^{p} \lambda_{im}, \delta_{ij}^{*} = -\sum_{m=j+1}^{q} \delta_{im} \quad (6)$$

If ϕ_i is meaningful and negative, then there exists a long run relationship between y_{it} and s_{it}. With the purpose of obtaining the PMGE estimator, this equation can be estimated with the maximum likelihood method. This regression can also be estimated with β_i coefficients for the individual units that are used for calculating the MGE estimator; and the homogeneity of the slope coefficients can be tested by using a Hausman based test. Under the hypothesis of $\phi_i < 0$, there exists a long run homogenous relationship between y_{it} and s_{it};

$$y_{it} = \theta_i s_{it} + \eta_{it}, \quad (7)$$

where $\theta_i = -(\beta_i / \varphi_i)$ and η_{it} is stationary. The long run coefficients do not change across the individual units, they are fixed[2].

3. Empirical Results

In this study, the data, belonging to the variables of logarithm of health expenditures and GDP per capita logarithm, for the time period between 1975 and 2005, in the 20 OECD countries, were obtained to create a balanced panel data set. The first step, before investigating the existence of a cointegrated relationship between the health expenditures and GDP, is to investigate whether these variables contain a unit root or not. When Table 1 is examined, it was observed that both variables of GDP and health expenditures were integrated order one (I(1)) according to the Breitung and IPS tests. The country effect and trend were added to both tests; and Schwarz information criteria were used to determine the lag length.

[2] See Shin and Smith (1999) and Pesaran and Smith (1995) for more detailed information.

Table 1. Panel Unit Root Test Results

Panel Unit Root Test	IPS		Breitung	
	y_{it}	s_{it}	y_{it}	s_{it}
Level	5.37009 (1.0000)	-1.13468 (0.1283)	-0.20273 (0.4197)	1.67774 (0.8785)
First difference	-9.31263 (0.0000)	-6.23255 (0.0000)	-9.93099 (0.0000)	-5.10307 (0.0000)

* The values in the parenthesis are the probability values.

The cointegration test was conducted to determine the long term relationship between GDP and health expenditures. The results of the panel cointegration tests, proposed by Pedroni (2000) and Kao (1999), can be seen in Table 2. The lag length was chosen by using the Schwarz Information Criteria; and the country effect and trend was added to the test.

Table 2. Panel Cointegration Results

Panel v	Panel rho	Panel PP	Panel ADF	Group rho	Group PP	Group ADF
-0.283 (0.383)	1.782 (0.081)	0.522 (0.348)	-3.375 (0.001)	2.755 (0.009)	1.223 (1.888)	-3.154 (0.003)

* The values in the parenthesis are the probability values.

The results in Table 2 display that four statistics reveal panel cointegration at 10 percent level or better: panel ADF and group ADF tests are statistically significant at 1 percent level, providing support for cointegrated relationship between the two series. The next step, however, is to estimate this long run relationship between the GDP and health expenditures. FMOLS and DOLS estimation results, used for estimating the long run coefficients, and PMGE and MGE estimation results, used for estimating both the short and long run coefficients, are summarized in Table 3. When the estimations are made, Akaike information criteria were used for choosing the lag length for every country; and Newton-Raphson method was used in the first and second derivative of the log-likelihood function.

Table 3. Panel Short and Long Run Coefficients

Δy_{it}	PMGE	MGE	DOLS	FMOLS	Hausman Test
Long Run Coefficients (θ_i)	0.326 (39.289)	0.250 (5.840)	0.342 (13.68)	0.31 (-166.35)	3.22 (0.07)
Error Correction Coefficients (ϕ_i)	-0.104 (-4.699)	-0.019 (-1.218)			
Short Run Coefficients					
s_{it} (β_i)	0.034 (4.699)	0.038 (4.215)			
Δy_{it-1}	0.392 (6.255)	0.397 (6.446)			
Δy_{it-2}	-0.015 (-1.000)	-0.015 (-1.000)			
Δs_{it}	0.021 (1.023)	0.005 (0.209)			
Δs_{it-1}	-0.060 (-2.780)	-0.084 (-2.761)			
Δs_{it-2}	-0.028 (-2.065	-0.038 (-2.051)			
Int.	0.349 (4.795)	0.538 (5.043)			

* The values in the parenthesis are the t-statistics. Only for Hausman Test, the values in the parenthesis are the probability values.
** t table value at 5 percent significance level is 1.96.

The findings of the Hausman Test (Pesaran, Shin and Smith, 1999), used in Table 3 for testing the hypothesis that long run coefficients are the same for all of the countries, display that the null hypothesis could not be rejected. Thus, the PMGE estimator is valid; in other words, the long run coefficients are homogenous and do not change according to the country. Therefore, the interpretations would be through the results of this estimation method. According to the PMGE results, the error correction coefficient is meaningful and negative. This confirms the existence of a long term relationship between GDP and health expenditures. Moreover, the long run coefficient is meaningful and positive. When the short run coefficients are examined, however, the one period lagged for the economic growth, and the one and two period lagged for the health expenditures are meaningful. The

long run income elasticity of health expenditures is 0.33. MGE, DOLS, and FMOLS also presented similar results.

Table 4. Long Run Elasticities and Error Correction Coefficients for the Individual Countries

	Long Run Coefficients				Error Correction Coefficients	
	PMGE	**MGE**	**DOLS**	**FMOLS**	**PMGE**	**MGE**
Australia	0.326 (40.75)	0.348 (9.666)	0.333 (14.48)	0.32 (-42.35)	-0.214 (-1.926)	-0.204 (-1.678)
Austria	0.326 (40.75)	0.277 (10.65)	0.273 (12.41)	0.28 (-60.79)	-0.078 (-1.205)	-0.178 (-1.641)
Belgium	0.326 (40.75)	0.070 (0.065)	0.310 (17.22)	0.29 (-51.93)	0.048 (0.664)	-0.023 (-0.200)
Canada	0.326 (40.75)	-0.265 (0.06)	0.337 (1.904)	0.28 (-25.44)	0.022 (0.223)	-0.015 (-0.126)
Denmark	0.326 (40.75)	0.369 (11.53)	0.385 (14.26)	0.36 (-31.87)	-0.153 (-1.940)	-0.223 (-2.139)
Finland	0.326 (40.75)	0.587 (1.906)	0.439 (20.91)	0.38 (-17.86)	-0.055 (-0.581)	0.086 (0.725)
Germany	0.326 (40.75)	-0.013 (0.029)	0.456 (9.120)	0.36 (-31.04)	-0.194 (-3.252)	-0.085 (-1.053)
Iceland	0.326 (40.75)	0.255 (5.666)	0.292 (14.60)	0.27 (-33.54)	-0.092 (-0.794)	0.226 (-1.354)
Ireland	0.326 (40.75)	0.481 (1.223)	0.647 (24.89)	0.60 (-9.870)	0.017 (0.616)	0.033 (0.407)
Japan	0.326 (40.75)	0.186 (1.631)	0.354 (2.810)	0.34 (-25.63)	-0.163 (-2.953)	-0.131 (-2.113)
Holland	0.326 (40.75)	0.337 (4.955)	0.372 (14.88)	0.34 (-26.72)	-0.062 (-1.095)	-0.065 (-0.989)
New Zealand	0.326 (40.75)	0.258 (4.161)	0.199 (2.430)	0.20 (-25.32)	-0.109 (-2.459)	0.158 (-2.047)
Norway	0.326 (40.75)	0.329 (25.31)	0.345 (20.29)	0.33 (-61.82)	-0.298 (-2.459)	-0.311 (-2.291)
Portugal	0.326 (40.75)	0.314 (14.95)	0.372 (11.63)	0.32 (-38.04)	-0.219 (-3.243)	-0.218 (-3.020)
Spain	0.326 (40.75)	0.331 (10.34)	0.351 (13.50)	0.32 (-31.50)	-0.117 (-2.543)	-0.115 (-2.297)
Sweden	0.326 (40.75)	0.378 (8.042)	0.377 (8.976)	0.36 (-24.74)	-0.172 (-1.880)	-0.193 (-1.983)
Switzerland	0.326 (40.75)	0.166 (16.60)	0.210 (4.884)	0.17 (-89.12)	0.014 (0.362)	-0.532 (-3.235)
Turkey	0.326 (40.75)	0.290 (3.718)	0.214 (7.925)	0.21 (-37.30)	-0.154 (-2.335)	-0.197 (-1.417)

United Kingdom	0.326 (40.75)	0.337 (11.23)	0.346 (16.48)	0.32 (-36.14)	-0.153 (-1.895)	-0.152 (-1.702)
United Nations	0.326 (40.75)	-0.031 (-0.027)	0.291 (1.470)	0.26 (-42.88)	0.057 (0.626)	-0.075 (-0.750)

* The values in the parenthesis are the t-statistics. Only for Hausman Test, the values in the parenthesis are the probability values.
** t table value at 5 percent significance level is 1.96.

The results obtained for each country are presented in Table 4. According to PMGE, the error correction coefficients is meaningful and negative for Germany, Japan, New Zealand, Norway, Portugal, Spain and Turkey; thus, a long term relationship exists between the health expenditures and economic growth in the aforementioned countries. According to PMGE, all long run coefficients are positive and meaningful; and their value is the same for all of the countries while the long term elasticity is 0.33. When the other estimation methods were used, the long run coefficients of New Zealand, Switzerland and Turkey were found to be lower in compared to the other countries.

4. Conclusion

In this paper, long run and short run relationships between the GDP per capita and health expenditures per person, which represents the human capital, were examined for 20 OECD countries for the time period of 1975-2005. The stationarity of the GDP and health expenditures series were examined, and then the existence of a cointegrated relationship between the two series was analyzed. Having found that both series were I(1) and cointegrated, short and long run elasticities were attempted to be obtained. The results both for the whole panel and for each country show that every extra investment, both in short and long run, would increase growth. The value of the long run elasticity for the OECD countries was 0.33%; health care services were not luxury for these countries.

In conclusion, human capital, besides the physical capital, would contribute to the economic growth of the OECD countries included in the analysis. Consequently, one of the ultimate aims of the countries should be to invest in the human capital (education and health) to improve the life standards of their citizens.

References

Breitung, J. (2000) "The Local Power of Some Unit Root Tests for Panel Data," In: B. Baltagi (ed.), Nonstationary Panels, Panel Cointegration, and Dynamic Panels. *Advances in Econometrics* 15, pp. 161-178 JAI: Amsterdam.

Blomqvist, A.G. and R.A.L. Carter (1997) "Is Health Care Really a Luxury?" *Journal of Health Economics* 16: 207-229.

Chakroun, M. (2009) "Health Care Expenditure and GDP: An International Panel Smooth Transition Approach." *Université de Sfax*. Tunisia MPRA. Paper No. 14322.

Dregen, C. and H.E., Reimers (2005) "Health Care Expenditures in OECD Countries: A Panel Unit Root and Cointegration Analysis." *International Journal of Applied Econometrics and Quantitative Studies* 2: 5-20.

Gerdtham, U.G. et al. (1992) "Econometric Analysis of Health Expenditure: A Cross-Sectional Study of the OECD Countries." *Journal of Health Economics* 11: 63-84.

Gerdtham U.G. and M., Löthgren (2000) "On Stationarity and Cointegration of International Health Expenditure and GDP." *Journal of Health Economics* 19: 461-475.

Gerdtham U.G. and M., Löthgren (2002) "New Panel Results on Cointegration of International Health Expenditure and GDP." *Applied Economics* 34: 1679-1686.

Hansen P. and A., King (1996) "The Determinants of Health Care Expenditure: A Cointegration Approach." *Journal of Health Economics* 15, pp. 127-137.

Hitiris T. and J., Posnett (1992) "The Determinants and Effects of Health Expenditure in Developed Countries." *Journal of Health Economics* 11: 173-181.

Hlouskova J. and M., Wagner (2006) "The Performance of Panel Unit and Stationary Tests: Results From A Large Scale Simulation Study." *Econometric Reviews* 25: 85–116.

Im K.S., Pesaran M.H. and Y., Shin (2003) "Testing for Unit Roots in Heterogeneous Panels." *Journal of Econometrics* 115 (1): 53-74.

Jewell T. et al. (2003) "Stationarity of Heath Expenditures and GDP: Evidence From Panel Unit Root Tests with Heterogeneous Structural Breaks." *Journal of Health Economics* 22: 313-323.

Judson R. (2002) "Measuring Human Capital Like Physical Capital: What Does It Tell Us?" *Bulletin of Economic Research* 54: 209-231.

Kao C. (1999) "Spurious Regression and Residual-Based Tests for Cointegration in Panel Data." *Journal of Econometrics* 90: 1-44.

Lucas, R. (1988) "On the Mechanics of Economic Development." *Journal of Monetary Economics* 22 (1): 3-42.

McCoskey S.K. and T.M., Selden (1998) "Health Care Expenditure and GDP: Panel Data Unit Root Test Results." *Journal of Health Economics* 17: 369-376.

Pedroni P. (1999) "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Repressors." *Oxford Bulletin of Economics and Statistics* Special Issue: 653-670.

Pedroni P. (2000) "Fully Modified OLS for Heterogeneous Cointegrated Panels," In: B. Baltagi (ed.), Nonstationary Panels, Panel Cointegration, and Dynamic Panels. *Advances in Econometrics* 15: 93-130.

Pesaran H. and R., Smith (1995) "The Natural Rate Hypothesis and Its Testable Implications", *The Natural Rate of Unemployment: Reflections on 25 Years of the Hypothesis (ed.)* R. Cross, Cambridge University Press: Cambridge.

Pesaran M.N., Shin Y. and R.P., Smith (1999) "Pooled Mean Group Estimation of Dynamics Heterogeneous Panels." *Journal of the American Statistical Association*. 94 (446): 621-34.

Philips P. and H., Moon (1999) "Linear Regression Limit Theory for Nonstationary Panel Data." *Econometrica* 67 (5): 1057-111.

Romer, P. M. (1990) "Endogenous Technological Change." *Journal of Political Economy* 98: 71-102.

Stock J.H. and M.W., Watson (1993) "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems." *Econometrica* 61: 783–820.

Swift R. (2010) "The Relationship between Health and GDP for OECD Countries in the Very Long Run." *Health Economics* Early View.

Wöβmann L. (2003) "Specifying Human Capital", *Journal of Economic Surveys* 17: 239-70.