Convergence of Total Health Expenditure as a Share of GDP: Evidence from Selected OECD Countries

Fallahi, Firouz

University of Tabriz

2011

Convergence of Total Health Expenditure as a Share of GDP: Evidence from Selected OECD Countries

Firouz Fallahi*
University of Tabriz, Iran

Abstract

This paper studies convergence in the ratio of total health expenditures to GDP (HEGDP) for a sample of OECD countries over the period 1960-2006. Stochastic convergence is tested using unit root tests, without and with a structural break. Moreover, $\beta-$convergence is examined by applying a method that allows for a structural break and is robust to the presence of unit roots and serial correlation in the errors. We examine whether these countries (1) are converging to the US in terms of HEGDP and (2) share a common structural break.

The results support the existence of stochastic convergence for all countries. $\beta-$convergence, however, is supported for some countries only before the break points (regime 1). In regime 2 (the period after the break points) all countries are experiencing divergence. In addition, the estimated break dates are clustered around 1981 and 1988.

Keywords: convergence, structural breaks, health expenditure, OECD, GDP.

JEL classification: C22, I10.

*Faculty of Economics, University of Tabriz, 29 Bahman Bolv, Tabriz, Iran. Telephone: +98-9144190447, Fax: +98-4113356013, E-Mail Address: ffallahi@tabrizu.ac.ir

1 Introduction

In 2006, OECD countries spent an average 9.7% of their GDP on health care, which shows a 1.3 and 2.5 percentage points increase from 1996 and 1986, respectively.[1] In addition, since 1982 the US allocated the highest share of GDP to health expenditure in OECD countries, 9.8% and 15.3% in 1982 and 2006, respectively.[2] Aging population and changes in medical technologies are among the possible causes of growth in health expenditure (HE hereafter). Despite the similar trend of ratio of total HE to GDP (HEGDP) in these countries, they experience different rates of growth and the disparities among these countries are observable.

Researchers use different measures of regional disparities, such as the relative per capita income (Rodríguez, 2006; Tomljanovich & Vogelsang, 2002; Coulombe & Lee, 1995), per capita earning (Kane, 2001), wage (Gernandt & Pfeiffer, 2007), unemployment rate (Baddeley, 1998; Myatt, 1992), health care expenditure (Narayan, 2007), and so on. In this paper, we use the difference in the HEGDP of a sample of OECD countries from that of the US as the disparity indicator. The main objective of this paper is to study the convergence in HEGDP for these countries using a recent methodology and data. In addition, we want to investigate the structural breaks in the disparities to see whether or not these countries share a common structural break.

Convergence has a simple notion which comes from neoclassical growth models (see Solow (1956) for example). In these models, if the countries only differ from each other in the initial level of per capita income and capital, they will reach the same steady-state level, since the productivity of capital in the poor countries is higher than that of the rich countries. Therefore, the poor countries will experience a higher growth rate than the rich countries. Consequently, the former will eventually catch-up, the disparity gap will shrink and eventually

[1] In theory, these changes could be the result of an increase in health expenditure, a decrease in GDP or both; however, it is shown that health expenditure and GDP are highly correlated and move in the same direction (Newhouse, 1977; Hitiris & Posnett 1992).

[2] This is a clear indication of the importance of health sector in the GDP.

close over time. On the other hand, if the growth rates of the rich countries are higher than the rates for poor countries, the disparity gap will increase over time. In this case, we say that these countries are diverging from each other.

Barro and Sala-i-Martin (1991) divided the concept of convergence into three categories: σ-convergence, absolute β-convergence and conditional β-convergence. The σ and β–convergence are the main concepts and measure two different phenomena.[3] σ-convergence occurs when the dispersion of, say, per capita income or HEGDP shrinks over the span of the study. In contrast β-convergence examines whether or not the poor countries are catching-up with the rich countries. Absolute β-convergence, implies that the countries converge to the same level of, say, income or HEGDP, whereas conditional β-convergence takes into consideration the differences in the countries, such as different endowment, weather, infrastructure, and so on. Therefore, according to conditional β-convergence, the countries could have different steady state levels and do not need to converge to the same steady state level.

Another type of convergence considered in the literature is called "stochastic convergence", developed by Bernard and Durlauf (1995). This concept deals with the effect of shocks on the variable under study, mainly using unit root tests and cointegration techniques. To have stochastic convergence in any variable, the variable must be stationary, i.e., the shocks to the variable must die-out exponentially. According to Carlino and Mills (1993) the necessary conditions for convergence are: 1) the series must be stationary to satisfy the stochastic convergence and 2) the series must also satisfy β-convergence. In other words, both stochastic and β-convergence are necessary for having a real convergence.

Stochastic convergence in the HE and HEGDP has been studied by Carrion-i-Silvestre (2005), Jewell et al. (2003), Gerdtham and Löthgren (2000), McCoskey and Selden (1998), Blomqvist and Carter (1997), and Hansen and King (1996, 1998), amongst many. These authors have used univariate unit root tests along with panel unit root tests, with and without structural breaks.

Aslan (2009) studied the per capita HE in OECD countries during the period

[3] Sala-i-Martin (1996) has shown that β-convergence implies σ-convergence.

1970-2005. The results from panel unit root tests show that the null hypothesis of unit root cannot be rejected; therefore, the author concluded that the inequality in the HE of OECD countries is very persistent. Alcalde-Unzu et al. (2009) using data on the OECD countries and decomposing cross-country disparities in per capita HE into various factors showed that the inequality in per capita HE has decreased throughout the study period, 1975-2003. Kerem et al. (2008) using cross section data in EU countries and different types of convergence tests observed that the convergence is not evident in these countries. The per capita HE and its components across the US states are studied by Wang (2008); he found a moderate evidence of convergence in total HE and diverse results for its components. Narayan (2007) using unit root tests examined the convergence in per capita HE of OECD countries and showed that the per capita HE in these countries converge to the per capita HE of the US over 1960-2000. Carrion-i-Silvestre (2005) studied HE and real per capita GDP for a sample of OECD countries and concluded that these variables can be characterized as stationary processes around a broken trend. Jewell et al. (2003) applied a panel LM unit root test, developed by Im et al. (2002), to HE and GDP of 20 OECD countries and rejected the null hypothesis of unit root for these variables. Gerdtham and Löthgren (2000) using univariate and panel unit root tests show that the real per capita HE and GDP in a sample of 21 OECD countries are non-stationary. Nixon (1999) analyzed the HE in EU countries and found that HE variables are converging towards the EU mean.

It is worth noting that the sample period used in most empirical analysis, including the present paper, covers at least three decades and it is obvious that during this period many countries have experienced structural changes due to booms, recessions, and so on. Therefore, ignoring the possibility of structural breaks could provide misleading results. Thus, in order to get the correct results the model must allow for structural breaks in the variables. With this in mind, we use two LM type tests to study the stochastic convergence in the HEGDP of a sample of 10 OECD countries. These tests are the Kwiatkowski-Phillips-Schmidt-Shin's (KPSS, 1992) test of stationarity and a minimum Lagrange multiplier (LM) type statistic introduced by Lee and Strazicich (2003) which considers one break under the alternative hypothesis. In addition, we use an econometric method proposed by Vogelsang (1998) to study the $\beta-$convergence in HEGDP of these OECD countries to that of the US. This method is robust to the presence of unit roots and serial correlations and allows for one break point in the data. The robustness of this method to the presence of unit roots guarantees that the results will not be spurious.

The remainder of this paper is organized as follows: Section 2 provides the methodological issues and the class of tests developed by Vogelsang (1998). Section 3 provides a brief look at the data and the empirical results. Finally, section 4 concludes.

2 Methodology

2.1 Stochastic convergence

Let h_t^i denote the HEGDP of country i at period t, then stochastic convergence implies that shocks to h_t^i will have temporary effects. Formally, stochastic convergence exists if h_t^i found to be stationary. Consequently, a common test for stochastic convergence will be testing for a unit root in h_t^i. Rejection of the unit root hypothesis would confirm the existence of stochastic convergence. Conversely, failure to do so would mean a stochastic divergence. There are many unit root tests in the literature, however, in this paper we use the stationarity test proposed by Kwiatkowski-Phillips-Schmidt-Shin (KPSS, 1992) and a unit root test developed by Lee and Strazicich (2003). Both of these tests are Lagrange multiplier (LM) type statistic and the latter considers one break under the alternative hypothesis.[4]

The one-break LM unit root test statistic can be estimated according to the LM (score) principle as follows:

$$\Delta y_t = \delta^{'} \Delta Z_t + \phi \tilde{S}_{t-1} + u_t, \qquad (1)$$

[4] The break date is determined endogenously.

where $Z_t = [1, t, D_t, DT_t]'$, $D_t = 1$ for $t \geq T_B + 1$, and zero otherwise; T_B is the time of the structural break, $DT_t = t - T_B$ for $t \geq T_B + 1$ and zero otherwise. $\tilde{S}_t = y_t - \tilde{\psi}_x - Z_t\tilde{\delta}$ for $t = 2, ..., T$ and $\tilde{\delta}$ are the coefficients in the regression of Δy_t on ΔZ_t; $\tilde{\psi}_x$ is given by $y_1 - Z_1\tilde{\delta}$ (see Schmidt and Phillips 1992), and y_1 and Z_1denote the first observations of y_t and Z_t, respectively. The unit root null hypothesis is described by $\phi = 0$ and the LM t-test statistic is defined as $(\tilde{\tau})$.

To correct for autocorrelation in the error terms, the augmented terms of $\Delta\tilde{S}_{t-j}$, $j = 1, ..., k$ are included in the equation (1) and the optimal lag length is selected based on general to specific procedure as suggested by Ng and Perron (1995). In addition, the location of the break date (T_B) is determined through searching all possible break dates and the one that has the minimum t statistic is selected as the break point. Unlike conventional unit root statistics, the distribution of the this LM statistic is invariant to the break point nuisance parameters. In addition, it does not suffer from bias and spurious rejections in the presence of breaks under null.[5] Therefore, rejection of null unambiguously shows that the series is a trend stationary process.

2.2 β-convergence

In this section we discuss a methodology developed by Vogelsang(1998), that we use to test for β-convergence . This method uses a linear deterministic trend function. Let y_t define the measure of the disparity and suppose that y_t is modeled as

$$y_t = \mu + \beta t + \epsilon_t$$

where μ represents the initial level of y_t, β represents the average change at y_t, and ϵ_t is a serially correlated random process with mean zero. β-convergence requires to have a negative relationship between μ and β, i.e. if $\mu > 0$ then $\beta < 0$ and if $\mu < 0$ then $\beta > 0$. Therefore, the evidence on β-convergence can be obtained from the estimates of the trend function.

[5] Monte Carlo simulations proves that this statistic has a good size and power.

If ϵ_t is serially uncorrelated, then we can use the OLS estimates of μ and β. These estimates will be unbiased and efficient. However, in practice ϵ_t might be autocorrelated and may even have a unit root. In addition, the interpretation of the trend parameters in the autoregressive representation of y_t depends on the nature of ϵ_t. When ϵ_t is an $I(0)$ process, then the inference about β can be obtained from the estimate of the slope. But if ϵ_t is an $I(1)$ process this coefficient is zero and inference must be made from an estimate of the intercept in the autoregressive representation of y_t. Therefore, the possibility of a unit root in ϵ_t can make the interpretation of the coefficients of the trend function very difficult. To overcome this problem, we need to use methods that are robust to the statistical properties of ϵ_t, i.e. unit roots and serial correlation.

Vogelsang (1998) proposed a class of statistics which is robust to the statistical properties of ϵ_t and gives the possibility of estimating and making inference about β-convergence. This method consists in estimating two OLS regressions. The first, y_t regression, is given as follows

$$y_t = \mu_1 DU_{1t} + \beta_1 DT_{1t} + \mu_2 DU_{2t} + \beta_2 DT_{2t} + \epsilon_t \tag{2}$$

where $DU_{1t} = 1$ if $t \leq T_B$ or zero otherwise; $DU_{2t} = 1$ if $t > T_B$ or zero otherwise; $DT_{1t} = t$ if $t \leq T_B$ or 0 otherwise, and $DT_{2t} = t - T_B$ if $t > T_B$ and 0 otherwise.[6] T_B is the date of a shift in the parameters of the trend function of y_t and is considered either known or unknown. However, if this date is treated as unknown it can be estimated from the data. To find the break date endogenously the regression (2) must be estimated for all possible breaks in the range T_b^*, $T_b^* + 1$, $T_b^* + 2, ..., T - T_b^*$, with $T_b^* = \lambda T$ where λ shows the amount of trimming.

The second regression, z_t regression, is given by:

$$z_t = \mu_1 DT_{1t} + \beta_1 SDT_{1t} + \mu_2 DT_{2t} + \beta_2 SDT_{2t} + S_t \tag{3}$$

where $z_t = \sum_{j=1}^{t} y_j$, $SDT_{it} = \sum_{j=1}^{t} DT_{ij}$, $i = 1, 2$, $S_t = \sum_{j=1}^{t} \epsilon_j$ and DT_{it} is as defined above. This regression is obtained using the partial sums of y_t.

[6] The parameters μ_1 and μ_2 show the disparities in periods 1 and T_B, respectively.

To test for convergence, we need to assess whether μ_1, μ_2, β_1, and β_2 are statistically significant and have the appropriate signs. For this purpose, a modified class of statistics proposed by Vogelsang (1998) can be used. Let t_y and t_z denote the $t-$statistics for testing the null hypothesis that the individual parameters in the y_t and z_t regressions are zero. The modified $t-$statistics for the y_t regression is $T^{-1/2}t_y$, where T is the sample size. On the other hand, the modified $t-$statistics for the z_t regression are defined as $t - PS_T = T^{-1/2}t_z \exp(-bJ_T)$, where b is a constant (to be calculated) and J_T is T^{-1} multiplied by the Wald statistic for testing $c_2 = c_3 = ... = c_9 = 0$ in the following regression[7]

$$y_t = \mu_1 DU_{1t} + \beta_1 DT_{1t} + \mu_2 DU_{2t} + \beta_2 DT_{2t} + \sum_{i=2}^{9} c_i t^i + \epsilon_t. \tag{4}$$

The J_T term can be calculated as $(RSS_Y - RSS_J)/RSS_J$, where RSS_Y is the sum of the squared residuals from regression (2), and RSS_J is the sum of the squared residuals from regression (4). For a given significance level, the constant value of b can be computed in such a way that the critical values of $t-$statistics are the same whether ϵ_t is $I(0)$ or $I(1)$. Consequently, the modified $t-$tests by J_T from the z_t regression are robust to $I(1)$ errors. Note that if $b = 0$, the J_T modification will not have any effect on t-tests. Therefore, the distribution of $t - PS_T$ is different when ϵ_t is $I(1)$ compared to the case when ϵ_t is $I(0)$. Hence, it is recommended to only use $b = 0$ if we are sure that the errors are $I(0)$. There is no need for any modification in the y_t regression because the $T^{-1/2}t_y$ statistics has a well defined asymptotic distribution when ϵ_t is $I(1)$ and when ϵ_t is $I(0)$ this statistic converges to zero. Therefore, test based on the $T^{-1/2}t_y$ statistic is conservative when the errors are stationary.

The asymptotic distributions of $T^{-1/2}t_y$ and $t - PS_T$ are not standard and they depend on the break date used in the regressions. Therefore, the break date will affect the critical values for these statistics. The break date can be assumed known or unknown. In the latter case, it must be estimated from the data. To prevent the estimation of break points too close to the beginning and

[7] J_T-statistic is a unit root statistic, which was proposed by Park and Choi (1988).

the end of the sample, we need to use trimming. Depending on the sample size, it is possible to use 5%, 10%, up to 25% trimming. For example, if we use 10% trimming from the beginning and the end of sample, the new sample will be $(0.1T, 0.9T)$. Next, from each regression we compute T^{-1} multiplied by the Wald statistics in order to test the joint hypothesis that $\mu_1 = \mu_2$ and $\beta_1 = \beta_2$. That is, to test the null hypothesis that there is no break in the trend function of the time series y_t. The estimated break date is the break that has the largest normalized Wald statistic.

3 Empirical results

The data employed in this paper are annual data on the HEGDP[8] for a sample of 11 OECD countries covering the period 1960-2006.[9] The countries are Austria, Canada, Finland, Iceland, Ireland, Japan, Norway, Spain, Switzerland, UK, and the US. All data are obtained from the OECD database 2008.

To test for stochastic convergence we apply the stationary test of Kwiatkowski-Phillips-Schmidt-Shin (KPSS)[10] and the minimum Lagrange Multiplier (LM) type statistic proposed by Lee and Strazicich (2003) which allows for one break point under the alternative hypothesis.[11] The results are reported in Table 1. The results of applying KPSS test on the series show that all the HEGDP series are stationary. This is confirmed when we apply the min-LM test with one break, with the exception of Ireland. That is the series are stationary with a broken trend. The break dates are shown in the last column of Table 1. Considering these results together, we may conclude that all the series are stationary and stochastic convergence holds for all these OECD countries. These results are in line with the results of Narayan (2007), Carrion-i-Silvestre (2005), and Jewell et al. (2003).

Next, we proceed to examine the existence of $\beta-$convergence in these coun-

[8] ratio of total health expenditure to GDP

[9] This sample of countries is selected based on data availability.

[10] The KPSS test statistic is a Lagrange multiplier (LM) type test and its null hypothesis is stationarity of the series.

[11] Due to small number of observation, we only consider the possibility of one break point in the series.

tries using the method of Vogelsang (1998). In order to study the $\beta-$convergence we define the disparity as the difference between the HEGDP of each country ($HEGDP_t^i$) and the HEGDP of the US ($HEGDP_t^{US}$) as follows

$$y_t^i = HEGDP_t^i - HEGDP_t^{US}.$$

Here, the HEGDP of the US, $HEGDP_t^{US}$, is the reference variable.[12] Therefore, $\beta-$convergence means that the HEGDP of these OECD countries move toward the HEGDP of US. Figure 1 shows y_t^i for each country during 1960-2006.[13]

Tables 2–4 present the results obtained using the $t - PS_T$ without the J_T correction, the $t - PS_T$ with the J_T correction, and the $T^{-1/2}t_y$ statistic, respectively. These statistics are calculated considering an unknown break date in the regressions. The last column in these tables shows the estimated break dates.[14]

Table 2 reports the estimated μ, β and the break dates using regression z_t (3). The $t - PS_T$ statistics without the J_T correction are given in parenthesis below each coefficient and the asymptotic critical values are given in the bottom two rows. The estimates of μ_1 and μ_2 for these countries are statistically different from zero for all countries except UK, which indicate that disparity existed between the HEGDP of the countries under study and the HEGDP of the US in 1960 and after break point. Therefore, the question of whether the HEGDP convergence has occurred in these countries is completely relevant. In addition, the results reveal that there is more evidence for deterministic convergence before the break than the after. However, as indicated in Tomljanovich and Vogelsang (2002) we should be cautious in using these results since these statistics are obtained assuming that the residuals are $I(0)$ process. The estimated break dates are clustered around 1981 and 1988. Austria, Ireland, Norway, and Spain have a structural break in 1980-1981 and the estimated break point for Canada, Iceland, Japan, Switzerland, and UK is located in 1987-1989. As for the Finland the break date is 1978. These break dates correspond to the recession in early

[12] In the OECD countries considered in this study the US has the highest HEGDP.
[13] Note that convergence exists when y_t^i moves toward zero.
[14] All the break dates are significant at the 10% significance level.

1980's in the US and UK, the collapse of the American stock market in 1987, and onset of high economic growth in Japan (Narayan, 2006).

The $t - PS_T$ statistics with J_T correction are shown in Table 3. The estimated coefficients are the same as Table 2, but the statistics are smaller now. In this table $t - PS_T$ statistics are reported for 5% and 10% in parenthesis below each coefficient. These results show that before the break, a deterministic convergence is found in Canada, Norway, and Spain and there is a divergence in Iceland. On the other hand, there is no evidence of deterministic convergence at all after the estimated breaks; Finland and Spain are the only countries that show deterministic divergence.

Table 4 reports the results using the $T^{-1/2}t_y$ statistics. In the periods before the break, there is a convergence in Canada, Ireland, Norway, and Spain; at the same time Finland, Iceland, Japan, and UK have experienced divergence. After the break, all the countries, except Austria and Norway, are diverging from the US and the gap between the HEGDP of these countries and US is increasing. No conclusion can be drawn for Austria and Norway.

Using the same notation as Rodríguez (2006), Table 5 summarizes the results of Tables 2, 3, and 4. In this table, a (capital) C denotes point estimates consistent with β-convergence, that is, $\mu > 0$ and $\beta < 0$, or $\mu < 0$ and $\beta > 0$. Also, in this case both estimates are statistically significant at least at the 10 percent level. A (small) c denotes point estimates consistent with β-convergence but only with one coefficient statistically significant at least at the 10 percent. Divergence is indicated using the D and d symbols, where D indicates that both coefficients are statistically significant and d signifies that only one coefficient is statistically significant. Lastly, the symbol u means that no conclusion is possible using all information from Tables 2-4.

Based on Table 5, there is no evidence of β-convergence at all for Austria, Finland, Iceland, Japan, and UK.[15] Canada, Norway, and Spain were converging to the US before the break, while Finland, Iceland, Japan, and UK were diverging. On the other hand, there is no sign of convergence in any country

[15] In fact, the results for Austria are inconclusive.

after the break dates and all the countries are diverging from the US, except for Austria and Norway which show unclear trend. In sum, the results support the convergence of Canada, Ireland, Norway, and Spain toward the US but only before the break dates.

4 Conclusion

In this paper we examined the stochastic and β-convergence of the HEGDP[16] in a sample of OECD countries during the period of 1960-2006. We tested for stochastic and deterministic convergence of HEGDP in these countries using the stationarity test of KPSS, the Min-LM statistic developed by Lee and Strazicich (2003), which allows for one break in the series, and a group of statistics developed by Vogelsang (1998).

The results show that the null of unit root can be rejected for all series, therefore, the stochastic convergence holds for all countries. On the other hand, the results indicate that Canada, Ireland, Norway, and Spain are the only countries that have experienced $\beta-$convergence before the break points. While, after the break dates all countries, except Austria and Norway, are experiencing a divergence.[17] So, real convergence holds for Canada, Ireland, Norway, and Spain only before the break dates. In addition, all the countries have experienced a structural break which are clustered around 1981 and 1988. These break dates correspond to the recession in early 1980's in the US and UK, the collapse of the American stock market in 1987, and onset of high economic growth in Japan.

References

[1] Alcalde-Unzu, J., Ezcurra, R., Pascual, P., 2009. Cross-country disparities in health-care expenditure: a factor decomposition. Health Economics 18, 479-485.

[16] The ratio of total health expenditure to GDP.
[17] The results for Austria are inconclusive.

[2] Aslan, A., 2009. Convergence of Per Capita Health Care Expenditures in OECD Countries. International Research Journal of Finance and Economics 24, 48-53.

[3] Baddeley, M., Martin, R., Tyler, P., 1998. European Reginonal Unemployment Disparities: Convergence or Persistence?. European Urban and Regional Studies 5, 195-215.

[4] Barro, R., Sala-i-Martin, X. 1991. Convergence across States and regions. Brooking Papers of Economy Activity 1, 107–182.

[5] Bernard, A. B., Durlauf, S.D., 1995. Convergence in International Output. Journal of Applied Econometrics 10, 97–108.

[6] Blomqvist, A.G., Carter, R.A.L., 1997. Is heath care really a luxury?. Journal of Health Economics 16, 207–229.

[7] Carrion-i-Silvestre, J.L., 2005. Health care expenditure and GDP: Are they broken stationary?. Journal of Health Economics 24, 839-854.

[8] Coulombe, S., Lee F. C.,1995. Convergence across Canadian Provinces, 1961 to 1991. The Canadian Journal of Economics 28, 886-98.

[9] Gerdtham, U.G., Löthgren, M., 2000. On stationarity and cointegration of international health expediture and GDP. Journal of Health Economics 19, 461–475.

[10] Gernandt, J., Pfeiffer, F., 2007. Rising Wage Inequality in Germany. Journal of Economics and Statistics 227, 358-380.

[11] Hansen, P., King, A., 1996. The determinants of health care expenditure: a cointegration approach. Journal of Health Economics 15, 127–137.

[12] Hansen, P., King, A., 1998. Heath care expenditure and GDP: panel data unit root test results – comment. Journal of Health Economics 17, 377–381.

[13] Hitiris, T., Posnett, J., 1992. The determinants and effects of health expenditure in developed countries. Journal of Health Economics 11, 173–181.

[14] Im, K.S., Lee, J.,Tieslau, M., 2002. Panel LM Unit Root Tests with Level Shifts. Mimeo, Department of Economics, University of Central Florida.

[15] Jewell, T., Lee, J., Tieslau, M., Strazicich, M.C., 2003. Stationarity of heath expenditures and GDP: evidence from panel unit root tests with heterogeneous structural breaks. Journal of Health Economics 22, 313–323.

[16] Kane, R., 2001. Investigating Convergence of the U.S. Regions: A Time-Series Analysis. The Journal of Regional Analysis & Policy 31, 1-22.

[17] Kerem, K., Püss, T., Viies, M., Maldre, R., 2008. Health And Convergence Of Health Care Expenditure In EU. International Business & Economics Research Journal 7, 29-43.

[18] Kwiatkowski, D., Phillips, P.C.B., Schmidt, P., Shin, Y., 1992. Testing the Null Hypothesis of Stationary against the Alternative of a Unit Root. Journal of Econometrics 54, 159-178.

[19] Lee, J., and Strazicich, M.C., 2003. Minimun LM Unit Root Tests with Two Structural Breaks. *Review of Economics and Statistics* 85, 1082-1089.

[20] McCoskey, S., Selden, T.M., 1998. Health care expeditures and GDP: panel data unit root test results. Journal of Health Economics 17, 369–376.

[21] Myatt, A., 1992. Provincial unemployment Rate Disparities: A Case of No Concern?. Canadian Journal of Regional Science 25, 101-119.

[22] Narayan, P.K., 2007. Do Health Expenditures "Catch-up"? Evidence From OECD Countries. Health Economics 16, 993–1008.

[23] Narayan, P.K., 2006. Examining structural breaks and growth rates in international health expenditures. Journal of Health Economics 25, 877–890.

[24] Newhouse, J.P., 1977. Medical-care expenditure: a cross-national survey. Journal of Human Resources 12, 115-25.

[25] Ng, S. and P. Perron, 1995. Unit Root Tests in ARMA Models with Data-Dependent Methods for the Selection of the Truncation Lag. Journal of the American Statistical Association 90, 269-281.

[26] Nixon, J., 1999. Convergence Analysis of Health Care Expenditure in the EU Countries Using Two Approaches. Discussion Papers in Economics, No.3, University of York.

[27] Park, J.Y., and Choi, B. (1988), "A new approach to testing for a unit root." CAE Working Paper No. 88-23, Cornell University, Ithaca, NY.

[28] Rodríguez. G., 2006. The role of the interprovincial transfers in the β-convergence process: further empirical evidence for Canada. Journal of Economic Studies 33,12-29.

[29] Sala-i-Martin, X., 1996. Regional cohesion: Evidence and theories of regional growth and convergence. European Economic Review. 40, 1325-1352.

[30] Solow, R.M., 1965. A Contribution to the Theory of Economic Growth. Quarterly Journal of Economics 70, 65-94.

[31] Tomljanovich, M., Vogelsang, T.J., 2002. Are US regions converging? Using new econometric methods to examine old issues. Empirical Economics 27, 49-62.

[32] Vogelsang, T.J., 1998. Trend function hypothesis testing in the presence of serial correlation. Econometrica 66, 123-48.

[33] Wang, Z., 2008. The Convergence of Health care Expenditures in The US States. Health Economics 18, 55-70.

Table 1: Results of Unit Root Tests

	Min-LM test with One Break			KPSS LM Test
	Optimal Lag	t-statistic	Break Date	t-statistic
Austria	4	-3.429*	1971	0.074
Canada	1	-4.142**	1985	0.072
Finland	6	-4.979**	1995	0.165
Iceland	0	-4.121**	1976	0.134
Ireland	4	-2.918	1979	0.182
Japan	4	-3.941**	1988	0.124
Norway	1	-4.810**	1973	0.190
Spain	5	-4.433**	1982	0.148
Sweden	1	-3.970**	1970	0.106
UK	2	-4.524**	1995	0.091

** and * denote significance at the 5% and 10%.

The critical values for KPSS test at the 1% and 5% are 0.216 and 0.146, respectively.

Table 2: Emprical results using the Z_t regression and $t - PS_T$ statistics without J_T correction

	$\hat{\mu}_1$ $(t - stat)$	$\hat{\beta}_1$ $(t - stat)$	$\hat{\mu}_2$ $(t - stat)$	$\hat{\beta}_2$ $(t - stat)$	$\hat{T}_B$
Austria	-0.792	-3.582	-3.212**	-3.613	1980
	(-1.497)	(-0.637)	(-4.877)	(-0.728)	
Canada	0.965**	-11.348**	-2.494**	-16.381**	1987
	(6.305)	(-8.904)	(-5.925)	(-3.722)	
Finland	-0.837**	-4.343	-1.742**	-20.465**	1978
	(-2.232)	(-0.999)	(-4.707)	(-7.934)	
Iceland	-1.819**	-3.187**	-4.585**	-0.593	1989
	(-8.956)	(-1.999)	(-6.477)	(-0.071)	
Ireland	-1.903**	6.431	-2.432**	-25.854**	1981
	(-3.097)	(1.023)	(-2.836)	(-3.838)	
Japan	-1.365**	-6.368**	-6.290**	-0.262	1988
	(-5.358)	(-3.091)	(-7.980)	(-0.030)	
Norway	-2.329**	1.900	-2.975**	-11.224**	1981
	(-5.396)	(0.430)	(-4.939)	(-2.372)	
Spain	-3.455**	2.069	-4.266**	-11.178**	1981
	(-19.606)	(1.147)	(-17.343)	(-5.786)	
Sweden	-0.525**	-5.586**	-3.626**	2.410	1988
	(-2.461)	(-3.239)	(-5.496)	(0.331)	
UK	-0.835**	-11.893**	-5.844**	-5.861*	1988
	(-5.584)	(-9.836)	(-12.633)	(-1.146)	
5 % critical value	± 2.190	±1.760	±1.500	±1.270	
10 % critical value	±1.570	±1.330	±1.140	±0.936	

** and * denote significance at the 5% and 10

Table 3: Emprical results using the Z_t regression and $t-PS_T$ statistics with J_T correction

	$\hat{\mu}_1$ (5% $t-stat$) (10% $t-stat$)	$\hat{\beta}_1$ (5% $t-stat$) (10% $t-stat$)	$\hat{\mu}_2$ (5% $t-stat$) (10% $t-stat$)	$\hat{\beta}_2$ (5% $t-stat$) (10% $t-stat$)	$\hat{T}_B$
Austria	-0.792	-3.582	-3.212	-3.613	1980
	(-0.309)	(-0.005)	(-0.009)	(-0.007)	
	(-0.391)	(-0.021)	(-0.046)	(-0.026)	
Canada	0.965*	-11.348	-2.494	-16.381	1987
	(1.883)	(-0.222)	(-0.047)	(-0.108)	
	(2.256)	(-0.659)	(-0.166)	(-0.292)	
Finland	-0.837	-4.343	-1.742	-20.465*	1978
	(-1.056)	(-0.102)	(-0.236)	(-0.889)	
	(-1.181)	(-0.199)	(-0.515)	(-1.642)	
Iceland	-1.819**	-3.187	-4.585	-0.593	1989
	(-3.552)	(-0.119)	(-0.160)	(-0.005)	
	(-4.078)	(-0.273)	(-0.420)	(-0.010)	
Ireland	-1.903	6.431	-2.432	-25.854	1981
	(-0.503)	(0.004)	(-0.002)	(-0.019)	
	(-0.661)	(0.020)	(-0.013)	(-0.084)	
Japan	-1.365	-6.368	-6.290	-0.262	1988
	(-0.527)	(-0.003)	(-0.001)	(0.000)	
	(-0.746)	(-0.021)	(-0.008)	(0.000)	
Norway	-2.329*	1.900	-2.975	-11.224	1981
	(-1.897)	(0.018)	(-0.075)	(-0.111)	
	(-2.218)	(0.045)	(-0.224)	(-0.262)	
Spain	-3.455**	2.069	-4.266*	-11.178*	1981
	(-9.379)	(0.121)	(-0.906)	(-0.669)	
	(-10.472)	(0.234)	(-1.958)	(-1.224)	
Sweden	-0.525	-5.586	-3.626	2.410	1988
	(-0.541)	(-0.032)	(-0.013)	(0.004)	
	(-0.679)	(-0.124)	(-0.062)	(0.014)	
UK	-0.835**	-11.893*	-5.844	-5.861	1988
	(-2.408)	(-0.753)	(-0.435)	(-0.098)	
	(-2.731)	(-1.606)	(-1.049)	(-0.195)	
5 % critical value	± 2.190	±1.760	±1.500	±1.270	
10 % critical value	±1.570	±1.330	±1.140	±0.936	

** and * denote significance at the 5% and 10

Table 4: Emprical results using the y_t regression and $T^{-1/2}t_y$ statistics

	$\hat{\mu}_1$ $(t-stat)$	$\hat{\beta}_1$ $(t-stat)$	$\hat{\mu}_2$ $(t-stat)$	$\hat{\beta}_2$ $(t-stat)$	$\hat{T}_B$
Austria	-0.859	-2.753	-3.082	-5.289	1980
	(-0.549)	(-0.221)	(-2.207)	(-0.585)	
Canada	0.927**	-11.073**	-2.528**	-15.930**	1987
	(1.597)	(-3.166)	(-3.542)	(-2.544)	
Finland	-0.896*	-3.614	-1.806	-20.055**	1978
	(-0.810)	(-0.372)	(-2.006)	(-3.697)	
Iceland	-1.837**	-3.070	-4.307*	-4.951	1989
	(-1.553)	(-0.461)	(-2.688)	(-0.317)	
Ireland	-1.761**	4.523	-2.382	-24.754**	1981
	(-1.077)	(0.363)	(-1.559)	(-2.409)	
Japan	-1.271**	-7.345	-5.764**	-5.943	1988
	(-1.072)	(-1.064)	(-3.770)	(-0.421)	
Norway	-2.286**	1.338	-2.858	-12.046	1981
	(-1.625)	(0.125)	(-2.176)	(-1.363)	
Spain	-3.409**	1.423	-4.154**	-11.892**	1981
	(-4.423)	(0.242)	(-5.769)	(-2.455)	
Sweden	-0.461	-6.167	-3.322*	-1.228	1988
	(-0.500)	(-1.150)	(-2.795)	(-0.112)	
UK	-0.778**	-12.468**	-5.612**	-8.122	1988
	(-1.084)	(-2.984)	(-6.061)	(-0.949)	
5 % critical value	± 0.875	± 2.000	± 3.000	± 2.010	
10 % critical value	± 0.671	± 1.470	± 2.370	± 1.480	

** and * denote significance at the 5% and 10

Table 5: Summary of the emprical results

	$t - PS_T$ $I(0)$ Errors Assumed		$t - PS_T$ Robust to $I(1)$ Errors		$T^{-1/2}ty$ Robust to $I(1)$ Errors	
	Pre-break	Post-break	Pre-break	Post-break	Pre-break	Post-break
Austria	u	d	u	u	u	u
Canada	C	D	c	u	C	D
Finland	d	D	u	d	d	d
Iceland	D	d	d	u	d	d
Ireland	c	D	u	u	c	d
Japan	D	d	u	u	d	d
Norway	c	D	c	u	c	u
Spain	c	D	c	D	c	D
Sweden	D	c	u	u	u	d
UK	D	D	D	u	D	d

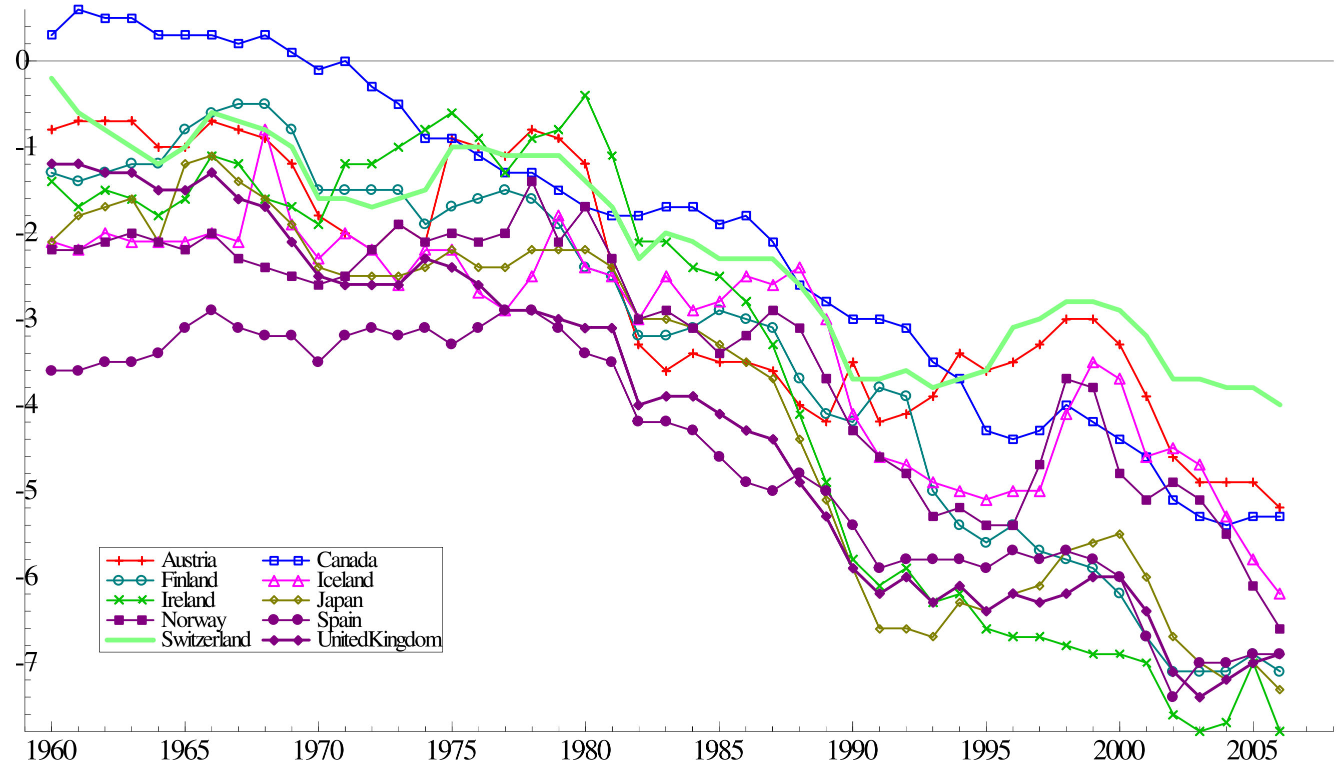

Figure 1: Deviation of Total Health Expenditure as a share of GDP of each country from that of the US