The Role of Human Capital in Economic Growth:

Evidence from Greek Regions

Nikos Benos[a*] & Stelios Karagiannis[b]

November 2007

[a] Lecturer, Department of Economics, University of Ioannina, University Campus, 451 10 Ioannina, Greece.
[b] Research Fellow, Centre of Planning and Economic Research (KEPE), 11 Amerikis Str, 106 72 Athens, Greece.
[*] Corresponding author. E-mail: nbenos@cc.uoi.gr

Abstract

The objective of this paper is to empirically examine the relation between growth and human capital for the Greek regions (NUTS III), for the period 1981-2003. We use the enrolment rates at lower and upper secondary education and the respective student/teacher ratios. Moreover, taking a broader view of human capital, we include two health care indicators (the number of medical doctors and hospital beds). We find that student enrolment rates at both levels of secondary education have a positive impact on growth, while a higher student-teacher ratio inhibits growth. Also, the number of medical doctors seems to boost growth. Besides, there are important human capital externalities across neighbouring regions. We define two regional groups (high and low income) and there is strong evidence of heterogeneity in rates of return to human capital. The above results are more robust for high income regions. Overall, this study incorporates the differences in rates of return to education between regional clubs. We believe that our findings have important policy implications and Greek authorities should take them into account in designing growth promoting policies at the national and regional level.

Keywords: Human capital, Regional growth, Panel data

JEL classification: O15, R11, C23

Acknowledgments: The authors would like to thank Prodromos Vlamis for constructive and helpful suggestions. Thanks also to Prodromos-Ioannis Prodromidis for the fruitful comments.

1. Introduction.

Human capital theory argues that there are positive educational externalities, that is benefits of individually acquired education are not restricted to the individual but spillover to higher levels of aggregation in the same industry, city, region or the macroeconomy as a whole. These externalities provide the economic justification for public funding of education.[1]

In the recent literature, attempts were made to empirically test the relationship between human capital and economic growth usually using cross-sectional country data. These works use measures of formal education as proxies for human capital, since investment in education plays a central role in human capital accumulation. They provide contrasting results regarding the impact of human capital on growth. Effects are found to be positive, statistically insignificant or even negative in some cases (Barro-Sala-i-Martin, 2004, Pritchett, 2001).

Neverthless, the main problem causing these puzzling results is that most growth studies use international data sets, but incorrectly impose equal returns on schooling (single coefficients) among sample countries (Di Liberto, 2007**;** Pritchett, 1996, Temple, 1999, Krueger-Lindahl, 2001). This problem arises when the education quality is affected by educational institutions. One explanation of the estimated low returns to education in international data sets is that national statistics are dissimilar. Moreover, returns to education may be higher in most countries with a better educated labour force as predicted by most growth models (Azariadis-Drazen, 1990). A second problem appears to be that acquisition of educational skills is not linked with productivity, that is education is not only an investment but also a consumption good for individual. Finally, in many countries, especially developing countries, the public sector employs most of the skilled labour force which creates distortions in the estimation of returns to schooling. This is due to

[1] We define human capital as the set of knowledge, skills, competencies and abilities embodied in individuals and acquired through education, training and experience (Bassetti, 2007).

measurement problems of public sector output, inefficiency and lack of innovative activities in this sector (Griliches, 1997).

In this paper, our objective is to estimate the impact of human capital on regional economic growth in Greece, and analyse the implications for economic policy at the national level. We focus on a more homogeneous data set, which is relatively diverse in terms of human capital characteristics of the various regions. Our approach features several important contributions. First, we define human capital more broadly than most of the literature, using various measures of educational as well as health care attainment of the population. Second, it represents, at the best of our knowledge, the first attempt to provide a comprehensive set of estimates of the impact of human capital dynamics on growth of Greek regions (NUTS III level) for a quite extensive time period (1981-2003). Third, we allow for human capital spillovers between neighbouring regions.

Additionally, we investigate systematic growth differences between regions, which vary in terms of income level and location. This way, we allow for heterogeneity of the effect of human capital across regions. Our analysis is carried out using Random Effects (RE) and enhanced GMM (Arellano-Bond, 1991) estimators in order to handle endogeneity and unobserved heterogeneity problems. Concerning results, we find that the number of students in lower and upper secondary education levels affect growth positively. Also, a higher student/teacher ratio inhibits growth. Furthermore, the number of doctors fosters growth. Besides these, there are important human capital externalities across neighbouring regions. Finally, there is strong evidence of differential effect of the human capital variables between rich and poor regions.

The paper is organised as follows. In section 2, we present a review of the theoretical and empirical literature on human capital and growth. Section 3 describes the data, while Section 4 presents the econometric framework and methodology. In section 5, estimation results are reported, while section 6 offers policy considerations and concluding comments.

2. Human capital and economic growth

2.1 Theory

New growth theory (e.g. Romer, 1986, Lucas, 1988) argue that technological progress, the most important determinant of long-run growth, is endogenous. Also, Hall-Jones (1999) suggest that human capital is a basic determinant of income differences among countries. The theoretical literature on the relationship between human capital and economic growth provides different models. In the first group of models, growth is sustained by human capital accumulation. That is, human capital is a factor of production and its accumulation influences the growth process. In this type of models, human capital is a flow variable (Lucas, 1988). Therefore, growth rate differences across economic entities are due to differences in the rates of human capital accumulation.

In the second category, economic growth depends on the existing human capital stock, which generates new knowledge (Romer, 1990) or facilitates the imitation and adoption of foreign technologies (Nelson-Phelps, 1966). In this context, a higher stock of human capital implies a higher innovation rate, growth rate of productivity and output growth.

In a third class of models, human capital is a threshold variable, that is the impact of human capital depends on the human capital stock accumulated at a given time period. So, human capital matters as a stock and flow variable, because its accumulation is necessary to achieve the stock level, above which the impact of human capital takes place. One implication of these models is the existence of multiple equilibria in the growth path, since the growth path comprises various phases. If the conditions for transition from one phase to the next do not exist, the economic entity remains trapped in poverty. Therefore, human capital has nonlinear effects on growth.

2.2 Empirics.

The most recent approach to the investigation of the growth impact of human capital uses proxies for human capital, which are measures of formal education. This follows from the fact that investment in education is central to human capital accumulation and can be measured more easily than other elements, such as on-the job-training, experience and learning-by-doing. The most common proxies for human capital are adult literacy rates, school enrolment rates and average years of schooling.

In one of the first studies that examined the role of human capital on growth, Barro (1991) found that primary and secondary enrolment rates have a positive growth effect, but this was not true for adult literacy rates in all cases. Barro-Sala-i-Martin (1991, 1992) concluded that the initial enrolment rate is a basic determinant of steady-state per capita income. Mankiw-Romer-Weil (1992) estimated an elasticity of output with respect to the average percentage of the working-age population in secondary school of about one-third.

Benhabib-Spiegel (1994) found that the human capital flow did not have a statistically significant growth effect, while the average stock had a positive, though not always significant, growth impact. Barro-Sala-i-Martin (1995) found that human capital accumulation does not contribute to economic growth. De la Fuente-Domenech (2000) and Bassanini-Scarpetta (2001) estimated a positive effect of schooling years on growth. Bils-Klenow (2000) concluded that initial enrolment rates explain less than one-third of the variation in growth rates and half of this is due to the fact that anticipated increases in growth raise schooling. Pritchett (2001) estimated a negative growth impact of human capital growth. However, Krueger-Lindahl (2001) showed that higher education attainment has a positive effect on economic growth once measurement errors are taken into account. Also, they showed that linearity and parameter homogeneity are rejected by the data.

With respect to the class of models, that consider human capital a threshold variable, Feyrer (2003) found that there is a threshold level in human capital stock, which allows a country to benefit from technological spillovers. Durlauf-Johnson (1995) identified different growth regimes for groups of countries characterized by different initial GDP per capita and human capital levels supporting models with multiple equilibria. Liu-Stengos (1999) estimated a non-linear relationship between initial GDP per capita and GDP growth rate and

Kalaitzidakis et al (2001) found nonlinear effects of human capital on growth. Papageorgiou (2003) concluded that the role of human capital in the creation and adoption of technology increases with country income.

In a review of the empirical literature, Sianesi-Van Reenen (2002) pointed out that: a) returns to schooling are higher in LDCs than OECD countries; b) the effect of different levels of education depends on the development level of countries, that is higher levels of education have a larger growth impact on more developed countries; c) education implies indirect growth benefits in terms of physical capital, technology transfer, fertility and other dimensions of human capital (life expectancy, infant mortality) ; d) type of education, schooling quality and efficiency of resource allocation affect impact of education on growth.

2.3 Spatial dependence in economic systems.

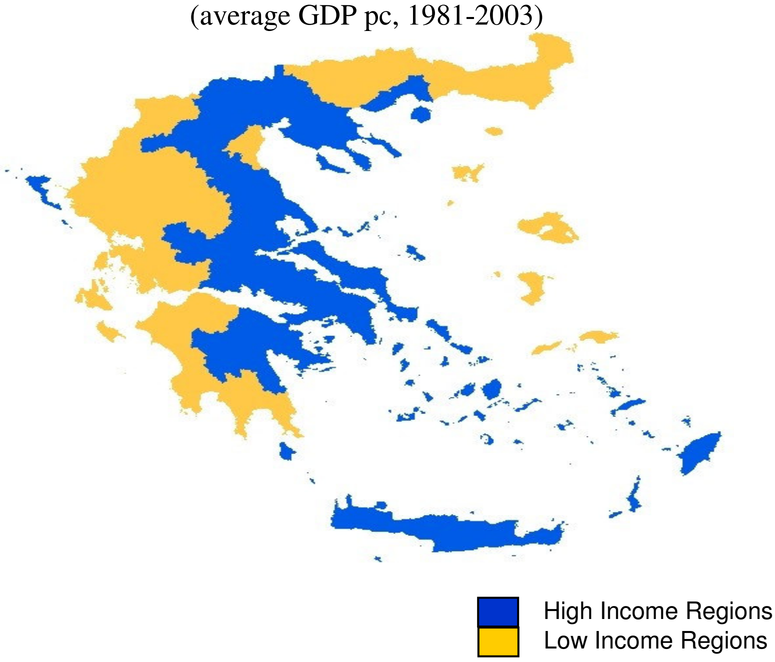
Recently, work has concetrated on the impact of human capital on growth of regions within countries. The idea is that knowledge produces spillovers, that is firms learn from other firms, e.g. by studying patent documents, and people get ideas from other people. So, accessibility to human capital facilitates accumulation of knowledge. In regions with high concentration and/or accessibility to human capital, such as large cities, ideas disseminate quickly and human capital externalities are more likely to arise. Knowledge flows between different localities and regions imply spatial dependence among adjacent regions, something that diminishes with distance. In line with that, Andersson-Karlsson (2007), Grasjo (2005) found spatial dependence among municipalities which belong to the same region, but not in different regions. Also, since each region consists of a central municipality, usually a large city, and smaller municipalities, human capital in adjacent surroundings of the city is small relative to its internal resources, while the opposite is true for small municipalities. As a result, the importance of accessibility to human capital is expected to be larger for small than large municipalities, implying asymmetric spatial dependencies within regions. The same argument holds for small vs. large regions. These are confirmed by Andersson et al

(2007). Thus, policy should account for such effects and increase supply as well as accessibility to human capital by means of transport infrastructure.

3. Description of the data.

We start our analysis with a brief description of the main regional educational and health care data. We apply regional data obtained from the social statistics division of the National Statistics Agency of Greece (ESYE). Our data includes the number of students attending the two levels of secondary education[2] (upper and lower) together with the respective number of teachers at both levels. Using the above figures we were able to construct the student/teacher ratio for the two levels of education[3]. In addition, we include two health care indicators, namely the number of medical doctors and hospital beds available per region. All our variables spans from 1981 through 2003 and includes statistics for all 51 regions of Greece (NUTS III level).

Map 1. High and Low income regions (NUTS III) in Greece
(average GDP pc, 1981-2003)



[2] We do not include data on the number of primary education students since there is no significant variation across regions. So, we would not be able to identify a distinct growth impact of such variables on regional growth.
[3] Detailed definitions of the variables are available in the Appendix (Table 1).

Map 1 above presents the division of the 51 NUTS III regions of Greece into two sub-groups, through the use of the average GDP pc for the 1981-2003 period. Tables 3 and 4 [4] provide the descriptive statistics of our variables based on the division of our sample into high and low income regions[5]. According to our calculation numerous income, educational as well as health care disparities exist among the Greek regions. High-income regions enjoy increased levels of per capita GDP when compared to low ones (mean over the period studied 10,834 and 7,967 respectively). Accordingly, they present different numbers of students attending the lower secondary education (mean around 583 and 590 students per 1000 of relevant age group respectively). On the contrary, low-income regions exhibit a greater number of students attending the upper level of education when compared to the high-income ones. Nevertheless, the student-teacher ratio, as a quality indicator, favours richer regions at both levels of education. Finally, health care variables reveal a greater inequality between the two sub-samples. The numbers of available hospital beds and, to a less extent, the number of medical doctors are more at high-income regions when compared to low-income ones (4.05 to 3.10 per 1000 people & 2.40 to 2.03 per 1000 people respectively).

4. Empirical model.

We study the role of human capital in the growth process, using the framework suggested among others by Barro-Sala-i-Martin (2004). Since data on physical capital are not available, we assume that a higher level of initial real per capita GDP corresponds to a large stock of physical capital per person. Thus output per capita growth rate for our panel data set is given as follows:

$$\frac{y_{it} - y_{i,t-1}}{y_{i,t-1}} \approx a y_{i,t-1} + X_{it}\beta + v_i + \tau_t + \varepsilon_{it} \qquad (1)$$

where, y_{it} is per capita gross domestic product (GDP) in region i ($i=1,\dots,51$) during period t

[4] The tables of descriptive statistics are available at the Appendix.

($t=1981,\ldots,2003$), $y_{i,\,t-1}$ is the (initial) per capita GDP in region i in period t-1, a is a negative parameter measuring the convergence speed, X_{it}, is a row vector of control variables in region i during period t with associated parameters β, v_i is a region-specific effect, τ_t is a period-specific effect common to all regions, and ε_{it} is the model's error term. Given that $\frac{y_{it}-y_{i,t-1}}{y_{i,t-1}} \approx \ln(y_{it} / y_{i,t-1})$ we can approximate equation (1) as:

$$\ln (y_{it} / y_{i,t-1}) = a \ln y_{i,t-1} + \ln X_{it}\, \beta + \mathrm{v}_i + \tau_t + \varepsilon_{it}\,. \qquad (2)$$

So, real per capita growth is related to initial income per capita and an array of control variables. We use an array of human capital indicators and population growth, which is standard in growth regressions. However, as it is generally accepted that human capital affects growth with time lags, we use lagged values of human capital indicators (Di Liberto, 2004, 2007, Midendorf, 2006). These include the following[6]: a) students at lower secondary education level; b) students at higher secondary education level; c) medical doctors per 1000 population d) hospital beds. The last two variables are intended to capture the impact of health capital on growth, which is considered important in recent studies (Malik, 2006, Ricci-Zachariadis, 2007). Thus, we take a broader view of human capital in this work than what is common in the literature, because we believe that a good health status affects positively the productivity of individuals given their education level. Additionally, we use student-teacher ratio in the two levels of education as a measure of the quality of education provision. Finally, we include two variables which explore the possibility of spatial externalities in terms of human capital.

Regarding the methodology of estimation, OLS assume that the error in each time period is uncorrelated with the explanatory variables in the same period. However, this assumption may be too strong and in fact a primary motivation for using panel data is to solve the problem of omitted variables, which are effectively part of the error term and cause bias in the coefficient estimates. So, we assume that there is a time-constant unobserved effect, which we treat as a random variable drawn from a population together

[6] For detailed definitions of the variables see Table 1 in Appendix.

with the observed explained and explanatory variables. The unobserved effect may represent area-specific historical and cultural factors. In our analysis, we assume that these characteristics are uncorrelated with the observed explanatory variables and proceed with random effects estimation, which exploits the serial correlation in the error, due to the presence of the unobserved effect in every period. We apply GLS and compute robust standard errors of the coefficients.

Furthermore, one of the most challenging problems in the empirical growth literature is the likely endogeneity of the right hand-side variables. This is particularly true in the case of human capital variables, since education is highly income elastic and high-income economies dominated by service sector require a well educated workforce. In order to cope with this problem, we use the General Method of Moments (GMM) estimator of Arellano and Bond (1991), which calls for first differencing and using lags of the dependent and explanatory variables as instruments for the lagged dependent variable as a regressor. First differencing removes region-specific effects, which are a potential source of omitted variable bias and deals with series non-stationarity. Furthermore, before we choose the instruments we allow the explanatory variables to be endogenous, which is least restrictive assumption we could make. Thus, we are more confident about GMM compared with RE results and we will emphasize these. At the same time, if the findings are similar, this is a signal of robustness.

5. Empirical results

5.1. Full sample

The estimated parameter of initial income indicates conditional convergence of Greek NUTS III regions at an annual rate of 1.5% (Table 5, col. 5-8). So, higher growth is predicted for regions with low initial income per capita, when the other explanatory variables are held constant.

Turning to human capital, students at lower-secondary level and higher-secondary level exert a positive, albeit small, effect on growth in most cases (Table 5, col. 1-8). This is in line with endogenous growth models, where human capital is a factor of production and its accumulation rate influences the growth process, i.e. it is a flow variable (Lucas, 1988). Also, it concurs with some previous empirical evidence (Barro, 1991, Sianesi-Van Reenen, 2002). Furthermore, the student-teacher ratios in lower and upper secondary education, which are measures of quality of education (Barro, 1991), exert a negative influence on growth in most cases as well. That is, a higher number of students relative to teachers, the lower human capital accumulation and growth. These findings accord with the fact that controlling for labour force quality reduces the impact of schooling on growth (Sianesi-Van Reenen, 2002).

Regarding health care indicators, we use the number of medical doctors, because we believe this variable reflects the quality of health services, therefore the health status of the population. This is expected to boost productivity and growth. The results confirm our intuition showing a positive impact on regional growth (Table 3, cols. 2, 4, 6 & 8).[7, 8]. Furthermore, we included in our model a number of geographical dummies (north/south, east/west, & islands/mainland) in order to capture spatial effects across groups of Greek regions. Our estimations exhibit a positive sign regarding mainland regions, meaning that these regions enjoy a positive growth differential with respect to islands. This might be explained by the insufficient public infrastructure and problematic connection of the islands with the mainland especially during the non-tourist period of the year. Finally, The population growth variable exerts a negative influence on per capita income growth in accordance with theory and previous evidence (Eckey at al, 2006).

[7] We tried also hospital beds per 1000 population, but it was not significant. We think this is because it a measure of the quantity of health services, in contrast with doctors who measure better the quality of services provided.

[8] We do not use variables employed in cross-country studies, like life expectancy and infant mortality, since there are no data at regional level in Greece and even if they existed, we think there is no significant variation of such variables among regions, so we would not be able to identify the growth impact of health.

5.2. Convergence club.

As it is mentioned in Section 2, there is a strong case, both theoretically and empirically, for different effects of human capital on growth among regions, which vary in terms of income. Consequently, we split regions in low-income and high-income according to whether their average GDP per capita is below or above the median for our sample period (1981-2003). Afterwards, we estimate the same equations as before for the two sub-samples.

According to Tables 6-7, for the rich and poor regions respectively, we see that lower secondary education students have a positive impact on growth in the former (Table 6, col. 1, 5-6), while they are not statistically significant in the latter (Table 7). Furthermore, there are positive growth returns to upper secondary education in the high-income regions (Table 6, col. 3, 7), while they are mostly insignificant in the low-income ones (Table 7, col. 3, 7). These differences among the income groups, explain the very weak growth influence of both variables in the full sample estimation.

Also, we identify a strongly statistically significant and negative effect on per capita growth of the student-teacher ratio at both the lower secondary and upper secondary education levels in the rich regions. On the contrary, the impact appears mostly insignificant in poor regions implying a much weaker effect of this variable in the full sample.

Besides these, the number of doctors boosts regional growth in both sub-samples, while the effect seems to be stronger in poor regions. This possibly reflects the lower number of doctors in these areas, combined with decreasing growth returns to health. Thus, our evidence seems to confirm the presence of parameter heterogeneity regarding the effect of human capital on growth confirming previous studies. Finally, conditional convergence seems to hold in both sub-samples, given this was the case for the whole sample.

5.3 Spatial externalities

Next, we proceed to examine if there is dependence of regional growth on human capital in neighboring regions, that is human capital externalities among regions. We construct three types of variables to capture these effects. The first type includes students of both the region in question and neighbouring regions. It replaces the students of the region in question in the regressions (*Regional Students*). The second type corresponds to the students of the neighbouring region only (*Extra Regional Students*). It is used in the equations in addition to the student variables used in the previous section. The third type refers to two variables (*University Medical Doctors* and *University Hospital Beds*). They add up to the medical doctors and hospital beds at regional level used in the original estimations, the number of university medical doctors and hospital beds when direct access to a university hospital is available.

By looking at Table 8, *Regional Students* of lower secondary (see col. 9-10) and upper secondary education (see col. 11-12), have a much stronger impact on growth than the original student variables (Table 5). This is in line with the evidence, which that shows that students of neighbouring regions (*Extra Regional Students*) have a positive effect on growth (Table 8, col. 13-14). Lower and upper secondary school students continue to affect growth positively in the latter case (Table 8, col. 10, 12-14). Regarding health care variables, *University Medical Doctors* affect growth positively and *University Hospital Beds* do not influence the growth process as before (Table 8, col. 15-16). Thus, there is quite strong evidence of spatial externalities, in the sense that regions seem to be affected by the performance of their neighbours in terms of education and health status. This is in accordance with recent findings for Sweden (Andersson et al, 2007).

When estimating the same equations in the two sub-samples of rich and poor regions, the estimates differ. By looking at Tables 9-10, we observe that the positive impact of *Regional Students* (both lower and upper secondary levels) on growth is much stronger in the wealthy regions compared to the lagging ones. The same pattern is true for the *Extra Regional Students* of both education levels. Besides these, *Students* of lower and upper secondary level education continue to exert a positive growth influence in all but one case in rich regions (Table 9, cols. 10, 12-13), while their effect is not statistically significant in the poor regions (Table 10, cols. 10, 12-14).

Furthermore, *University Medical Doctors* and *University Hospital Beds* do not affect growth in the affluent regions, contrary to the results for the whole sample, while they have a positive growth impact on poor regions (Tables 9-10, col. 15-16). This confirms the evidence presented in the previous section about the relatively more important role of health in the low-income regions. Also, in both sub-samples conditional convergence holds and population growth is detrimental to per capita output growth, as it is true for the whole sample. Thus, we find strong evidence of parameter heterogeneity regarding human capital variables in Greek regions, when we take into account spatial externalities.

5.4. The Oaxaca-Blinder decomposition of economic growth difference

We apply the Oaxaca-Blinder decomposition approach (see for example Ledyaeva & Linden, 2006; Wei, 2005; Blinder, 1973; Oaxaca, 1973) to examine the contribution of the education and health care variables to the difference in regional GDP per capita growth between the two sub-samples (high and low income regions). As predicted by neoclassical growth theory, the poor regions tend to grow faster than richer ones. In Greek regions, this proposition is not true for the analysed period (see Table 1 below). The result motivates use of the Oaxaca–Blinder method in analysing the factors retarding convergence.

Table 1. Growth rate difference between low income and high income regions (1981-2003).

Mean of lower-income regions growth rates during the 1981-2003 period	(1)	0.0155
Mean of higher-income regions growth rates during the 1981-2003 period	(2)	0.0162
Difference (1) – (2)		0.0007

As long as the expected means of the error terms in the regressions are both zeros, the total estimated difference in average GDP per capita growth between the sub-samples can be represented by

$$\overline{\ln(y_{it}/y_{i,t-1})_{li}} - \overline{\ln(y_{it}/y_{i,t-1})_{hi}} = \hat{\beta}'_l\, \overline{\ln X_{li}} - \hat{\beta}'_h\, \overline{\ln X_{hi}} \qquad (3)$$

where, $\hat{\beta}'_h$ and $\hat{\beta}'_l$ represent, the estimated panel Random Effect (RE)[9] coefficients of regressions for higher-income and lower-income regions (sub-samples) respectively (including constant). The $\overline{\ln X_{hi}}$ and $\overline{\ln X_{li}}$ represent the averages of modeled factors of economic growth for the two sub-samples. The total estimated difference or gap can be further decomposed into the following three components:

$$\overline{\ln(y_{it}/y_{i,t-1})_{li}} - \overline{\ln(y_{it}/y_{i,t-1})_{hi}} =$$

$$\hat{\beta}'_h(\overline{\ln X_{li}} - \overline{\ln X_{hi}}) + (\hat{\beta}'_l - \hat{\beta}'_h)\, \overline{\ln X_{hi}} + (\hat{\beta}'_l - \hat{\beta}'_h)(\overline{\ln X_{li}} - \overline{\ln X_{hi}}) \qquad (4)$$

$$= E + C + CE$$

The first component on the right-hand side (E) is the portion of the gap due to the difference in structural and control factors. The second coefficient component C is attributable to differences unexplained by these factors. CE is the interaction factor between these two components. Note that method also generates detailed decomposition results for individual regressors (specified factors of economic growth).

Table 11 (see Appendix) reports the (predicted) difference decomposition of growth rates between low-income and high-income regions from estimated panel RE model. A more detailed linear decomposition is presented in Tables 12 and 13 (see Appendix). As the results are based on panel RE estimation, the conclusions are preliminary and approximate, but some useful inferences can be drawn. We decided to include two specifications of the Oaxaca-Blinder decomposition approach, taking into account the education variables and the spillover effects. The mean predictions across the sub-samples do not differ significantly in both specifications (see Table 11). According to the first specification there is little evidence of convergence between the high and low income group (Table 12). We find that

[9] Oaxaca-Blinder decomposition was originally derived for classical OLS regression (see e.g. Yun, 2004). The GMM approach allows in theory for decomposition but computational problems exist.

the lower students-teacher ratio (upper secondary level) in poor regions compared with the rich ones retard convergence. The same holds for population growth, as the smaller population growth of the low income regions holds back convergence with the higher income ones. On the other hand, when looking at the specification that includes the regional spillovers (Table 13) we conclude that smaller number of students attending the upper secondary level of education in the poorer regions when compared to the richer regions impedes convergence. Again, the same conclusion can be drawn for population growth.

6. Conclusions

This paper estimates the social returns to human capital at regional level in Greece using education and health care indicators. We estimate the effect of these variables separately for poor and rich regions, allowing this way for spatial heterogeneity of rates of returns to human capital. Overall, we find that they are differences between the two regional clubs. In particular, our results show a positive impact of education and health care variables on growth in high-income regions, while the evidence is much weaker for low-income regions. Thus, our evidence suggests a positive relationship between the development level of an economy and returns to human capital in line with theoretical models, which consider human capital a threshold variable. In addition, there are important human capital externalities across neighbouring regions.

We conclude with some possible research extensions. We could employ alternative estimation methods as a check for the robustness of the results. We might also use other measures of human capital taking into account in a more comprehensive way its quality, additional stages of education (higher education) and other forms of education (job training). These are left for future work.

APPENDIX

Table 1. Description of Variables

Dependent Variable	**Description**	**Source**
GDP per capita	in Euros, at 2000 constant prices;	National Statistics Agency of Greece, Quarterly Regional & Satellite Accounts Section
Explanatory Variables		
Students; Lower Secondary Level	Number of students attending the lower secondary level of education at regional level (NUTS 3). The variable is denoted per 1000 children aged 10 to 14 years of age.	National Statistics Agency of Greece, Social Accounts Section
Student; Upper Secondary Level	Number of students attending the upper secondary level of education at regional level (NUTS 3). The variable is denoted per 1000 children aged 10 to 14 years of age.	National Statistics Agency of Greece, Social Accounts Section
Students – Teachers Ratio; Lower Secondary Level	The number of students divided with the number of teachers at the lower secondary level of education at regional level (NUTS 3). Teachers are denoted per 1000 inhabitants at regional level.	National Statistics Agency of Greece, Social Accounts Section
Students – Teachers Ratio; Upper Secondary Level	The number of students divided with the number of teachers at the upper secondary level of education at regional level (NUTS 3). Teachers are denoted per 1000 at regional level.	National Statistics Agency of Greece, Social Accounts Section
Medical Doctors	Number of medical doctors per 1000 inhabitants at regional level (NUTS 3).	National Statistics Agency of Greece, Social Accounts Section
Hospital Beds	Number of hospital beds per 1000 inhabitants at regional level (NUTS 3).	National Statistics Agency of Greece, Social Accounts Section
Regional Students; Lower Secondary Level	Number of students attending the lower secondary level of education at regional level (NUTS 3), including students at the same level of education from the neighbouring regions.	National Statistics Agency of Greece, Social Accounts Section
Regional Students; Upper Secondary Level	Number of students attending the upper secondary level of education at regional level (NUTS 3), including students at the same level of education from the neighbouring regions.	National Statistics Agency of Greece, Social Accounts Section
Extra Regional Students; Lower Secondary Level	Number of students attending the lower secondary level of education from the neighbouring regions only (NUTS 3).	National Statistics Agency of Greece, Social Accounts Section
Extra Regional Students; Upper Secondary Level	Number of students attending the upper secondary level of education from the neighbouring regions only (NUTS 3).	National Statistics Agency of Greece, Social Accounts Section
University Medical Doctors	Number of university medical doctors per 1000 inhabitants at regional level (NUTS 3). The number of university medical doctors (when direct access to the respective university hospital is available) is added to the stock of medical doctors at regional level (NUTS 3).	National Statistics Agency of Greece, Social Accounts Section
University Hospital Beds	Number of university hospital beds per 1000 inhabitants at regional level (NUTS 3). The number of university hospital beds (when direct access to the respective university hospital is available) is added to the stock of hospital at regional level (NUTS 3).	National Statistics Agency of Greece, Social Accounts Section

Table 2. Descriptive Statistics: Greek Regions, 1981 – 2003 (NUTS III)

	obs.	mean	st. dev.	min	max
GDP per capita	1173	9373.0	2796.8	5272.6	33490.7
GDP growth	1173	0.016	0.069	-0.349	0.521
Population growth	1173	0.003	0.010	-0.121	0.060
Students; Lower Secondary Level	1168	587.2	71.8	300.8	995.8
Student; Upper Secondary Level	1168	393.0	124.9	140.2	775.9
Students – Teachers Ratio; Lower Secondary Level	1168	1168	207.8	41.7	80.0
Students – Teachers Ratio; Upper Secondary Level	1168	1170	180.2	32.2	87.5
Medical Doctors	1173	1173	2.211	1.152	0.47
Hospital Beds	1173	1173	3.569	1.964	0.51

Table 3. Descriptive Statistics: Low Income Regions, 1981 – 2003 (NUTS III)

	obs.	mean	st. dev.	min	max
GDP per capita	598	7967.7	1435.9	5272.6	16509.5
GDP growth	572	0.016	0.071	-0.256	0.400
Population growth	572	0.003	0.009	-0.072	0.060
Students; Lower Secondary Level	595	583.8	80.7	300.8	995.8
Student; Upper Secondary Level	596	394.8	123.7	151.1	700.1
Students – Teachers Ratio; Lower Secondary Level	595	205.8	40.7	95.4	365.7
Students – Teachers Ratio; Upper Secondary Level	596	177.1	28.6	107.9	271.9
Medical Doctors	598	2.03	1.04	0.47	7.11
Hospital Beds	598	3.10	1.25	1.03	8.12

Table 4. Descriptive Statistics: High Income Regions, 1981 – 2003 (NUTS III)

	obs.	mean	st. dev.	min	max
GDP per capita	575	10834.6	3103.1	6377.4	33490.7
GDP growth	550	0.016	0.067	-0.349	0.521
Population growth	550	0.004	0.012	-0.121	0.040
Students; Lower Secondary Level	573	590.7	61.2	380.9	755.2
Student; Upper Secondary Level	574	391.2	126.2	140.2	775.9
Students – Teachers Ratio; Lower Secondary Level	573	209.9	42.7	80.0	342.7
Students – Teachers Ratio; Upper Secondary Level	574	183.6	35.3	87.5	505.1
Medical Doctors	575	2.40	1.23	0.75	6.83
Hospital Beds	575	4.05	2.41	0.51	15.88

Table 5. Panel Data Estimates: Education and Health Care Variables (All Regions)

	Random Effects Estimates				Arrelano Bond Estimates			
Explanatory Variables [4]	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Students; Lower Secondary Level	0.001** (2.55)	0.150** (2.38)	-	-	0.000*** (3.58)	0.000 (1.40)	-	-
Students – Teachers Ratio; Lower Secondary Level	-0.063*** (-5.93)	-0.024** (-2.17)	-	-	-0.027 (-1.03)	0.000 (0.02)	-	-
Student; Upper Secondary Level	-	-	0.001*** (5.94)	0.001** (1.99)	-	-	0.001*** (3.04)	0.001*** (3.88)
Students – Teachers Ratio; Upper Secondary Level	-	-	-0.033*** (-2.70)	-0.011** (-2.51)	-	-	-0.024 (-1.04)	-0.012*** (-0.57)
Medical Doctors	-	0.020*** (4.26)	-	0.015*** (2.65)	-	0.092*** (4.55)	-	0.092*** (4.62)
GDP Initial [1]	-0.003 (-0.36)	-0.008 (-0.84)	-0.007 (-0.71)	-0.010 (-1.03)	-0.182*** (-6.24)	-0.164*** (-5.81)	-0.178*** (-6.12)	-0.156*** (-5.54)
Population Growth	-1.126*** (-5.74)	-1.341*** (-6.97)	-1.109*** (5.69)	-1.318*** (-6.79)	-1.398*** (-5.65)	-1.543*** (-6.57)	-1.39*** (-5.68)	-1.544*** (-6.68)
Obs.	1071	1020	1071	1020	1020	969	1020	969
R^2	0.068	0.072	0.083	0.078	-	-	-	-
Sargan Test (p-value) [2]	-	-	-	-	0.107	0.114	0.122	0.138
Autocovariance test of order 2 (p-value) [3]	-	-	-	-	0.190	0.148	0.144	0.142

Note: Dependent variable GDP per capita in region *i* (i =1,…,51) in period *t* (t =1981,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. [1] Initial per capita GDP in region *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] See Table 1 in the Appendix for the definition of the variables used. Explanatory variables lagged 2 periods. All the explanatory variables were used as instruments.

Table 6. Panel Data Estimates: Education and Health Care Variables (High Income Regions)

	Random Effects Estimates				Arrelano Bond Estimates			
Explanatory Variables [4]	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Students; Lower Secondary Level	0.061** (2.22)	0.016 (0.62)	-	-	0.242*** (3.52)	0.0182** (2.35)	-	-
Students – Teachers Ratio; Lower Secondary Level	-0.055*** (-3.84)	-0.025 (-1.29)	-	-	-0.049** (-1.85)	-0.028** (-2.09)	-	-
Student; Upper Secondary Level	-	-	0.039*** (4.46)	0.029** (2.36)	-	-	0.101*** (3.71)	0.010*** (3.90)
Students – Teachers Ratio; Upper Secondary Level	-	-	-0.056** (-2.10)	-0.046** (-3.16)	-	-	-0.057** (-2.71)	-0.048** (-1.87)
Medical Doctors	-	0.0124 (2.10)	-	0.055** (1.89)	-	0.060** (2.16)	-	0.053** (1.91)
GDP Initial [1]	-0.002 (-0.15)	-0.001 (-0.06)	-0.015 (-1.10)	-0.017 (-1.09)	-0.128*** (-3.10)	-0.126*** (-3.02)	-0.002*** (-3.05)	-1.117*** (-2.82)
Population Growth	-1.009*** -4.09	-1.156*** (-6.45)	-1.117*** (-4.67)	-1.142*** (-4.72)	-1.391*** (-4.76)	-1.472*** (-5.13)	-1.358*** (-4.70)	-1.474*** (-5.20)
Obs.	523	500	525	500	500	475	500	475
R^2	0.073	0.062	0.089	0.017	-	-	-	-
Sargan Test (p-value) [2]	-	-	-	-	0.086	0.094	0.104	0.112
Autocovariance test of order 2 (p-value) [3]	-	-	-	-	0.158	0.182	0.147	0.157

Note: Dependent variable GDP per capita in region *i* (i =1,…,25) in period *t* (t =1981,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. [1] Initial per capita GDP in region *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] See Table 1 in the Appendix for the definition of the variables used. Explanatory variables lagged 2 periods. All the explanatory variables were used as instruments.

Table 7. Panel Data Estimates: Education and Health Care Variables (Low Income Regions)

	Random Effects Estimates				Arrelano Bond Estimates			
Explanatory Variables [4]	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Students; Lower Secondary Level	-0.010 (-0.54)	-0.018 (-0.94)	-	-	-0.032 (-0.65)	-0.036 (-0.76)	-	-
Students – Teachers Ratio; Lower Secondary Level	-0.060** (-2.97)	-0.029 (-1.40)	-	-	-0.006 (0.20)	-0.009 (-0.28)	-	-
Student; Upper Secondary Level	-	-	0.019** (1.92)	-0.006 (-0.50)	-	-	0.007 (0.31)	0.002 (0.10)
Students – Teachers Ratio; Upper Secondary Level	-	-	-0.325 (-1.40)	-0.017 (-0.78)	-	-	0.003 (0.11)	-0.001 (-0.05)
Medical Doctors	-	0.028** (4.15)	-	0.033 (4.29)	-	0.089*** (3.68)	-	0.087*** (3.62)
GDP Initial [1]	-0.048** (-1.81)	-0.038 (-1.46)	-0.049** (-1.85)	-0.045* (-1.71)	-0.213*** (-5.54)	-0.213*** (-5.60)	-0.215*** (-5.60)	-0.215*** (-5.64)
Population Growth	-1.454*** (-5.76)	-1.554*** (-6.13)	-1.390*** (-5.19)	-1.595*** (-5.86)	-1.685*** (-4.40)	-1.707*** (-4.50)	-1.648*** (-4.31)	-1.653*** (-4.36)
Obs.	520	520	520	520	494	494	494	494
R^2	0.058	0.088	0.061	0.097	-	-	-	-
Sargan Test (p-value) [2]	-	-	-	-	0.079	0.059	0.068	0.085
Autocovariance test of order 2 (p-value) [3]	-	-	-	-	0.051	0.064	0.075	0.069

Note: Dependent variable GDP per capita in region *i* (i =1,…,25) in period *t* (t =1981,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. [1] Initial per capita GDP in region *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation.[4] See Table 1 in the Appendix for the definition of the variables used. Explanatory variables lagged 2 periods. All the explanatory variables were used as instruments.

Table 8. Panel Data Estimates: Regional & Extra Regional Education and Health Care Variables (All Regions)

	Random Effects Estimates								Arrelano Bond Estimates							
Explanatory Variables [4]	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Regional Students; Lower Secondary Level	-0.005 (-1.61)	-0.011*** (-3.32)	-	-	-	-	-	-	0.253*** (4.79)	0.236*** (4.41)	-	-	-	-	-	-
Regional Students; Lower Secondary Level	-	-	0.003 (1.07)	0.002 (0.79)	-	-	-	-	-	-	0.092*** (4.03)	0.783*** (3.37)	-		-	-
Extra Regional Students; Lower Secondary Level	-	-	-	-	-0.003 (-0.83)	-	-	-	-	-	-	-	0.295*** (3.88)	-	-	-
Extra Regional Students; Upper Secondary Level	-	-	-	-	-	-0.003 (-0.85)	-	-	-	-	-	-	-	0.086** (2.27)	-	-
Students; Lower Secondary Level	-	-	-	0.000 (1.24)	-0.026 (-1.51)	-	-	-	-	-	-	0.155*** (3.43)	0.086** (1.39)		-	-
Students; Upper Secondary Level	-	0.000*** (7.16)	-	-	-	0.045*** (5.66)	-	-	-	0.047** (2.34)	-	-	-	0.001** (0.02)	-	-
University Medical Doctors	-	-	-	-	-	-	0.016 (3.19)	-	-	-	-	-	-	-	0.106*** (3.99)	-
University Hospital Beds	-	-	-	-	-	-	-	0.002 (0.45)	-	-	-	-	-	-	-	0.038 (1.26)
GDP Initial [1]	-0.003 (-0.39)	-0.003 (-0.35)	-0.009 (-0.95)	-0.010 (-0.99)	-0.003 (-0.29)	-0.004 (-0.45)	-0.015 (-1.62)	-0.011 (-1.17)	-0.186*** (-6.40)	-0.182*** (-6.28)	-0.174*** (-6.01)	-0.176*** (-6.10)	-0.187*** (-5.92)	-0.167*** (-5.29)	-0.168*** (-5.93)	-0.163*** (-1.26)
Population Growth	-1.168*** (-5.73)	-1.231*** (-6.17)	-1.045*** (-5.12)	-1.075*** (-5.24)	-1.220*** (-5.39)	-1.123*** (-5.56)	-1.233*** (-6.43)	-1.210*** (-6.29)	-1.37*** (-5.60)	-1.369*** (-5.60)	-1.389** (-5.70)	-1.350*** (-5.53)	-1.482*** (-5.56)	-1.493*** (-5.60)	-1.629*** (-6.96)	-1.147*** (-6.35)
Obs.	1071	1071	1071	1071	903	903	1020	1020	1020	1020	1020	1020	860	860	969	969
R^2	0.031	0.080	0.051	0.040	0.035	0.079	0.064	0.043	-	-	-	-	-	-	-	-
Sargan Test (p-value) [2]	-	-	-	-	-	-	-	-	0.656	0.722	0.632	0.740	0.629	0.832	0.680	0.741
Autocovariance test of order 2 (p-value) [3]	-	-	-	-	-	-	-	-	0.530	0.563	0.788	0.707	0.621	0.813	0.941	0.799

Note: Dependent variable GDP per capita in region *i* (i =1,…,51) in period *t* (t =1981,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. [1] Initial per capita GDP (PPS) in region *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation.[4] See Table 1 in the Appendix for the definition of the variables used. Explanatory variables lagged 2 periods and Doctors University & Beds University lagged 3 periods. All the explanatory variables were used as instruments.

Table 9. Panel Data Estimates: Regional & Extra Regional Education and Health Care Variables (High Income Regions)

	Random Effects Estimates								Arrelano Bond Estimates							
Explanatory Variables [4]	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Regional Students; Lower Secondary Level	-0.004 (-0.89)	-0.010** (-2.08)	-	-	-	-	-	-	0.345*** (4.19)	0.293*** (3.45)	-	-	-	-	-	-
Regional Students; Lower Secondary Level	-	-	0.004 (1.08)	0.003 (0.85)	-	-	-	-	-	-	0.113*** (3.71)	0.089*** (2.83)	-		-	-
Extra Regional Students; Lower Secondary Level	-	-	-	-	-0.001 (-0.32)	-	-	-	-	-	-	-	0.309*** (2.81)	-	-	-
Extra Regional Students; Upper Secondary Level	-	-	-	-	-	-0.002 (-0.50)	-	-	-	-	-	-	-	0.475** (2.43)	-	-
Students; Lower Secondary Level	-	-	-	0.037 (1.35)	-0.039 (-1.28)	-	-	-	-	-	-	0.184*** (2.65)	0.007** (1.19)		-	-
Students; Upper Secondary Level	-	0.045*** (5.04)	-	-	-	0.048*** (4.35)	-	-	-	0.068** (2.44)	-	-	-	-0.086** (2.27)_	-	-
University Medical Doctors	-	-	-	-	-	-	0.008 (1.11)	-	-	-	-	-	-	-	0.052 (1.42)	-
University Hospital Beds	-	-	-	-	-	-	-	0.004 (0.54)	-	-	-	-	-	-	-	0.004 (0.11)
GDP Initial [1]	-0.007 (-0.49)	-0.009 (-0.66)	-0.014 (-0.98)	-0.013 (-0.87)	-0.005 -0.32	-0.011 (-0.72)	-0.018 (-1.18)	-0.011 (-0.77)	-0.130*** (-3.15)	-0.122*** (-2.96)	-0.114*** (-2.77)	-0.119*** (-2.89)	-0.150*** (-3.43)	-0.127*** (-2.91)	-0.116*** (-2.79)	-0.117*** (-2.81)
Population Growth	-1.08*** (-4.36)	-1.254*** (-5.10)	-0.984*** (-3.96)	-1.064*** (-4.17)	-1.117*** -4.33	-1.125*** (-4.73)	-1.125*** (-4.66)	-1.082*** (-4.50)	-1.35*** (-4.69)	-1.393*** (-4.82)	-1.348*** (-4.69)	-1.385*** (-4.81)	-1.368*** (-4.52)	-1.369*** (-4.52)	-1.428*** (-4.98)	-1.349*** (-4.79)
Obs.	525	525	525	525	462	462	500	500	500	500	500	500	440	440	475	475
R^2	0.039	0.087	0.051	0.055	0.039	0.089	0.054	0.047	-	-	-	-	-	-	-	-
Sargan Test (p-value) [2]	-	-	-	-	-	-	-	-	0.872	0.541	0.911	0.852	0.853	0.832	0.734	0.741
Autocovariance test of order 2 (p-value) [3]	-	-	-	-	-	-	-	-	0.946	0.827	0.761	0.2808	0.762	0.813	0.638	0.622

Note: Dependent variable GDP per capita in region *i* (i =1,…,25) in period *t* (t =1981,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. [1] Initial per capita GDP in region *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] See Table 1 in the Appendix for the definition of the variables used. Explanatory variables lagged 2 periods and Doctors University & Beds University lagged 3 periods. All the explanatory variables were used as instruments.

Table 10. Panel Data Estimates: Regional & Extra Regional Education and Health Care Variables (Low Income Regions)

	Random Effects Estimates								Arrelano Bond Estimates							
Explanatory Variables [4]	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Regional Students; Lower Secondary Level	0.005 (1.27)	0.011 (2.51)	-	-	-	-	-	-	0.150** (2.38)	0.148** (2.32)	-	-	-	-	-	-
Regional Students; Lower Secondary Level	-	-	0.002 (0.61)	0.015 (0.37)	-	-	-	-	-	-	0.057* (1.77)	0.054* (1.67)	-		-	-
Extra Regional Students; Lower Secondary Level	-	-	-	-	-0.004 (-0.79)	-	-	-	-	-	-	-	0.266*** (2.98)	-	-	-
Extra Regional Students; Upper Secondary Level	-	-	-	-	-	-0.003 (-0.59)	-	-	-	-	-	-	-	0.080* (1.67)	-	-
Students; Lower Secondary Level	-	-	-	0.019 (0.95)	0.026 (1.18)	-	-	-	-	-	-	0.042 (0.81)	0.020 (0.30)		-	-
Students; Upper Secondary Level	-	0.051*** (5.25)	-	-	-	0.045*** (3.79)	-	-	-	0.014 (0.53)	-	-	-	-0.033 (-0.84)	-	-
University Medical Doctors	-	-	-	-	-	-	0.025*** (3.43)	-	-	-	-	-	-	-	0.094*** (3.00)	-
University Hospital Beds	-	-	-	-	-	-	-	0.001 (0.15)	-	-	-	-	-	-	-	0.071*** (0.01)
GDP Initial [1]	-0.299 (-1.14)	-0.039 (-1.52)	-0.382 (-1.46)	-0.043 (-1.62)	-0.040 (-1.20)	-0.047 (-1.48)	-0.022 (-0.87)	-0.035 (-1.34)	-0.024*** (-6.20)	-0.248*** (-6.17)	-0241*** (-6.04)	-0.241*** (-6.05)	-0.237*** (-5.30)	-0.022*** (-4.99)	-0.224*** (-5.92)	-0.219*** (-5.69)
Population Growth	-1.26*** (-3.61)	-1.171*** (-3.42)	-1.102*** (-3.14)	-1.094 (-3.12)	-1.32 (-3.18)	-1.199*** (-2.92)	-1.153*** (-3.43)	-1.154*** (-3.40)	-1.443*** (3.58)	-1.419*** (-3.50)	-1.456*** (-3.62)	-1.416*** (-3.50)	-1.861*** (3.85)	-1.898*** (-3.92)	-1.771*** (-4.75)	-1.657*** (-4.40)
Obs.	546	546	546	546	441	441	546	546	520	520	520	520	420	420	494	494
R^2	0.025	0.080	0.032	0.032	0.029	0.070	0.072	0.026	-	-	-		-	-	-	-
Sargan Test (p-value) [2]	-	-	-	-	-	-	-	-	0.810	0.781	0.881	0.970	0.997	0.747	0.897	0.789
Autocovariance test of order 2 (p-value) [3]	-	-	-	-	-	-	-	-	0.982	0.954	0.854	0.910	0.781	0.968	0.741	0.822

Note: Dependent variable GDP per capita in region *i* (i =1,…,26) in period *t* (t =1981,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. [1] Initial per capita GDP in region *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] See Table 1 in the Appendix for the definition of the variables used. Explanatory variables lagged 2 periods and Doctors University & Beds University lagged 3 periods. All the explanatory variables were used as instruments.

Table 11. Predicted growth rate difference between low income and high income regions (1981-2003).

Mean of lower-income regions growth rates during the 1981-2003 period	(1)	0.01660
Mean of higher-income regions growth rates during the 1981-2003 period	(2)	0.01647
Difference (1) – (2)		0.00012

Table 12. Detailed linear decomposition of growth rate difference between low income and high income regions (Education effects)

	Factors	Coefficients	Interaction
GDP Initial	-0.009 -1.43	0.189 (0.72)	0.005 (0.72)
Students; Upper Secondary Level	-0.001 -0.74	-0.002 (-0.03)	0.001*** (0.02)
Students – Teachers Ratio; Upper Secondary Level	-0.001** -1.97	0.132 (1.01)	0.001 (0.93)
Population Growth	-0.002** -2.12	0.001 (0.11)	0.001 (0.93)
Total	-0.013** -2.10	0.007 (1.37)	0.006 (0.86)

Note: z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively.

Table 13. Detailed linear decomposition of growth rate difference between low income and high income regions (Spillover effects).

	Factors	Coefficients	Interaction
GDP Initial	-0.010 -1.52	0.261 (0.32)	0.007 (0.99)
Regional Students; Lower Secondary Level	-0.001* -1.73	0.010 (0.83)	0.001 (0.20)
Students; Upper Secondary Level	-0.001 -0.75	-0.037 (-0.48)	0.001 (0.28)
Population Growth	-0.002** -2.12	-0.001 (-0.20)	-0.001 (-0.19)
Total	-0.014** -2.14	0.006 (1.20)	0.007 (1.02)

Note: z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively.

REFERENCES

Andersson, M., Grasjo, U. & Karlsson, C. (2008) Hunan Capital and Productivity in a Spatial Economic System-Relating the Extent of Spatial Dependence to Localities Position, *Annals of Economics and Statistics* [forthcoming].

Andersson, M. & Karlsson, C. (2007). Knowledge in Regional Economic Growth-The Role of Knowledge Accesibility, Industry and Innovation, 14, 2, 129-149.

Arellano, A. & Fullerton, T.M. JR. (2005). Educational Attainment and Regional Economic Performance in Mexico, International Advances in Economic Research, 231-242.

Azariadis, C., & Drazen, A. (1990). Threshold Externalities in Economic Development. *Quarterly Journal of Economics*, 105, 501–526.

Arellano, M., Bond, S., (1991). Some Tests of Specification or Panel Data: Monte Carlo Evidence and an Application to Employment Equations, *The Review of Economic Studies,* 58 (2), 277-297.

Barro, R.J. (1991). Economic Growth in a Cross Section of Countries, *Quarterly Journal of Economics*, 106, 407-443.

Barro, R.J & Sala-i-Martin, X., (2004). *Economic Growth*. MIT Press.

Barro, R.J & Sala-i-Martin, X., (1992). Convergence. *Journal of Political Economy* 100(2), 223-251.

Barro, R.J & Sala-i-Martin, X., (1991). Convergence Across States and Regions, *Brookings Papers on Economic Activity*, 1, 107-182.

Bassanini, A. & Scarpetta S. (2001). The Driving Forces of Economic Growth: Panel Data Evidence for the OECD Countries, *OECD Economic Studies,* 33, 9-56.

Bassetti, T. (2007). Human Capital and Economic Growth: A Selective Survey, *PRIN 2005, Working Paper 018*, May, 1-35.

Benhabib, J. & Spiegel, M. (1994). The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-Country Data, *Journal of Monetary Economics,* 34, 143-174.

Bils, M. & Klenow, P.J. (2000). Does Schooling Cause Growth?, *American Economic Review*, 90, 1160-1183.

Blinder, A. (1973). Wage Discrimination: Reduced Form and Structural Estimates, *Journal of Human Resources*, 8(4), 436-455.

De la Fuente, A. & Domenech, R. (2000). *Human Capital in Growth Regressions: How Much Difference Does Data Quality Make ?*, Mimeo, Universidad Autonoma de Barcelona, January.

Di Liberto, A. (2007). Education and Italian Regional Development, *Economics of Education Review,* [forthcoming].

Di Liberto, A. (2004). *Convergence Clubs, and the Role of Human Capital in Spanish Regional Growth*, CRENOS Working Paper, 2004/18.

Durlauf, S.N & Johnson, P.A (1995) Multiple Regimes and Cross-Country Growth Behaviour, *Journal of Applied Econometrics*, 10, 365-384.

Eckey, H-F, Dreger, C., Turck, M. (2006). *European Regional Convergence in a Human Capital Augmented Solow Model,* University of Kassel Working paper, 88, 1-19.

Feyrer, J. (2003). *Convergence by Parts*, Mimeo, Dartmouth College.

Hall, R. & Jones, C.I. (1999), Why Do Some Countries Produce So Much More Output Per Worker than Others?, *Quarterly Journal of Economics*, 114(1), 83-116.

Grasjo, U. (2005) *Human capital, R&D and Regional Exports*, Working Paper Series in Economics and Institutions of Innovation, 50, Royal Institute of Technology, CESIS.

Griliches, Z. (1997). Education, Human Capital and Growth: A Personal Perspective. *Journal of Labour Economics*, 15, 330–344.

Kalaitzidakis, P., Mamuneas, T., Savvides, A. & Stengos, T. (2001). Measures of Human Capital and Nonlinearities in Economic Growth, *Journal of Economic Growth*, 6, 229-254.

Krueger, A. B., & Lindahl, M. (2001). Education for Growth: Why and For Whom? *Journal of Economic Literature*, 39, 1101–1136.

Ledyaeva, S., Linden, M. (2006). *Foreign Direct Investment and Economic Growth: Empirical Evidence from Russian Regions*. Discussion Paper No. 17, Bank of Finland, Helsinki.

Liu, Z. & Stengos, T. (1999). Non-Linearities in Cross-Country Growth Regressions: A Semi-Parametric Approach, *Journal of Applied Econometrics*, 14, 527-538.

Lucas, R. E. (1988). On The Mechanics of Economic Development, *Journal of Monetary Economics*, 22, 3–42.

Malik, G. (2006). An Examination of the Relationship Between Health and Economic Growth, *Working Paper, ICRIER September.*

Mankiw, N. Romer, D. & Weil, D. (1992). A Contribution to the Empirics of Economic Growth, *Quarterly Journal of Economics,* 108, 407-437.

Middendorf, T., (2006). Human Capital and Economic Growth in OECD Countries, *Jahrbucher Fur Nationalokonomie Und Statistik,* 226(6), 670-686

Nelson, R.R and Phelps, S.E (1966). Investment in Humans, Technological Diffusion, and Economic Growth, *American Economic Review*, 56, 69-75.

Oaxaca, L. (1973). Male-Female Wage Differentials in Urban Labour Markets, *International Economic Review*, 14, 693-709.

Papageorgiou, C. (2003). "Distinguishing Between the Effects of Primary and Post-Primary Education on Economic Growth, *Review of Development Economics*, 7 (4), 622-635.

Pritchett, L. (2001). Where Has all the Education Gone?, *World Bank Economic Review, 15, 3,* 367-391.

Ricci, F. & Zachariadis, M. (2007). Determinants of Public Health Outcomes: A Macroeconomic Perspective, June, *Mimeo*.

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

Romer, P. M. (1986). Increasing Returns and Long-Run Growth, *Journal of Political Economy*, 94, 5, 1002-1037.

Sianesi, B. & Van Reenen, J. (2002). The Returns to Education: A Review of the Empirical Macroeconomic Literature, *Institute for Fiscal Studies, Working Paper 02/05.*

Temple, J. (1999). The New Growth Evidence, *Journal of Economic Literature*, 37, 112-156.

Yun, M. (2004). Decomposition Differences in the First Moment, Economic Letters, 82, 275-280.

Wei, W. (2005). China and India: Any difference in their FDI Performance?, *Journal of Asian Economics*, 16, 719-736.