The Cumulative Effect of Human Capital on Economic Growth: Using Panel Data Method

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This article studies the controversial relationship between human capital and growth through different channels using a cross-country panel approach applied for 104 countries, including 79 developing countries and 25 developed countries (OECD) during 1980-2011. The analysis yields important insights into the relationship between human capital and growth. Firstly, we find a significant relationship between high levels of human capital and technology adoption Secondly, considering the levels of human capital directly as a innovation component in the productivity function shows that there is a non-linear relationship between this factor and growth. The results provide a new understanding of this relationship and to some extent contradict some earlier studies.

Keywords: Human capital, Economic growth, Panel approach
JEL Classifications: O1, O2

I. Introduction

Human capital is assumed to be one of the main determinants of growth, but the evidence for the effect of human capital on growth

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has been weak and controversial (Apergis, 2009), (Benhabib and Speigel, 1994), (Emadzadeh, (2003), (Hamzeloo, 2002), (Kyriacou, 1991), (Mankiw *et al*, 1992).) and the growth regressions have generally failed to find a significant contribution of human capital to economic growth. In particular, the evolution of human capital over time is not found to be statistically related to output growth (Topel, 1999).

There are some explanations for these contradictory findings including: the role of outlier observations (Temple, 1999), the way human capital is measured in terms of quantity or quality (Barro, 2001), (Hanushek and Woessmann, 2008). Data quality of human capital measures (Cohen and Soto, 2007), (De la Fuente and Domenech, 2006),(Portela *et al*, 2010) and the correct specification of human capital in the growth regression (in terms of a log specification in the context of a production function or in terms of levels in a Mincerian specification (Krueger and Lindahl, 2001).

On the other hand the channels used for measuring this relationship over time are often different. Two distinct channels are: human capital might accelerate growth by augmenting or complementing the existing factors of production as in an augmented framework (Solow, 1956) or in a model along the lines of (Lucas, 1988). Secondly, human capital might affect growth through facilitating the diffusion and adoption of new technologies in the tradition of (Nelson and Phelps 1966) or through innovation as in endogenous growth models in the tradition of (Aghion and Howitt, 1998), (Romer, 1990a), (Hanushek and Woessmann, 2008).. It is often argued that high levels of human capital facilitate technology adoption (Acemoglu, 2003a), (Autor *et al*, 1998), (Benhabib and Speigel, 1994), (Benhabib and Speigel 2005), (Berman *et al*, 1998), (Berman and Machin, 2000), (Caselli and Coleman II, 2002), (Caselli and Coleman II, 2006), (Nelson and Phelps, 1966).

The aim of this article is to provide a thorough analysis of the dependence structure between human capital and economic growth in

different economies and suggests an explanation for the contradictory finding in the literature that complements earlier explanations. As human capital is a factor of production, it is plausible to assume that indeed both of the proposed channels are relevant for the economic growth. we contribute to the literature based on these assumptions, and use a panel approach to examine our assumptions. Estimates which are based on restrictive specifications that only account for a subset of these channels are likely to suffer from an omitted variable bias (Benhabib and Speigel, 1994).
The rest of the article is organized as follows: Section II introduces the methodology used in this paper. section III, describes the considered data and presents the empirical results of our study. The study finishes with a conclusion.

II. Methodology

In this section we represent the approach used to investigate the relationship between human capital and economic growth. According to the endogenous growth that utilize the assumption of non-decreasing returns in order to derive the growth rate (Sala-i-Martin, 1990a). Many candidates have been recommended as the source of non-decreasing returns; particularly, the stock of human capital (Lucas, 1988). accumulated capital (Rebelo, 1991). research and development (Romer, 1986), (Romer, 1990a) or public infrastructure investment (Barro, 1991).Thus, endogenous growth models highlight sectors of the economy that influence the growth path of an economy. This can be simply shown in a Cobb-Douglas production function as follows:

$$Y_t = A_t(H_t)K_t^{\alpha}L_t^{\beta}\varepsilon_t$$

Where

Y_t: per capita income, L_t : Labor, K_t : physical capital, H_t : human capital

By taking log differences, we have:

$$(logY_t - logY_0) = [logA_T(H_t) - logA_0(H_t)] + \alpha(logK_T - logK_0) + \beta(logL_t - logL_0) + (log\varepsilon_T - log\varepsilon_0]$$
(1)

In light of the previous literature, it is hypothesized that the rate at which the latest theoretical technology is realized depends upon educational attainment and the gap between the theoretical level of technology (that is defined as the best-practice level of technology that would prevail if technological diffusion were completely instantaneous and advances exogenously at a constant exponential rate $(\lambda: T(t) = T_0 e^{\lambda t},\ \boldsymbol{\lambda} > 0))$ and the level of technology in practice which equals the theoretical level of technology in previous years. (Nelson and Phelps, 1966).

$$A(t) = c(h)[T(t) - A(t)]$$
(2)

Equivalently:

$$\frac{\dot{A}}{A} = c(H)\left[\frac{T(t) - A(t)}{A(t)}\right] \qquad c(h)' > 0 \qquad c(0) = 0$$
(3)

Thus the rate of technology improvements in practice (not the level) is an increasing function of education attainment and proportional to the gap, $(T(t) - A(t))/A(t)$ (Nelson and Phelps, 1966). On the other hand the growth of A has been modeled directly as a function of the educational level in more recent theories (Lucas, 1988).It has also been argued that the level of human capital may have an influence on growth of A, both directly and through its effect on the speed of the catching-up process (Romer, 1990b)..

By adopting two above hypothesis, for the country i, the growth of total factor productivity depends on two factors. The first is the level of human capital, reflecting the effect of domestic endogenous innovation. The second is an interactive term that involves the level of human capital and the technological lag of a country behind the leader[2] to capture the catch-up effects, as following: (Benhabib and Speigel, 1994).

$$[logA_T(H_t) - logA_0(H_t)]_i = c + gH_i + mH_i[\frac{Y_{max}-Y_i}{Y_i}] \quad (4)$$

where, c represents exogenous technological progress, gH_i indicates endogenous technological progress associated with the ability of a country to innovate new technologies domestically, and is a function of human capital, and $mH_i[\frac{Y_{max}-Y_i}{Y_i}]$ [3] represents the diffusion of technology from abroad, which is also a function of human capital. The term "domestic innovation" shows that human capital stocks enhance technological progress independently, while the term "catch-up" indicates that with keeping human capital levels constant, countries with low level of productivity will experience faster rates of growth of technology (Benhabib and Speigel, 1994).

Equation 4 can be written as follows:

$$[logA_T(H_t) - logA_0(H_t)]_i = c + (g-m)H_i + mH_i(\frac{Y_{max}}{Y_i}) \quad (5)$$

[2] Country with the highest initial technology level, A (0)

[3] Y_{max} is the initial income per worker for the leading country, that Luxembourg had highest Y_i in 1980

$$(logY_T - logY_0) = c + (g - m)H_i + mH_i\left(\frac{Y_{max}}{Y_i}\right) + \alpha(logK_T - logK_0) + \beta(logL_T - logL_0) + (log\varepsilon_T - log\varepsilon_0)$$
(6)

III. Empirical analysis

Data

To validate the above-mentioned assumptions, a set of data have been collected at five year intervals according to the availability for 104 countries including 79 developing countries and 25 developed countries (OECD) during 1980-2011.

The per capita GDP in constant prices and income per worker derived from Penn World Table (PWT version 6.3), labor force is available in the World Bank data. we use the Average years of schooling in total population over age 15 which has been constructed by [8] as a proxy for human capital. The series of physical capital stock is obtained through the perpetual inventory method in which $K_t = K_0(1-s)^t + \sum I_i(1-S)^{t-1} \quad i = 1, \ldots, t-1$, an initial value of the capital stock series for each country I, is generated by: $K_0 = I_1/(g_1 + \delta)$. Where K_0 is the capital stock, I_1 is the capital flow at the first or the second year, g_1 is the 5-year average annual growth rate and δ is the depreciation which is assumed to be the same in countries (0.06) [13]. The data on investment-to-GDP ratio and real GDP growth are from the Penn World Table (PWT version 6.3).

Results and Discussions

Unit-root tests

Before undertaking an empirical analysis, unit root tests should be investigated for data series, once regression analysis carried out with non-stationary variables, it may invalidate many of the assumptions of the analysis. If a time series has a unit root, a widespread and convenient way to remove non-stationary would be taking first differences of the relevant variable. A non-stationary series, which transfers to a stationary one by d times differentiation, is called an integration of order d and denoted as I(d) (Charemza and Deadman, 1997). Five types of panel unit root tests that are computable in Eviews (Breitung, 2000), (Hadri, 2000), (Im *et al*, 2003), (Levin *et al*, 2002), (Maddala *et al*, 1999). The results of some unit root tests for the variables are presented in Table 1.

Cointegration tests

In the second step, we need to determine whether a group of non-stationary series is cointegrated or not. If such stationary linear combination exists, it may be interpreted as a long-run equilibrium relationship among the variables (Kao, 1999), (Pedroni, 1999), and Fisher-type test are types of panel cointegration tests using an underlying Johansen methodology (Maddala *et al*, 1999).. The results of Kao cointegration test are presented in the Table 2. The results indicate that cointegration or long-run equilibrium relationship exists between variables.

F Test for choosing pool or panel data

In this step, we need to recognize which one of the pooling or panel data models is appropriate. For this purpose, F test will be used:

$$F = \frac{(SSR_{panel} - SSR_{pool})/(n-1)}{(1-SSR_{panel})/(N-n-k)}$$

$SSR_{pool} = 13.12503$
$SSR_{panel} = 7.54804$
$N = 624$
$n = 104$
$k = 4$

$F = 4.5$ $F_{0.05,103,\infty} = 1.5$

Therefore null hypothesis is rejected in significant level of 0.05 and panel data is appropriate for model estimation.(4.5>1.5)

Hausman test for the choice between fixed and random effects

A central assumption in random effects estimation is the assumption that the random effects are uncorrelated with the explanatory variables. One common method for testing this assumption is to employ a Hausman test (Hausman, 1978) to compare the fixed and random effect estimates of coefficients (Baltagi, 2001), (Wooldridge, 2002). Table 3 represents the result of Hausman test. we find that estimation of model is more suitable with fixed effects specification.

Estimation of panel data model

Following the model described in section II, we estimate equation 6, using the cross-country panel approach for three groups of countries. The results are displayed in Table 4.

we find coefficients for physical capital accumulation and labor force enter in all models positively and significantly, while the coefficient for developing countries is 0.55 meaning with considering all the other factors constant, every additional percent of labor force will increase economic growth 0.55. But this figure for developed countries is a little more about 0,69. This trend is the same when comparing the effect of physical capital on growth in two groups of countries, the coefficients are 0.19 and 0.43 respectively.

In the case of human capital. we find human capital indirectly through catch-up component affects growth positively and significantly in all models. However this effect is greater in OECD countries about 1 percent than developing countries with 0.2 percent. We find different results for the relationship between human capital levels and economic growth. Our results to some extent contradict earlier studies by

(Benhabib and Speigel, 1994) and (Nelson and Phelps, 1966) who suggest no statistically significant or even negative correlations between human capital levels and economic growth. Here, it turns out that this dependence is nonlinear and U shape. Figures 1,2 and 3 provide plots of the actual relationship between human capital levels and growth for three suggested models.

The results show that in developing countries, if the average years of schooling would be more than 10.5 years it can have positive effects on economic growth (Fig.2) while in developed countries human capital needs to study at least 23 years to affect growth positively through innovation (Fig.3). But overall the minimum average years of schooling required in all countries is about 11.5 (Fig,1).

As can be seen there is a significant difference in the minimum years of education required in two groups of countries which is much higher in developed countries. This could be because of the high growth of technology in these countries which make the need for more specialist and more educated people. A comparison of economic growth between two groups of countries is represented in table 5.

IV. Conclusion

The aim of this article is to deepen the understanding the relationship between human capital and growth. We apply the model presented by (Benhabib and Speigel, 1994), where human capital contributes to growth trough two channels: Firstly, human capital levels directly influence the rate of domestically produced technological innovation (Romer, 1990a) Secondly, human capital stock affects the speed of technology adoption from abroad (Nelson and Phelps, 1966). In the model, at any time, there existed some country which was the world leader in technology. The speed, which nations caught up to the leader country, was a function of their human capital stocks.

We find evidence of a non-linear relationship between levels of human capital and economic growth which means human capital with low education has not only a positive effect but also a negative effect on growth. There is a minimum level of education required to influence growth and of course it is different in different countries according to their level of development. These results can be an appropriate explanation for previous contradictory achievements. We also find human capital accumulation as a more effective factor on economic growth in developed countries.

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Table 1

Unit root test results

Variable	Levin, Lin and Chu t*		Im, Pesaran and shin w-stat		ADF-Fisher chi-squar		pp-fisher chi squar	
	F	T	F	T	F	T	F	T
LRGDP	-3.73	-49.96	4.90	-1.50	121.02	241.73	159.38	412.82
H	-11.89*	-11.62*	0.94	1.04	146.12	55.99	233.96*	106.45
H (Y_{max}/ Y)	7.41	-20.71*	4.40	-0.93	144.54	172.46	236.73	279.24*
LL	-5.91*	-8.77*	3.99	3.13	187.27	113.90	384.31*	196.37
LK	-6.56*	-56.49*	1.55	-1.51	262.30*	261.41*	459.00*	471.98*
D (LRGDP)	-43.35*	-522.8*	-14.35*	-43.13*	389.3*	351.5*	441.8*	496.5*

D (LL)	-12.47* - 54.85*	-2.24* - 9.26*	222.31 283.13*	262.31* 425.09*
D (LK)	-53.09* - 22.43*	-11.15* - 47.01*	358.51* 316.39*	432.43* 455.82*

Note: F and T indicate the models that allow for an intercept and intercept and trend, respectively.
Asterisk * shows significance at 1% level. Maximum lag is used as lag length.

Table 2
Kao cointegration tests results

Null	Rho	Prob.	t-statistic	Prob.
No cointegration				
DF	-7.617328	0.0000	-12.44178	0.0000
DF*	-4.839625	0.0000	-11.19954	0.0000

Table 3
Hausman test results

Test summary	Chi-sq.statistic	chi-sq.d.f.	prob
Cross section random	153.836712	4	0.0000

Table 4

Panel estimation-depended variable: ΔlogY[a] 1980-2008

Variable	Coefficient	Std.error	t-statistic	Prob
Model 1[b]				
C	-0.034	0.087	-0.394	0.693
H	-0.055	0.026	-2.085	0.037
H^2	0.004	0.001	2.535	0.011
$H(Y_{max}/Y)$	0.002	0.000	11.53	0.000
ΔlogL	0.557	0.121	4.576	0.000
ΔlogK	0.197	0.058	3.389	0.000
F	4.42			
R^2	0.53			
Model 2[c]				
C	-0.008	0.097	-0.091	0.927
H	-0.091	0.033	-2.756	0.006
H^2	0.008	0.002	3.221	0.001
$H(Y_{max}/Y)$	0.002	0.000	10.50	0.000
ΔlogL	0.562	0.141	3.967	0.000

ΔlogK	0.194	0.065	2.967	0.003
F	4.38			
R^2	0.53			
Model 3[d]				
C	0.461	0.173	2.651	0.009
H	-0.116	0.041	-2.825	0.006
H^2	0.004	0.002	2.083	0.041
$H(Y_{max}/Y)$	0.012	0.001	7.007	0.000
ΔlogL	0.690	0.152	4.523	0.000
ΔlogK	0.431	0.431	4.289	0.000
F	7.84			
R^2	0.77			

[a]:Δ logX, refers to the log difference of end and initial period in variable X.
[b]: Including all countries in the sample.
[c]: Including 79 developing countries.
[d]: Including 25 of OECD countries

Table 5
Comparison of growth in two groups of countries (2008)

Variable	Developed	Developing
GDP Per Capita ($)	31254.652	5986.751
Growth rate (%)	10	12
Required years of schooling (years)	23.5	10.5
Minimum years of education (years)	6	0.5

Figure 1
Relation between human capital levels and growth in total-sample (104 countries)

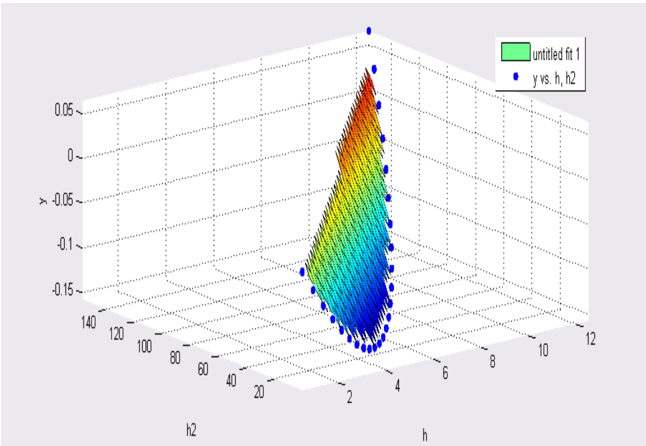

Figure 2
Relation between human capital levels and growth in developing countries

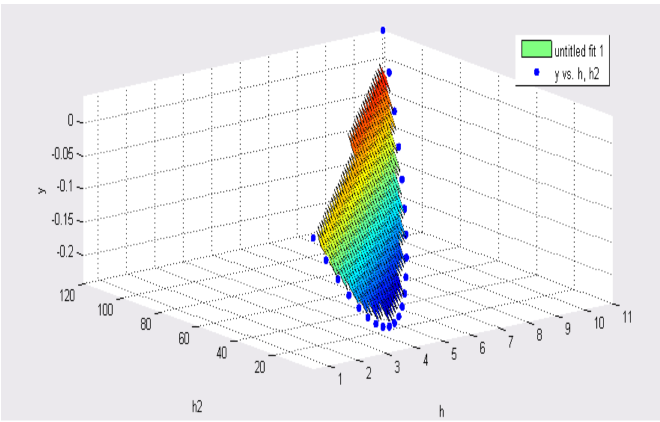

Figure 3
Relation between human capital levels and growth in OECD countries