LONG RUN PRODUCTIVTY GROWTH:
WHAT ARE THE GAINS TO BE MADE FROM ACCESSING SECONDARY AND HIGHER EDUCATION?

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Abstract

In this paper we rescue the importance of factor accumulation for long run productivity growth by learning about their contribution. The model pays particular attention to human capital accumulation in the form of accessing primary, secondary and higher education. Also the model shed some light on the link between factor accumulation and institutional effect on long run productivity growth. On the empirical side, the proposed non-linear econometric specification of human capital function is tested against the ones presented in the literature. The main result is that factor accumulation does cause economic growth. However, in our view the physical capital data used also bears important effect of private and public institutions, especially economic policies. Although important, access to education can not be regarded as the only prime cause of long run productivity growth according to the data used. However, our result does show a long run productivity gain yet to be made by most countries from accessing secondary and higher education. This is because the productivity gains from accessing secondary education starts when 40% of population 25 years and old reach that level and from higher education it requires 25%. In this sense, this paper foresees long run productivity increase for most of the countries in the future from population access to secondary and higher education.

Key words: Economic growth, education, panel dynamic estimation.
JEL: O15, C33.

Resumo

O objetivo deste artigo é o de demonstrar a importância da acumulação dos fatores de produção pra o crescimento da produtividade no longo prazo. Atenção especial é dada ao acesso à educação em níveis primário, secundário e terciário. O modelo desenvolvido de crescimento econômico destaca o papel importante do capital humano, contudo também considera a acumulação de capital físico. Este modelo ajuda também a esclarecer o relacionamento entre instituições e crescimento econômico. Nas estimativas a especificação não-linear resultante do modelo é testada com as demais especificações da literatura. O resultado principal é que a acumulação de fatores é a causa do crescimento da produtividade no longo prazo. O acesso a educação, apesar de importante, não é o único determinante, políticas econômicas que afetam a acumulação de capital humano também o são. No entanto, o crescimento da produtividade advindos do acesso à educação por pessoas com idade acima de 25 anos começa quando 40% destes concluem o secundário e 25% o terciário. Como grande maioria dos países da amostra ainda não atingiu esta condição, portanto existe um imenso ganho de produtividade a ser realizado no longo prazo.

Palavras chaves: Crescimento econômico, educação, estimativas dinâmicas.
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Julho 2008

1.0 Introduction

The objective of this paper is to rescue the importance of studying the human and physical capital accumulations for the long run economic productivity growth. The reason is that the physical capital accumulation and education to economic growth as pointed out by Solow (1956), Schultz (1962), Denison (1962), Uzawa (1965), Lucas (1988) and Romer (1990) has not echoed with the same intensity on empirical tests as expected by these theories, as we shall see in our reviewed literature. As a consequence of this mild result some researchers moved their attention to the role of the institutions. For instance the paper by Hall and Jones (1999) put the social capital as the explaining factor behind economic development. Beck, Levine and Loayza (2000), Easterly e Levine (2001) and Dias and McDermott (2005) posed institutions in the form of policies as prime cause for economic growth.

A natural question that arises from the above literature posit the following conjecture to be tested, is the human capital that causes better institutions or the other way around? The paper by Denny (2003) exploits this issue finding that education can be regarded as exogenous and the cause of their measure of social capital. Also the influential paper by Glaeser, La Porta, Lopez-de-Silanes e Shleifer (2004) has the same issue as the centerpiece on their research. Their main findings is that the level of education is a stronger predictor of country's better institution and growth can be seen as the natural outcome of that. As one may see, these results were not the end of the quest. As a matter of fact, the paper by Tavares and Wacziarg (2001) and Acemoglu et all (2005) have shown that institutions like democracy are the ones that affects education and by extension economic growth. Also Dias & McDermott (2006) show through simulation of their model that the feedback of education on improving economic policies cause less impact than a straight economic policy of cutting tax on entrepreneurial activity over the long run growth. They also have shown that entrepreneurs are one of the causes of human capital accumulation.

However, is that possible to have more efficient governments that cut taxes and better institutions including entrepreneurial ones that account for democracy constraints on power without corresponding human capital to account for that or for any institution efficiency for the matter?

Our attempt in contributing for this answer are related to the gains yet to be made by most countries from accessing secondary and higher education. Hence, in rescuing the importance of factors' accumulation this paper focus on the long run effect of human capital accumulation. In order to do that the causality aspects of the factors accumulations are exploited in a model and in the econometric specifications.

More specifically, we posit that access to education, a strong measure of education investment being made, generates individuals that are more qualified and therefore improves institutions and innovation making factors of production like physical capital become more productive. Hence, these knowledgeable individuals are in a broad sense the ones that create more advanced machineries, new production processes, manage private and public institutions, impose new laws and most important of all make institution quality to reflect of their own competence. Nonetheless, we do not disregard the importance of institutions on long run productivity growth. Quite the opposite we think that physical capital accumulation can not be seen as only accruing from human capital accumulation, but a good set of economic policies and institutions. In this respect we agree that physical capital accumulation is the single most important measure of institutional aspects of any economy. Therefore, we use it as being the representing variable of private and public institutions of the economy.

Hence, differently from those studies on institutions in this paper we aim at factors accumulation as the mechanism that causes of economic growth. Hence, we will not attempt to explain other set of institutions used in the literature or test them against factor accumulation on explaining long run economic growth. Therefore, we develop a very simple model were human and physical capital accumulation play important role. The human capital enters in the production process through the level of technology as in Romer (1990). However, the way we specify it is little different in the sense that is the flow of human capital that affects the innovation growth rate. The specification of the human capital flow is the major difference between our model and the existing ones. As a result we obtain a reduced form equation where the flow of human capital and the growth rate of physical accounts for the economic growth in the economy. Nonetheless, we can not separate on the physical capital accumulation data the effects of human capital and public and private institutions; hence, we assume that both are present on the physical capital data to be used and therefore deserve equal importance.

This reduced form is then estimated using dynamic panel data technique proposed by Arellano and Bover (1995) and Blundell and Bond (1997). We use this technique to account for problems like measurement errors, reverse causality and most important of all unobserved heterogeneous effects among the variables.

In order to be coherent with the literature we apply this technique to the GDN-growth Development Network dataset compiled by Easterly and Levine (2001). Our model specification is able to account for most of problems identified by the reviewed literature. We anticipate some of the results. First of all, the country's initial conditions do not play an important role on economic growth. In another words we do not find any correlation between explaining variables and the initial condition, first order correlation. Second country's policy regarding access to primary and mainly secondary education are of key importance to explaining growth; however, as expected, it is not a linear function as tested by many of the studies to be reviewed. Third the physical capital growth rate accounts for the most part of the economic growth rate. Interesting enough, the above results remain valid even when these two variables are lagged as instrument for five, ten and even 25 years. Most important of all, the long run productivity gains are yet to be made from human capital accumulation.

This paper has four sections. The first one is the introduction and the coming one is the review of literature. In the Third Section the model specification is presented. The Fourth Section deals with the econometric issues and mainly with the dynamic panel issues.

2.0 Review of Literature

The empirical problem that challenges studies that uses physical and human capital to explain economic growth or level of productivity is in representing properly human capital. The first and most influential paper to posit an empirical role for the human capital was written by Romer, Mankiw and Weil (1992). In their specification of human capital they used as proxy the working-age population enrolled in secondary education. They found a positive and significant effect for human capital on productivity level. In the same line Chien (1997) constructed a weighted human capital function using primary, secondary and university enrollment rates with weights being 0.2, 0.3 and 0.5 respectively. As a result the author also found a positive and significant role for their human capital function in explaining production level.

Another example of human capital function was built by Kyriacou (1991). For a sample of countries the author estimated the labor force average years of schooling. This proxy for human capital was used to explain growth by Benhabib and Spiegel (1994). Their main result was that the human capital plays only a dismal role on growth.

With the availability of new data for several countries on schooling made by Barro and Lee (1993), several studies sprung out relating growth to human capital. For example, Barro and Lee (1994) and Barro (1997) did exploit the relationship between growth and human capital. Their first paper did find a significant role for male secondary education and its difference indicating that education influences growth through its level and rate of growth. However, when human capital is broken into secondary enrollment and average years of university education no effect was found on growth. Klenow and Rodriguez-Clare (1997) made use of Barro and Lee (1993) dataset to construct a human capital function for 98 countries with the Mincer-intercept affecting school quality differences. The authors found, according to their own words, a very modest role for growth in human capital per worker in explaining economic growth. Latter on Lorgelly and Owen (1999) showed that the results by Barro and Lee (1994) and Barro (1997) were due to influential observations and that taking out some Asian countries neither the level of the secondary education and its flow (enrollment rates on secondary education of the population) were significant to explain growth. A more recent cross-country study done by Wolf (2000) also confirmed the modest role played by the secondary and tertiary education enrollment to growth.

A much more elaborate approach was developed by Hall and Jones (1999). They built a piece wise Macro-Mincer[1] human capital function to explain productivity levels. When this function was used in the differenced mode to explain productivity changes the human capital was significant, but negatively correlated. However, when considering both variables in level, human capital showed to be positive and significant. Nonetheless, the simultaneous causality issue aroused. Therefore, they made their option for variables that represents institutions to explain productivity as way to overcome the reverse causality problem.

Also using a Mincerian approach Pritchett (1999) built a human capital function that was used to explain economic growth through a production function. Latter on using available datasets[2], Temple (2001) also exploit several experiments on estimating production functions using human capital functions applied to the datasets. The best result was found when estimating log of production on level of human capital using dataset from Barro and Lee (1993). But, human capital was only strongly significant when regional fixed effects dummies were not considered. Hence, these dummies seem signal that there are some important unobserved factors.

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[1] Mincer (1974).

[2] Barro and Lee (1993), Nehru, Swanson and Dubey (1995) Benhabib and Spiegel (1994) and Pritchett (1999).

Further questioning about the ability of schooling to explain growth was done by Bils and Klenow (2000). They use Mincerian coefficients to build a function to predict schooling levels for 93 countries. Their initial finding was that the documented relationship running from schooling to growth was too weak. Moreover, by reversing the causality from growth to schooling they were able to generate much of the estimated coefficients. Another important aspect was mentioned by the authors. According to them, the significant schooling effect on growth found by some studies may be due to omitted factors on their regressions.

From the paragraphs above one can easily infer that average years of education, investment in education captured through enrollment rates or even more elaborate Mincerian approach were not able to represent human capital in explaining economic growth or productivity levels as expected. As a matter of fact, Krueger and Lindahl (2001) showed that previous studies relied on human capital function built upon available datasets has little noise or almost no signal. They estimate the reliability ratio for the datasets and use it to correct the human capital coefficient for potential measurement error. However, they went a step further by positing that the rate of growth of productivity may be related to level of human capital in a non-linear way. Their final result was that the productivity growth has U inverted relationship to human capital, average years of education.

Another approach sought to explain economic growth by education quality, Hanusheck and Kimko (2000). Using worldwide math and science scores from tests applied to students they found this quality index to be a consistent factor in explaining economic growth. They create an index and linked it to the primary enrolment rate and average years of education of population. By using these variables and indicator variables that minimized fixed effects they are able to provide results that were claimed to be reverse causality free. Thus, education quality in their view does explain economic growth. Following them, De la Fuente and Doménech (2001) corrected existing datasets for lack of noise and they confirmed the importance of the education quality in explaining growth. However, the authors did not find similar results when using Barro and Lee (1993) and Nehru, Swanson and Dubey (1995) datasets.

Using panel data approach on the same line as Mankiw, Romer and Weil (1992), we have papers done by Knight, Loyaza and Villanueva (1993), Benhabib and Spiegel (1994), Caselli, Esquivel, and Lefort (1996), Lee, Pesaran, and Smith (1997) for example. In general these studies rely more on time-series variations compared to cross-section, therefore yielding insignificant role for human capital. Moreover, Durlauf and Quahl (1998) made a stronger advertence against such studies. According to the authors studies that relies on the within estimator, because of fixed effects, loose important information on the long growth average represented by intercept coefficient of each country. Thus, the countries intercept which is exactly the unexplained long run cross country growth variation due to its correlation to the explaining variables end up out the study. This also applies to first-difference estimators applied to either cross-section or panel data estimates.

Also another important problem that arises from the above literature, besides measurement error, is the reverse causality issue. Easterly and Levine (2001) using a more sophisticated econometric technique found clear evidence on causality running from economic policies to economic growth when accounted for these problems. Despite their claim that something else besides factor accumulation like physical capital plays a more important role to economic growth especially economic policies, the average schooling years of working population was included in their measurement of economic policies. As a result they found that this human capital variable was associated with faster economic growth. The innovation on their paper resided on the use of dynamic panel data technique proposed by Arellano and Bover (1995) and Blundell and Bond (1997). This technique estimates a system of equations on differences and on levels to obtain the coefficients by using the generalized method of moments (GMM) that accounts for the problem of causality and measurement errors. Therefore, the critics by Durlauf and Quahl (1998) do not apply to their study.

Had laid of most of the problems associated with the economic growth literature the following challenges remains in our view: i) the importance of human capital for economic growth has been dismal and very much dependent on the specification; ii) the complete abandon of the role played by the physical capital accumulation. The coming sections have as objective to recover the role played by the accumulation of such inputs.

2.0 The Theoretical Model

We present a model that has some specific characteristics. First the amount of effort for human or physical capital accumulation is endogenous. Human capital accumulation is at end done through access to education. Hence, we start by specifying the following production function per worker.

$$y = \tau A(h)k^{\alpha} \tag{1}$$

Where y is product per worker; τ represents the work effort devoted to the production process; $A(h)$ is the level of technology or input efficiency that depends on human capital; and k is the physical capital per worker.

The level of technology depends upon the level of knowledge being accumulated by the representative consumer. We assume that the technology growth rate is proportional to the human capital being accumulated. Latter on in this paper this function will be specified to make clear the role played by the human capital.

The welfare function has the following shape:

$$\text{u(c)} = \int_0^t \frac{c^{1-\sigma}-1}{1-\sigma} e^{-\rho t}\, dt \quad \text{for } \sigma \neq 1. \tag{2}$$

The consumer per worker is c in the above function. The parameter σ is the consumption intertemporal elasticity and ρ is the discount rate. The physical capital accumulation function follows the traditional one.

$$\dot{k} = \tau A(h)k^{\alpha} - c \tag{3}$$

Where the amount not consumed is invested into physical capital per worker. To simplify we assume that number of workers are not growing over time and the physical does not suffer depreciation.

While not working the representative consumer devote the remaining time to learn. Therefore, (1-τ) represents the effort to absorb knowledge from existing human capital in the economy. In this sense, we follow Lucas (1988) and posit the following human capital accumulation function:

$$\dot{h} = \delta(1-\tau)h \tag{4}$$

The discounted Hamiltonian for the above problem where equation (2) is the objective while equations (3) and (4) are the constraints ones is the following:

$$H=\frac{c^{1-\sigma}}{1-\sigma}+\lambda_1[\tau A(h)k^{\alpha}-c]+\lambda_2\delta(1-\tau)h \quad (5)$$

Under this set up the representative consumer chooses the optimal level of consumption and work effort that satisfies the following set of equations.

$$\frac{\partial H}{\partial c}=0 \Rightarrow \; c^{-\sigma}=\lambda_1 \quad (6)$$

$$\frac{\partial H}{\partial \tau}=0 \Rightarrow \; \lambda_1 A(h)k^{\alpha}=\lambda_2\delta h \quad (7)$$

$$\dot{\lambda}_1-\rho\lambda_1=-\frac{\partial H}{\partial k} \quad (8)$$

$$\dot{\lambda}_2-\rho\lambda_2=-\frac{\partial H}{\partial h} \quad (9)$$

The transversatilities condtions are

$$Lim_{t\to\infty}k(t)\lambda_1(t)e^{-\rho t}=0 \quad (10)$$

$$Lim_{t\to\infty}h(t)\lambda_2(t)e^{-\rho t}=0 \quad (11)$$

The solution to the equations (8) and (9) are

$$\frac{\dot{\lambda}_1}{\lambda_1}=-\alpha\tau A(h)k^{\alpha-1}+\rho \quad (12)$$

$$\frac{\dot{\lambda}_2}{\lambda 2}=-\tau\delta h\frac{A_h}{A(h)}-\delta(1-\tau)+\rho \quad (13)$$

In the solution of equation (13), we have used equation (7). In this equation A_h stands for A(h) derivative regarding to h, more specifically or $\frac{\partial A(h)}{\partial h}=A_h$.

The balanced growth path solution proposed here uses the transversatility condition represented by equations (10) and (11). The transversatilities conditions are satisfied as long as the sum of the growth rate of the variables and their shadow prices are equal to the discount rate. More specifically, we have the following:

$$\frac{\dot{k}}{k}+\frac{\dot{\lambda}_1}{\lambda_1}=\rho \text{ and} \quad (14)$$

$$\frac{\dot{h}}{h}+\frac{\dot{\lambda}_2}{\lambda_2}=\rho. \quad (15)$$

By combining equations (14) and (15), the growth rate of physical capital may be represented by the following equation:

$$\frac{\dot{k}}{k}=\frac{\dot{h}}{h}+\frac{\dot{\lambda}_2}{\lambda_2}-\frac{\dot{\lambda}_1}{\lambda_1} \quad (16)$$

To find the growth rate of the economy, we recall equation (1). By taking the logarithm of this equation and deriving regarding time, the following emerges:

$$g_y = \frac{\dot{A}}{A} + \alpha \frac{\dot{k}}{k}. \tag{17}$$

After substituting equation (16) into (17) and using equations (4), (12) and (12), we arrive to the following growth rate of the economy.

$$g_y = \frac{\dot{A}}{A} - \alpha\tau\delta h \frac{A_h}{A(h)} + \alpha^2 \tau A(h) k^{\alpha-1} \tag{17}$$

According to equation (14), the growth rate of physical capital can be written as

$$g_k = \frac{\dot{k}}{k} = \alpha\tau A(h) k^{\alpha-1}. \tag{18}$$

By replacing equation (18) into (17) we have that the growth rate of the economy can be expressed as

$$g_y = \frac{\dot{A}}{A} - \alpha\tau\delta h \frac{A_h}{A(h)} + \alpha g_k \tag{19}$$

Let us assume that the level of technology depend upon the human capital per worker in the following way $A = e^{\theta h}$, where $\theta > 0$ is a parameter. According to this specification the growth rate of technology is a linear function of the human capital accumulation process or

$$\frac{\dot{A}}{A} = \theta \dot{h}. \tag{20}$$

Under this hypothesis positive changes in human capital accumulation implies positive growth rate of technology; however, negative changes also brings the growth rate of technology to the negative side (depreciation). Hence, in this case technology will not grow if knowledge accumulation is not present in the economy. Moreover, the ratio $\frac{A_h}{A}$ is equal to one. Hence, the final growth rate can be written as

$$g_y = \theta\delta(1 - \tau - \alpha\tau)h + \alpha g_k \tag{21}$$

The final expression for the growth rate of the economy was reached by using equation (4). As one may see the growth rate depends upon the level of human capital in the economy and the growth rate of the physical capital. It is this growth rate that we will estimate in the next section.

3.0 The Econometric Section

In order to specify the final version of equation (21) that will be empirically estimate, we must explicit the human capital function. We start by using two versions that are present in the literature in order to compare the results.

$$h = \beta_0 + \beta_1 \text{schooling} + \beta_2 (\text{schooling})^2 . \tag{20}$$

$$hm = \beta e^{(0.201*pyr+0.139*syr+0.11*hyr)} \tag{21}$$

In equation (20), we follow Krueger and Lindahl (2000) by admitting that the human capital function is non-linear on average years of schooling of population with age 25 years and above. Equation (21) follows the methodology proposed by Hall and Jones (1999) and built a Mincerian human capital function based on rate of returns. Here, we made use of Psacaropoulos (1994) average returns to education coefficients to build the human capital function (hm).

In addition to the above well known methodologies, we propose a simple definition that uses the percentage of population age 25 and above that has complete primary (pr), secondary (sc) and higher (hs) education in a non-linear way. The main characteristic of these definitions is its capacity to capture access to education. Also, differently from the other two, the access to secondary and higher education has a cost to be bared by society. This cost represents the amount of goods not produced or the opportunity cost of going to secondary and higher education. In our view, the posited U shape for accessing secondary and higher education may explain the contradictory empirical results present in the literature for the use of access to higher education as proxy for the human capital in a linear way. More specifically, we propose the following definition

$$h = \beta_0 + \beta_1 \text{pr} - \beta_2 \text{sc} + \beta_3 (\text{sc})^2 . \tag{22}$$

$$h = \beta_0 + \beta_1 \text{pr} - \beta_2 \text{hs} + \beta_3 (\text{hs})^2 . \tag{23}$$

As mentioned before pr, sc and hs stands for the percentage of population age 25 and above with complete primary, secondary and higher education levels. The beta coefficients in the set of equation (20) – (22) are constants to be estimate.

By replacing the functions (20) – (23) in equation (19) we have the set of equations to be empirically estimated. To estimate these equations we use the data from two sources, the Barro and Lee (2000) and Easterly and Levine (2001) datasets. The combined datasets produce a panel data for 95 countries with interval of five years for the years 1960-2000. The characteristics of the data are as follows.

Table 1 – Five Year Interval Panel Data: 1960 – 2000

Variables	Sample	Mean	Std. Dev.	Observations
g_y	Overall	0.0141	0.030	N=760
	Between		0.014	n=95
	Within		0.027	T=8
g_k	Overall	0.0106	0.0172	N=760
	Between		0.0077	n=95
	Within		0.0154	T=8
schooling	Overall	4.533	2.902	N=855
	Between		2.687	n=95
	Within		1.126	T=9
pr	Overall	14.547	10.727	N=855

	Between		9.425	n=95
	Within		5.203	T=9
sc	Overall	8.324	8.721	N = 855
	Between		7.649	n=95
	Within		4.253	T=9
hs	Overall	3.730	4.164	N=855
	Between		3.309	n=95
	Within		2.548	T=9
hm	Overall	2.583	1.412	N=855
	Between		3.309	n=95
	Within		2.548	T=9

Source: Barro and Lee (2000) and Easterly and Levine (2001).

The variable g_y in the table represents the yearly average growth rate for the five year interval of 1.41% for the output per worker; the standard deviations are 3.04%, 1.40% and 2.70% for the overall, between and within samples. The average growth rate of physical capital per worker for the five year interval is 1.06% with standard deviations 1.72%, 0.77% and 1.54% for the overall, between and within samples. The average schooling years of population 25 years old and above variable is 4.53 years with standard deviations of 2.902, 2.687 and 1.126, respectively. The variables pr, sc and hs are the percentage of population age 25 and above that concluded primary, secondary and higher education and their respective standard deviations. The hm variable was explained according to equation (21).

The econometric results to be displayed in the coming tables are for the following models: FE-Fixed Effect; RE-Random effect; FGLS-Feasible Generalized Least Square; PW-Prais Winstem. In the tables the standard deviation are reported below the coefficients in parenthesis. The Corr(α_i,Xβ) stands for the correlation between the constants and the independent variables and Prob. F(α_i=0) is the probability of the fixed effects to be null.

The explanation for estimating the models FGLS and PW is related to the set of tests applied to the estimated equations. First, the Hausman (1978) specification test that compares random (RE) and fixed effects (FE) was applied to each set of equations on the tables. The main result showed to be that the best specification is the fixed effect model for every specification. In another words, the difference in coefficients between the FE and RE models are systematic indicating that the correlation between the independent variables and the fixed effects are present. Second, the Breusch and Pagan (1980) test for each set of FE e RE equations showed that the random specification was not significant. Also, this test was done considering the panel autocorrelation as proposed by Baltagi e Li (1995). This test rejected the random specification for every specified equation. Third, the panel autocorrelation was confirmed also by the panel autocorrelation test proposed by Wooldridge (2002). An additional test applied was the Greene (2000) groupwise heterokesdasticity test. This test also confirmed the presence of panel heterokesdasticity in every specification estimated. Therefore, the presence of autocorrelation and heterokesdasticity in the panel lead us to estimate the FGLS and PW considering the presence of both.

Table 2 – Model I:
Productivity growth (g_y) and Schooling (h)

Variables	FE (Std. Dev.)	RE (Std. Dev.)	FGLS (Std. Dev.)	PW (Std. Dev.)
Constant	0.493 (00.58)	0.0030 (0.0031)	0.0026 (0.0025)	0.0011 (0.0031)
L.g_y				0.224 (0.0847)*
g_k	0.528 (0.0623)*	0.765 (0.0576)*	0.683 (0.0442)*	0.595 (0.091)*
h	-0.0109 (0.0021)*	0.0011 (0.001)	0.0023 (0.0009)**	0.00047 (0.00121)
h2	0.00034 (0.0018)***	-0.00008 (0.00011)	-0.00016 (0.00008)**	0.00117 (0.00318)
N	760	760	760	665
Overall R^2	0.017	0.20	-	0.23
Corr(α_i,Xβ)	-0.72	0	-	-
Prob. F(α_i=0)	0.00	-	-	-

Table 3 – Model II:
Productivity growth (g_y) and Mincerian Human Capital (hm)

Variables	FE (Std. Dev.)	RE (Std. Dev.)	FGLS (Std. Dev.)	PW (Std. Dev.)
Constant	0.0406 (0.0052)*	0.004 (0.002)**	0.0067 (0.0018)*	0.0010 (0.0022)
L.g_y				0.223 (0.084)*
g_k	0.572 (0.626)*	0.767 (0.057)*	0.689 (0.044)*	0.596 (0.091)*
hm	-0.0123 (0.0018)*	0.00061 (0.00074)	0.0007 (0.0004)	0.0007 (0.0007)
N	760	760	760	664
Overall R^2	0.03	0.19	-	0.24
Corr(α_i,Xβ)	-0.64	-	-	-
Prob. F(α_i=0)	0.00	-	-	-

Table 4 – Model III:
Productivity growth (g_y) and Access to Secondary Education (sc)

Variables	FE (Std. Dev.)	RE (Std. Dev.)	FGLS (Std. Dev.)	PW (Std. Dev.)
Constant	0.243 (0.004)*	0.00055 (0.0020)	0.0010 (0.0016)	-0.0005 (0.002)

L.g_y				0.201 (0.086)*
g_k	0.578 (0.063)*	0.720 (0.057)*	0.644 (0.043)*	0.583 (0.089)*
pr	0.00009 (0.0002)	0.0005 (0.0001)*	0.0005 (0.00006)*	0.0003 (0.001)*
sc	-0.0027 (0.0005)*	-0.0004 (0.0003)	-0.00006 (0.00020)	-0.0002 (0.0003)
sc2	0.000038 (0.000012)*	0.000010 (0.00009)	0.000002 (0.000004)	0.000006 (0.000008)
N	758	758	758	664
Overall R^2	0.05	0.22	-	0.23
Corr(α_i,Xβ)	0.36	0	-	-
Prob. F(α_i=0)	0.00	-	-	-

Table 5 – Model IV:
Productivity growth (g_y) and Access to Higher Education (hs)

Variables	FE (Std. Dev.)	RE (Std. Dev.)	FGLS (Std. Dev.)	PW (Std. Dev.)
Constant	0.0215 (0.0042)*	0.0024 (0.0020)	0.005 (0.001)*	0.0010 (0.002)
L.g_y				0.186 (0.086)**
g_k	0.545 (0.063)*	0.694 (0.057)*	0.612 (0.042)*	0.570 (0.089)*
pr	0.00007 (0.0002)	0.0006 (0.0001)*	0.0005 (0.00005)*	0.0004 (0.0001)*
hs	-0.0049 (0.0007)*	-0.0018 (0.0005)*	-0.0017 (0.0003)*	-0.0013 (0.0005)*
hs2	0.00015 (0.00004)*	0.00008 (0.00003)*	0.000068 (0.000015)*	0.000062 (0.00002)*
N	758	758	758	664
Overall R^2	0.11	0.23	-	0.24
Corr(α_i,Xβ)	-0.33	0	-	-
Prob. F(α_i=0)	0.00	-	-	-

The main result is that the physical capital accumulation does account for the average growth productivity in every specification. More than half of the growth in physical capital translates into productivity growth. On the human capital accumulation side the best proxy is the access to higher education. It presents increasing return with a small cost to be paid in the beginning of the process. This may explain why human capital accumulation is deterred to the physical capital accumulation as economic policy. However, once the initial cost of human capital accumulation is overcome the impact on productivity growth is increasing.

Although these results seems to confirm that the factors accumulation are important for productivity growth they certainly may well be contested on the grounds of causality. One way to prove the causality effect is to consider the variables under an exogeneity specification. According to Woodridge (2002), weak exogeneity test a can be easily performed under dynamic specification estimate.

$$\mathbf{y_{it} = x_{it}\,\beta + y_{it-1}\alpha + \eta_i + u_{it}}, \qquad (24)$$

where y_{it} is the dependent variable vector, x_{it} and the β are the vectors of the independent variables and coefficients to be obtained in the estimates, η_i represents the fixed effects and the u_{it} the component error vector. Under contemporaneous exogeneity the errors should not be correlated with the explaining variables, the initial condition or the fixed effects, $E(u_{it}|x_{it}, y_{it-1}, \ldots, x_{i1}, y_{i0}, \eta_i) = 0$. This is equivalent to perform two tests. First, the second order autocorrelation on the panel residuals should no be present $E(u_{it}|u_{it-1}, \ldots, u_{i1}) = 0$. Second, the instruments variables must be exogenous $E(u_{it}|x_{it}, \ldots, x_{i1}) = 0$.

To achieve the above objective equation (24) is estimated together with the following equation:

$$\mathbf{y_{it} - y_{it-1} = (x_{it} - x_{it-1})\beta + (y_{it-1} - y_{it-2})\,\alpha + (u_{it} - u_{it-1})}. \qquad (25)$$

The simultaneous estimate of both equations using as instruments for the first equation the variable in differences and for the second equation the variable in levels was proposed by Arellano e Bond (1991), Arellano e Bover (1995) e Blundell e Bond (1998). This dynamic equation system can be easily tested for contemporaneous exogeneity. As matter of fact the Hansen (1978) test can be performed for the over identification of the instruments together with the second order autocorrelation test on the panel residuals. The coming tables show the results of the estimates of the above equations under two dynamic specifications. Since the results showed to be consistent with the instruments lagged as much as four periods, we opted to report for the first and last period of the estimate.

Table 6 – Dynamic Models I:
Productivity Growth (g_y) and Human Capitals (h, hm, sc and hs)

Variables	Model I	Model II	Model III	Model IV
Constant	0.0051 (0.004)	0.0006 (0.0026)	0.0009 (0.0024)	0.0026 (0.0026)
L.g_y	0.281 (0.0497)*	0.279 (0.053)*	0.243 (0.050)*	0.228 (0.050)*
g_k	0.512 (0.0935)*	0.521 (0.104)*	0.445 (0.103)*	0.442 (0.096)*
h	-0.0011 (0.0019)			
h2	0.00010 (0.00018)			
hm		0.00081		

		(0.0007)		
pr			0.00067 (0.00017)*	0.00062 (0.00016)*
sc			-0.00127 (0.00049)*	
sc2			0.000033 (0.000013)*	
hs				-0.0026 (0.00077)*
hs2				0.00011 (0.000049)*
N=n*T	665	665	664	664
AR(1)	0.24	0.12	0.95	0.45
AR(2)	0.43	0.34	0.65	0.75
Hansen-Overid	0.23	0.27	0.93	0.94
Hansen-Exogeneity	0.99	0.98	0.99	0.99

Table 7 – Dynamic Models II:
Productivity Growth (g_y) and Human Capitals (h, hm, sc and hs)

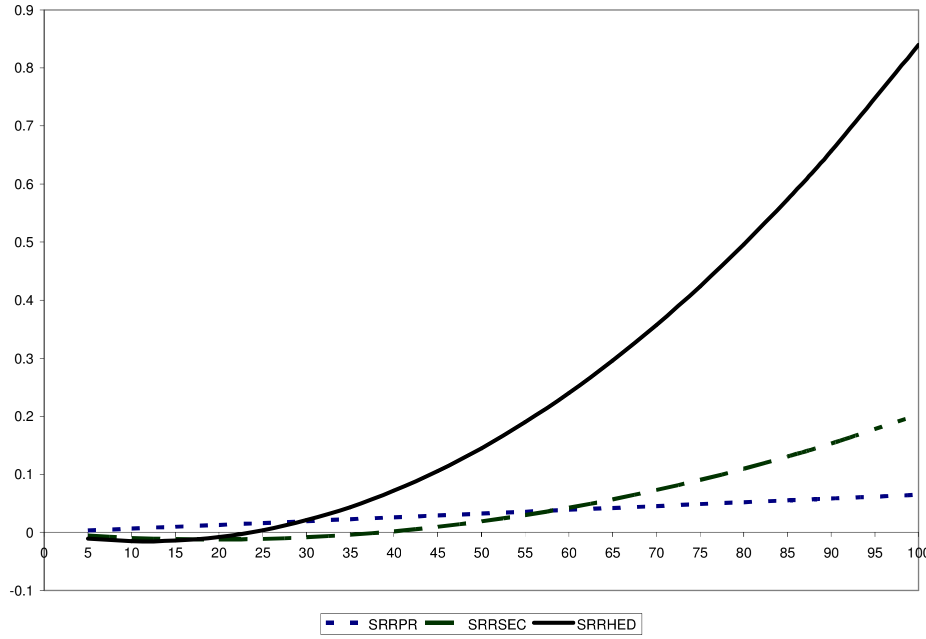
Variables	Model I	Model II	Model III	Model IV
Constant	0.0313 (0.0151)**	0.0190 (0.0118)	0.0124 (0.0078)	0.0302 (0.0093)*
deap	0.0040 (0.141)	0.0064 (0.0160)	-0.0024 (0.0112)	0.00002 (0.0096)
dlac	0.0006 (0.0135)	0.00065 (0.0138)	-0.0125 (0.0060)***	-0.0161 (0.0055)*
dmena	-0.0298 (0.0144)**	-0.0380 (0.0192)**	-0.0026 (0.0146)	0.0166 (0.0106)
dsa	-0.0210 (0.0232)	-0.0174 (0.0220)	-0.0078 (0.0137)	-0.0132 (0.0139)
dssa	-0.0257 (0.0119)**	-0.0182 (0.0100)**	-0.0086 (0.0084)	-0.0248 (0.0109)**
dte	-0.0086 (0.0479)	0.0033 (0.0511)	-0.0029 (0.0395)	-0.0544 (0.0671)
L.g_y	0.260 (0.0596)*	0.260 (0.0566)*	0.237 (0.056)*	0.206 (0.052)*
g_k	0.419 (0.119)*	0.454 (0.132)*	0.4009 (0.099)*	0.355 (0.096)*
h	-0.0050 (0.0035)			
h2	0.00024 (0.00026)			
hm		-0.0023 (0.0020)		
pr			0.0005	0.00014

			(0.0002)*	(0.00019)
sc			-0.0018 (0.0006)*	
sc2			0.000042 (0.000015)*	
hs				-0.0046 (0.0014)*
hs2				0.00018 (0.00008)**
N=n*T	665	665	664	664
AR(1)	0.20	0.23	0.67	0.03
AR(2)	0.24	0.25	0.62	0.38
Hansen-Overid	0.06	0.08	0.61	0.57
Hansen-Exogeneity	0.99	0.99	0.99	0.99

In the above estimates the instruments are lagged one period, but lagging the explaining variables up to three periods do not have any influence on the results. Also, there is no change when time dummies are included as instruments. In Table 7 the reported results do consider indicator variables according to Barro and Lee (2000) assembled characteristics which are deap (East Asia and Pacific), dlac (Latin American and Caribbean), dmena (Middle East and North Africa), dsa (South Asia), dssa (Sub-Saharan Africa), dte (Transitional Economies) and the suppressed one dac (Advanced countries). As one may see when these dummies are included the best results are for human capital definition that uses secondary education.

Here, we focus our analysis on the definition of human capital that considers access to secondary and higher education, models III and IV on Tables 6 and 7. As we may see on Table 6 both models are significant indicating the advantage education policies that favor primary over secondary and higher education. The reason is that the gain to be made for investment in secondary and higher education is yet to be made by most countries. To give an idea this potential social rate of return for an educational policy favoring secondary and higher education we draw a figure using the results from Table 6.

Figure 1 – Estimate Human Capital Social Rate of Return
Primary (SRRPR), Secondary (SRRSEC) and Higher Education (SRRHED)



As one may see while social rate of return to primary education is positive for any positive level of access to education from 5% to 100%. The same can not be said for secondary and higher education. The secondary education has a social positive outcome only when more than 40% of population has concluded secondary education. Higher education show to be quite important, but the gains accruing from its access come only after 25% of population having acquired higher education degree. In other words, the potential gain from having population age 25 and above with higher education is incredible higher; however, it is yet to be made by most countries in the world, according to our sample. The sample average is an incredible 3.73%. Therefore, particular attention should be given to this kind of policy in order to have the social gain made.

Another interesting result is related to the fact that the constant that represents the average long run productivity growth rate to be explained is null in the majority of the models. In simple words, the models seem to leave very little to be explained of the long run productivity growth rate outside of factors accumulation.

The results here also support the empirical researches that found access to primary education as one of the causes of long run economic growth, besides the physical capital accumulation. In this regard this study advance a step further showing also the potential gain to be made by accessing secondary and higher education and their cost to be bared by most of the countries.

4.0 Conclusion

The access to secondary and higher education does improve long run average productivity growth, but these gains are yet to be made by most of the countries. It seems that long run productivity gains are coming from human capital accumulation that improves physical capital productivity and economic policies that generate market incentives for physical capital accumulation or investment growth. Therefore, growth in physical capital accumulation should capture such policy differences among countries.

However, the most important policy is to assure full access to primary education. When such policies are combined they establish necessary conditions for having long run productivity growth.

In sum, the main results are that the access to further education indeed generates future gain for the long run productivity growth rate, but it is yet to be made by most countries. It demands 40% of population with age 25 and above with secondary education and at least 25% of the same population in higher education.

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