The importance of health and education in explaining economic growth: an empirical analysis of the production function for different regions of the world

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Abstract

We estimate a production function model of aggregate economic growth by including two important dimensions of human capital - education and health. Our main intention was to study the importance of health in explaining economic growth in different countries and in different regions. In order to achieve this ambition we divided the countries into four regions: Africa Sub Saharan; Latin America and the Caribbean; South Asia, Middle East, North Africa, East Asia, and Pacific; and Europe, Central Asia, and North America. Our findings suggest that health has a positive and statistically significant effect on economic growth. For the whole world, it suggests that an increase in one-year life expectancy leads to a growth of output per capita in the countries of around 1.36% when we control for the worldwide technological frontier and about 2.10% when we do not control for this fixed effect in time. The results we found suggest that the omission of health produces a misspecification bias of the coefficients of the production function. In most part of the empirical exercises we did, we found that the effect of schooling was also positive and statistically significant, even when we controlled for health capital. By analyzing the importance of these two dimensions of human capital in the different regions, we found that education is more important in Latin America and African Sub-Saharan countries than in countries from the region Europe, Central Asia, and North America, whereas life expectancy is more important in explaining the growth in this last region. Our results indicate that the role of different forms of capital in the growth process change as income rise.

Keywords: Human capital, Health Capital, Education, Economic Growth, Production function approach

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1 Introduction

After the theoretical framework presented in the articles of Romer (1986) and Lucas (1988), who highlighted the importance of human capital in stimulating economic growth, a substantive part of the literature on growth directed its efforts in quantifying and studying the role of human capital. In order to study the role of human capital a lot of articles began to use education as a proxy for it, arguing that a greater level of education leads to economic growth. As a result, the literature on the role of education on economic growth substantially increased and empirical studies trying to measure its effect began to acquire great importance. Among these empirical studies, we can cite the articles of Romer (1989) and Barro (1989), which have supported that education positively contributes to economic growth.

Another great contribution to the importance of human capital on growth came with the article of Mankiw et al. (1990), who pointed out that if we have multiple forms of capital, then the omission of one of its forms causes bias in the estimation of the coefficients. Therefore, the inclusion of education as a proxy for human capital improved a lot the way everyone was measuring economic growth.

However, it has long been argued that human capital is a complex input and consists of more than knowledge. Given that, some authors began to argue that an important dimension of human capital is also health, as pointed out by Knowles & Owen (1995). Hence by using the idea of Mankiw et al. (1990), if health is an important dimension of human capital, even if the models include education, the omission of health results in a model with misspecification bias.

It is not surprising that health is an important dimension of economic growth since a healthy workforce is more productive because workers are more energetic and mentally more robust. Moreover, good health is also associated with less absenteeism at work, which in turn raises production. We can also expect that illness is associated with lower wages, with this effect being strong in developing countries, where more part of workers is engaged in manual activities. Low wages contribute to lower consumption and savings and these factors in turn can hinder the economic growth of a country. Hence, improvement in health can raise wages, which in turn increases consumption and savings and lead to economic growth.

Beyond the factors mentioned above, improvement in health raises the incentive to acquire schooling, since if a person has good health and a good life expectancy can amortize the costs of acquiring schooling over a long lifetime Kalemli-Ozcan et al. (2000). Furthermore, healthier students lack less in school and have better cognitive skills, which makes their learning process better than those students who are not healthy, and in the future, they will be more productive workers in their respective jobs.

Despite the importance of health on economic growth, part of the literature has ignored its role in explaining the growth of output. Given this, we intend to study the importance of health on economic growth, especially its importance and connection with another important factor in human capital, education. We are going to accomplish this by using a production function approach in a panel of countries divided into the following regions: Africa Sub Saharan; Latin America and the Caribbean; South Asia, Middle East, North Africa, East Asia, and Pacific; and Europe, Central Asia, and North America. In our production function, two important inputs will be health and education. By doing the division into regions our intention is to study mainly the role of health and education in explaining the economic growth and the relative importance of each one of these forms of human capital in each region that we are going to consider. One important policy implication of our article is that health is very important in explaining growth, despite its importance not being the same in the different regions. Therefore investment in the health care sector is of supreme importance and depending on the region is something necessary, since a better health system according to our results can lead to economic growth.

Our main findings suggest that an increase in one-year life expectancy leads to a growth of output per capita in the countries of around 1.36% when we control for the worldwide technological frontier and about 2.10% when we do not control for this fixed effect in time. Moreover, by creating dummies of interaction between these different regions and the two variables we were more interested in - health and education - we obtained that the effect of health capital and education were not the same across different regions, being the effect of life expectancy larger in Europe, Central Asia, and North America, indicating a possible link between health and productivity. The effects of health capital in Africa Sub Saharan and in Latin America were not as expressive as the effects in Europe, Central Asia, and North America, whereas the effects on schooling for these two regions were greater than the effects found in Europe, Central Asia, and North America.

Before we continue it is important to highlight that a series of other authors have already studied the contribution of health on economic growth and between these authors we can cite the article presented by Barro et al. (1996), who uses a panel data to investigate the importance of health in explaining the economic growth, using life expectancy as a proxy for the measure of health capital. In this article, the authors found a positive and statistically significant coefficient for the measure of health capital, which highlights the importance of this input in economic growth.

We can cite as well the article of Gallup & Sachs (2001), who showed that after control for factors such as tropical location, colonial history, and geographical isolation, countries with intensive malaria had income levels in 1995 of only 33 % that of countries without malaria, whether or not the countries were in Africa. By using a cross-sectional regression in a period of 25 years (1965-1990) the authors found an important connection between malaria and economic growth, which also highlights the connection between health and economic growth.

The article proceeds as follows. In the following section, we briefly develop the model we are going to use to make the regressions and measure the importance of health and education on growth. In section 3 we describe the data and the regions we are going to consider in our model. In section 4 we describe the main results we got and in the last session, we have some concluding remarks.

2 The model

Our production function approach is such that we assume that we are able to decompose the growth of output in two sources, the growth in the level of inputs and the growth in the level of total factor productivity. The inputs of our model will be capital, labor, and human capital. The human capital in our model will be decomposed into two factors, education and health. Given that, the production function we are going to estimate will be such that:

$$Y = AK^{\alpha}L^{\beta}\mathrm{e}^{\gamma_1 E+\gamma_2 H} \tag{1}$$

where Y is the output of gross domestic product (GDP), A is the total factor productivity, K represents the stock of capital, L represents the labor force, E is some measure of education and H is a measure of health that affects the gross domestic product (GDP).

In our studies, we are going to proxy the variable L as being the labor force participation rate, which is the proportion of the population ages 15-64 that is economically active: all people who supply labor for the production of goods and services during a specified period. The proxy we use for capital is gross fixed capital formation as a percentage of the GDP. The variable for education will be measured by the average years of schooling and health will be measured by life expectancy. One problem with using life expectancy as a proxy for health is that we can have some problems of simultaneity, since a country with a higher level of life expectancy, by the factors we highlighted in the introduction, can have more productive workers and then a greater level of output. On the other hand, a country with a higher level of output can invest more in health and with this, its population will have a higher life expectancy. We can solve this problem of simultaneity by using an appropriate instrumental variable for health. In the following section, we are going to discuss more it.

Note that by using this functional form we have that the logarithm of the wages depends on the level of education and health status, which makes sense when we think of the wage a worker receives. In order to improve this measurement we could have also included the experience of the worker in this functional form since it makes sense to imagine that the logarithm of the wages also depends on the experience of the worker. An extension of this article can be done by including this variable in equation (1) and arguing that an experience is also a form of human capital.

As someone can note, by using this kind of production function we implicitly assume that the effect of health and education in the output depends only on the average level of health and education in the economy and not on its distribution. In terms of policy implications we estimate the effects of increasing health and education on average, which means that it can affect the different sectors of a given country in different ways (e.g. for some groups increasing life expectancy can reduce the output per capita). For the purpose of this paper, we are not going to study this effect in the different sectors within the different countries. An interesting extension can be done in this way.

By taking the logarithm of equation (1) we obtain the following equation:

$$y_{it} = a_{it} + \alpha k_{it} + \beta l_{it} + \gamma_1 E_{it} + \gamma_2 H_{it} \tag{2}$$

where i represents the country and t represents the time. The variable y_{it} represents the logarithm of the output, k_{it} represents the logarithm of capital, l_{it} represents the logarithm of the labor, and a_{it} is the total factor productivity of the country i at time t, which we are going to assume to be ruled by the next equation.

$$a_{it} = a_i + a_t + \varepsilon_{it} \tag{3}$$

where a_i is the steady state level of total factor productivity of a country, this is a fixed effect of a country. The variable a_t is the worldwide technological frontier and we assume that it changes across time. The variable ε_{it} is a random shock that hits the country and we assume that it has the following distribution:

$$\varepsilon_{it} \sim N(0, \sigma^2) \tag{4}$$

where σ^2 is the variance of the random shock in the total factor productivity that affects each country.

By joining (3) into (2) we have the following equation that is the basis for the econometric estimates that we are going to make.

$$y_{it} = a_i + a_t + \alpha k_{it} + \beta l_{it} + \gamma_1 E_{it} + \gamma_2 H_{it} + \varepsilon_{it} \tag{5}$$

3 Data and estimation methodology

3.1 Estimation methodology

In this section, we develop the estimation methodology we are going to use in order to make the econometric analysis. In order to estimate the results we propose the following empirical exercises:

1. Pooled ordinary least squares;
2. Fixed effects estimator;
3. Instrumental variable by using two-stage least squares.

First of all, one can observe that in equation (5) we have the presence of a fixed effect of a country, which is given by the steady state level of total factor productivity. In order to get rid of this effect we can make the first difference in equation (5) and obtain the following result:

$$\Delta y_{it} = \Delta a_t + \alpha \Delta k_{it} + \beta \Delta l_{it} + \gamma_1 \Delta E_{it} + \gamma_2 \Delta H_{it} \tag{6}$$

where Δ represents the operator of first difference, such that $\Delta z_{it} \equiv z_{it} - z_{i,t-1}$.

Given this result, we can estimate the equation above by **pooled ordinary least squares** using time dummies to the panel we have.

Observe as well that by equation (4) we assume that the shock is random, then we have that:

$$\mathbb{E}[\varepsilon_{it}|x_{it}, a_i] = 0 \tag{7}$$

where x_{it} is the vector containing the variables a_t, k_{it}, l_{it}, E_{it} and H_{it}. The steady-state level of total factor productivity of a country can be related to one or more of the variables contained in the vector x_{it} (e.g. $\mathbb{E}(x_{it}a_i) \neq 0$), for this reason, our main idea is to eliminate it. By assuming we have a random sample $\{(y_{i1}, y_{i2}, ..., y_{iT}, x_{i1}, x_{i2}, ..., x_{iT}, a_i\}$ where T is the maximum time period of the sample, we can average the model represented by equation (5) and by doing this we obtain the following equation:

$$\bar{y_i} = a_i + \bar{a_t} + \alpha \bar{k_i} + \beta \bar{l_i} + \gamma_1 \bar{E_i} + \gamma_2 \bar{H_i} + \bar{\varepsilon_i} \tag{8}$$

where $\bar{z_i} \equiv \dfrac{\sum_{t=1}^{T} z_{it}}{T}$ and $\bar{a_t} \equiv \dfrac{\sum_{t=1}^{T} a_t}{T}$. By making the difference between equations (5) and (8) we obtain the following equation that is the equation that we are going to estimate by **fixed effects estimator** using time dummies in order to control for the worldwide technological frontier a_t. In order to use the fixed effects estimator, we have to assume as well that for all $t \neq s$, the idiosyncratic errors are uncorrelated (conditional on all explanatory variables and a_i). Moreover, we have to assume the normality of the error term ε_{it} conditional on the explanatory variables and in the fixed effect a_i.

$$(y_{it} - \bar{y_i}) = (a_t - \bar{a_t}) + \alpha(k_{it} - \bar{k_i}) + \beta(l_{it} - \bar{l_i}) + \gamma_1(E_{it} - \bar{E_i}) + \gamma_2(H_{it} - \bar{H_i}) + (\varepsilon_{it} - \bar{\varepsilon_i}) \tag{9}$$

The equation above is the equation we are going to estimate by fixed effect estimator.

The last empirical strategy we are going to implement is to use an **instrumental variable** for the measure we have for health, which is life expectancy, since according we pointed out in the introduction this can lead to a problem of simultaneity. A valid instrument vector z_{it} has to exogenous:

$$\mathbb{E}[z'_{it} v_{it}] = 0 \tag{10}$$

for all country i and time t, where $v_{it} \equiv a_i + \varepsilon_{it}$, and strong:

$$\mathbb{E}[z'_{it} \hat{x}_i] = 0 \tag{11}$$

for all country i and time t, where the vector $\hat{x}_i$ represents the vector of endogenous variables. In our case, the endogenous variable we are interested in fixing the problem since the variable we are more interested in is the variable life expectancy. In order to fix a little the problem we are going to use a weak instrument, which is the infant mortality rate, since there is a relationship between infant mortality and life expectancy and we may believe that infant mortality is less correlated with the error term of equation (5) than the life expectancy.

3.2 Data

In order to implement the empirical strategies in this paper we constructed a panel of 188 countries [1] for the following years: 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995, 2000, 2005, and 2010. We used these years, since the data we used as a measure of education stock (E_{it}), average years of schooling, are only available for each 5 years age interval. The data we used for average years of schooling provides information about the distribution of educational attainment of the adult population over age 15 and they are from Barro & Lee (2013). This data set contains information about the following levels of education: No education, completed primary, incomplete and completed primary, completed secondary, incomplete and completed secondary, completed tertiary, and incomplete and completed tertiary.

The data we used for y_{it} is the gross domestic product (GDP) per capita based on purchasing power parity (PPP) of the constant 2011 international dollar. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States and the source of this data is World Bank national accounts data, and OECD National Accounts data files. We assume that the stock of capital k_{it} is measured by the rate of investment in real GDP, for this reason, we used the data of gross fixed capital formation as a percentage of GDP. This data also comes from World Bank national accounts data, and OECD National Accounts data files.

The variable that measures l_{it} is the labor force participation rate, total (percentage of total population ages 15+). The data on the labor force participation rate is the proportion of the population ages 15 and older that is economically active. This data is from International Labor Organization.

The variables from health capital H_{it} are life expectancy at birth and infant mortality rate (per 1,000 live births). The source of life expectancy is derived from male and female life expectancy at birth from sources such as (1) United Nations Population Division. World Population Prospects, (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Report (various years), (5) U.S. Census Bureau: International Database,

[1] Afghanistan; Albania; Algeria; Andorra; Argentina; Armenia; Aruba; Australia; Austria; Azerbaijan; Bahamas, The; Bahrain; Bangladesh; Barbados; Belarus; Belgium; Belize; Benin; Bermuda; Bhutan; Bolivia; Bosnia and Herzegovina; Botswana; Brazil; Brunei Darussalam; Bulgaria; Burkina Faso; Burundi; Cabo Verde; Cambodia; Cameroon; Canada; Cayman Islands; Central African Republic; Chad; Chile; China; Colombia; Comoros; Congo, Dem. Rep.; Congo, Rep.; Costa Rica; Cote d'Ivoire; Croatia; Cuba; Cyprus; Czech Republic; Denmark; Dominica; Dominican Republic; Ecuador; Egypt, Arab Rep.; El Salvador; Equatorial Guinea; Eritrea; Estonia; Ethiopia; Fiji; Finland; France; French Polynesia; Gabon; Gambia, The; Georgia; Germany; Ghana; Greece; Greenland; Guatemala; Guinea; Guinea-Bissau; Guyana; Haiti; Honduras; Hong Kong SAR, China; Hungary; Iceland; India; Indonesia; Iran, Islamic Rep.; Iraq; Ireland; Israel; Italy; Jamaica; Japan; Jordan; Kazakhstan; Kenya; Korea, Rep.; Kuwait; Kyrgyz Republic; Lao PDR; Latvia; Lebanon; Lesotho; Liberia; Libya; Lithuania; Luxembourg; Macao SAR, China; Macedonia, FYR; Madagascar; Malawi; Malaysia; Maldives; Mali; Malta; Marshall Islands; Mauritania; Mauritius; Mexico; Moldova; Mongolia; Montenegro; Morocco; Mozambique; Myanmar; Namibia; Nepal; Netherlands; New Caledonia; New Zealand; Nicaragua; Niger; Nigeria; Norway; Oman; Pakistan; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Poland; Portugal; Puerto Rico; Qatar; Romania; Russian Federation; Rwanda; Samoa; Sao Tome and Principe; Saudi Arabia; Senegal; Serbia; Seychelles; Sierra Leone; Singapore; Slovak Republic; Slovenia; Somalia; South Africa; South Sudan; Spain; Sri Lanka; St. Lucia; St. Vincent and the Grenadines; Sudan; Suriname; Swaziland; Sweden; Switzerland; Syrian Arab Republic; Tajikistan; Tanzania; Thailand; Timor-Leste; Togo; Tonga; Trinidad and Tobago; Tunisia; Turkey; Turkmenistan; Uganda; Ukraine; United Arab Emirates; United Kingdom; United States; Uruguay; Uzbekistan; Vanuatu; Venezuela, RB; Vietnam; West Bank and Gaza; Yemen, Rep.; Zambia; Zimbabwe.

and (6) Secretariat of the Pacific Community: Statistics and Demography Programme. In turn, the data for mortality rate comes from estimates Developed by the UN Inter-agency Group for Child Mortality Estimation (UNICEF, WHO, World Bank, UN DESA Population Division) at www.childmortality.org. Although these variables have been criticized for proxy health capital, these data have been defended in the context of developing countries Sen (1998).

All the variables, except the data of average years of schooling, life expectancy, and mortality rate are in logarithm, according to the model we derived in equation (2). Besides the complete sample of 188 countries we also divided the whole sample into the following four regions: Africa Sub-Saharan (32 countries) [2]; Europe, Central Asia, and North America (42 countries) [3]; Latin America and Caribbean (25 countries) [4]; South Asia, Middle East, North Africa, East Asia, and Pacific (45 countries) [5].

The descriptive statistics for the whole sample of 188 countries are described in the table below:

Table 1: Descriptive statistics for the whole sample

Variable	Obs	Mean	Std. Dev.	Min	Max
y_{it}	907	8.892244	1.24309	5.508054	11.75721
k_{it}	1384	3.019401	.4147704	.0924063	5.065797
l_{it}	930	4.132008	.1677643	3.642836	4.506454
Average years of schooling	1584	5.878251	3.131746	.039138	13.18264
Life expectancy	2140	62.78392	11.65072	23.88454	83.15938
Mortality rate per 1,000 live births	1828	57.20498	48.1008	1.9	263.6

[2]Burundi; Benin; Botswana; Central African Republic; Cote d'Ivoire; Cameroon; Congo, Rep.; Gabon; Ghana; Gambia, The; Kenya; Liberia; Lesotho; Mali; Mozambique; Mauritania; Mauritius; Malawi; Namibia; Niger; Rwanda; Sudan; Senegal; Sierra Leone; Swaziland; Togo; Tanzania; Uganda; South Africa; Congo, Dem. Rep.; Zambia; Zimbabwe.

[3]Albania; Armenia; Austria; Belgium; Bulgaria; Canada; Switzerland; Cyprus; Czech Republic; Germany; Denmark; Spain; Estonia; Finland; France; United Kingdom; Greece; Croatia; Hungary; Ireland; Iceland; Italy; Kazakhstan; Kyrgyz Republic; Lithuania; Luxembourg; Latvia; Moldova; Netherlands; Norway; Poland; Portugal; Romania; Russian Federation; Serbia; Slovak Republic; Slovenia; Sweden; Tajikistan; Turkey; Ukraine; United States.

[4]Argentina; Belize; Bolivia; Brazil; Barbados; Chile; Colombia; Costa Rica; Cuba; Dominican Republic; Ecuador; Guatemala; Guyana; Honduras; Haiti; Jamaica; Mexico; Nicaragua; Panama; Peru; Paraguay; El Salvador; Trinidad and Tobago; Uruguay; Venezuela, RB.

[5]Afghanistan; United Arab Emirates; Australia; Bangladesh; Bahrain; Brunei Darussalam; China; Algeria; Egypt, Arab Rep.; Fiji; Hong Kong SAR, China; Indonesia; India; Iran, Islamic Rep.; Iraq; Israel; Jordan; Japan; Cambodia; Korea, Rep.; Kuwait; Lao PDR; Libya; Sri Lanka; Macao SAR, China; Morocco; Maldives; Malta; Myanmar; Mongolia; Malaysia; Nepal; New Zealand; Pakistan; Philippines; Papua New Guinea; Qatar; Saudi Arabia; Singapore; Syrian Arab Republic; Thailand; Tonga; Tunisia; Vietnam; Yemen, Rep.

4 Results

Now we are going to present the main results we got by making the three empirical exercises we described in the subsection estimation methodology. In order to present the main results, we are going to present the results for the whole sample and for each of the regions.

4.1 Results for the whole sample

We begin by estimating equation (6) by pooled ordinary least squares. The results we got are summarized in the table below:

Table 2: Production function estimation for the whole sample by pooled OLS

	1	2	3	4
VARIABLES	Robust to heteroskedasticity Δy_{it}	Robust to heteroskedasticity Δy_{it}	Robust to serial correlation Δy_{it}	Robust to serial correlation Δy_{it}
Δk_{it}	0.185*	-0.176**	0.185	-0.176
	(0.0968)	(0.0839)	(0.134)	(0.113)
Δl_{it}	-1.836***	-0.692***	-1.836***	-0.692**
	(0.187)	(0.187)	(0.333)	(0.319)
ΔE_{it}	0.287***	0.111***	0.287***	0.111***
	(0.0120)	(0.0170)	(0.0216)	(0.0302)
ΔH_{it}		0.0783***		0.0783***
		(0.00610)		(0.0104)
Constant	14.01***	6.379***	14.01***	6.379***
	(0.821)	(0.958)	(1.418)	(1.651)
Observations	516	515	516	515
R-squared	0.591	0.740	0.591	0.740

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
All the estimations contain year dummies.

We did the estimations by using a variance matrix robust to heteroskedasticity in columns (1) and (2) and robust to serial correlation in columns (3) and (4). By analyzing the table above we can perceive that the coefficients estimations are the same either using variance robust to heteroskedasticity or to serial correlation.

Analyzing the results presented in columns (1) and (3) where we only include as the variable to measure the human capital the average years of schooling, we have that the value of the coefficient has the expected signal and is statistically significant. Without including the measure of health capital we can perceive that the value of the coefficient that measures education is not low, which highlights the importance of schooling in the output of a country and gives a direction that we can have other dimensions of human capital that were not included in the model. Given this observation, when we include health capital (life expectancy) in the estimation process, columns (3) and (4), we have that the inclusion of health capital produces coefficients with the expected signal and substantially reduces the marginal significance level of the coefficient of education, although this coefficient is still significant. The result shown here supports the idea of Mankiw et al. (1990) that the lack of a coefficient produces misspecification bias, as in the case when we do not include the variable that measures the health capital.

Now the result we are going to analyze is the fixed effects estimation of the equation (9). By doing this regression and including year dummies we obtain the results summarized in Table 3.

Table 3: Production function estimation for the whole sample by fixed effects estimator with year dummies

	1	2	3	4
VARIABLES	Dummies in time logGDP_PPP	Dummies in time logGDP_PPP	Dummies in time logGDP_PPP	Dummies in time logGDP_PPP
log capital	0.0847**	0.0742**	0.0668*	0.0388
	(0.0327)	(0.0320)	(0.0339)	(0.0320)
log labor	-0.0188	0.0438	-0.0428	-0.0638
	(0.326)	(0.292)	(0.346)	(0.330)
schooling	0.0440*	-0.0216	0.0607***	0.0552***
	(0.0231)	(0.0276)	(0.0182)	(0.0192)
life expectancy		0.0666***		0.0136***
		(0.0139)		(0.00436)
dummy africa * health		-0.0608***		
		(0.0146)		
dummy america * health		-0.0548***		
		(0.0162)		
dummy asia * health		-0.0374**		
		(0.0151)		
dummy africa * education	-0.101***	0.0163		
	(0.0368)	(0.0438)		
dummy america * education	0.000994	0.0989**		
	(0.0308)	(0.0495)		
dummy asia * education	0.0691**	0.122***		
	(0.0267)	(0.0357)		
Constant	8.369***	5.999***	8.450***	7.763***
	(1.346)	(1.328)	(1.421)	(1.402)
Observations	649	648	649	648
R-squared	0.557	0.598	0.512	0.528
Number of idcode	139	139	139	139

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The dummy Africa is a variable that indicates if belongs to the region Africa Sub Saharan (from now on Africa); dummy America is a dummy indicating it belongs to Latin America and the Caribbean (from now on Latin America); and dummy Asia is a dummy for South Asia, Middle East, North Africa, East Asia and Pacific (from now on Asia). The basic region is Europe, Central Asia, and North America (from now on Europe).

In the result shown in Table 3, we include year dummies in order to control the worldwide technological frontier. The estimations for the log capital in all exercises have the expected signal, although it is not significant in the result shown in column (4) where we do not include the dummies interaction. The logarithm of labor do not have the expected signal in columns (1), (3), and (4) and is not significant in any of the exercises presented.

The result we have in column (1) shows us that when we include only the average years of schooling as a measure of human capital, we have that its effect on growth is positive and statistically significant. By controlling for the regions, we have that the interaction between the dummy of the region and the variable of education is statistically significant for Africa and Asia, indicating that the return of education in these two regions is different from the basis region, Europe. Note that given this, the return of schooling for the African region is the lowest one and the return of schooling in Asia is the greater one. The return of schooling for Latin America and Europe is approximately the same.

By including the variable that measures the health capital, and life expectancy, we have that the coefficient estimator for schooling reduces in columns (2) and (4). Analyzing the results contained in column (2) we have that the coefficient of life expectancy is statistically significant and it has the expected signal. Observing the dummies of interaction between regions and life expectancy, one can note that the return of an increase in one year of life expectancy in the different regions of the planet is statistically significant and different, where the lowest return is in Africa Sub-Saharan, followed by Latin America. This result is very interesting and shows us that although life expectancy is significant in these regions, its return is not the same as in the Europe region. Given the low returns of health capital in output in Africa and Latin America, one can imagine that the life expectancy can be associated with some factor of productivity of the workers in these regions, since we can imagine that a country that has a higher life expectancy has healthier workers and, hence, is more productive. Thus, if the life expectancy measure is associated with the productivity of a worker it is expected that the return of one year more life will be lower in Africa compared to Europe. An extension of the work presented here could control these possible effects including some measure of productivity.

We can see that increasing the life expectancy in Africa Sub-Saharan by one year represents a growth in the output per capita by approximately 0.58 %, whereas in Europe increasing life expectancy by one year increases the output per capita by approximately 6.6 %. Although the coefficient for education does not have the expected signal in column (2) and is not significant, we can perceive that the dummies for the interaction between regions and education were significant for the regions America and Asia, indicating that the return of schooling in both regions is different of the return of schooling in Europe.

In columns (3) and (4) we make the same empirical exercise without controlling for regions. Note that the return of schooling in both regressions is significant and has the expected signal, although after controlling for health capital, the return of schooling decreases. In column (3) we have that an increase in one year of schooling increases the output per capita by approximately 6.07%. On the other hand, in column (4) the inclusion of health capital diminish the return of one year of schooling and the life expectancy has the expected signal and is significant, indicating that in the whole sample of countries the increase in one year of life expectancy increases the output per capita by approximately 1.36%. The results shown here contribute to the view that health capital is one important dimension of human capital and once we controlled for it, the importance of schooling diminishes.

Now in the table below we present the same result shown in the table above, but in this empirical exercise, we do not include year dummies. Hence, in this case, we are not controlling the worldwide technological frontier.

In this case, we have that all variables have the expected signal, although the coefficient estimation for the log capital is not significant in column (4) and all the coefficient estimations for the labor are not statistically significant. By comparing the results in columns (1) and (2) we

Table 4: Production function estimation for the whole sample by fixed effects estimator without year dummies

	1	2	3	4
VARIABLES	No dummies in time logGDP_PPP	No dummies in time logGDP_PPP	No dummies in time logGDP_PPP	No dummies in time logGDP_PPP
log capital	0.107***	0.0834***	0.0897***	0.0410
	(0.0320)	(0.0319)	(0.0323)	(0.0301)
log labor	0.143	0.110	0.103	0.0217
	(0.314)	(0.277)	(0.327)	(0.307)
schooling	0.172***	0.0106	0.172***	0.130***
	(0.0216)	(0.0287)	(0.0134)	(0.0156)
life expectancy		0.0870***		0.0210***
		(0.0118)		(0.00494)
dummy africa * health		-0.0789***		
		(0.0127)		
dummy america * health		-0.0637***		
		(0.0166)		
dummy asia * health		-0.0439***		
		(0.0160)		
dummy africa * education	-0.0968**	0.0509		
	(0.0393)	(0.0431)		
dumy america * education	-0.00435	0.109**		
	(0.0377)	(0.0534)		
dummy asia * education	0.0525*	0.119***		
	(0.0303)	(0.0380)		
Constant	6.819***	4.544***	7.035***	6.407***
	(1.272)	(1.114)	(1.316)	(1.268)
Observations	649	648	649	648
R-squared	0.466	0.572	0.431	0.478
Number of idcode	139	139	139	139

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

have that after considering the health capital as an important dimension of human capital, the importance of schooling in explaining growth is reduced. In column (2) we have that in Europe the return of one year increase in life expectancy increases the output by approximately 8.7%. The return of life expectancy is different across regions, as shown by the interaction dummies between regions and health. As in the previous analysis, the return of life expectancy is lowest in Africa, indicating that an increase in one-year life expectancy increases output per capita in Africa by around 0.81%. As mentioned above, this difference is not surprising. When we do not include health capital, column (1), we have that the return of schooling is different across regions. In all regions, the effects of schooling are positive, although, the return of one more year of education is lower in Africa than in other regions. The greater effect is in Asia.

By analyzing the results in columns (3) and (4) we have that the inclusion of health capital reduces the effect of schooling, although this effect still remains positive. In column (3) the effect of one year of schooling increases output per capita by approximately 17.2%, which is a big effect. After controlling for life expectancy we have that the effect of one more year of schooling is 13% and we have that an increase in life expectancy increases output per capita by approximately 2.10%.

Therefore, we have that the return of one year of schooling by considering the results in Table 3 and Table 4 is between 5.52% and 13%, while the effect of a one-year increase in life expectancy in output per capita is between 1.32% and 2.10% approximately, with this effect being lower in Africa and Latin America when compared to other regions.

Now by using the Infant mortality rate as an instrumental variable for life expectancy and estimating equation (9) by two-stage least squares we obtain the results summarized in Table 5.

When we use the Infant mortality rate as an instrument for life expectancy and analyze the results in column (1) where we have the estimation with year dummies we have that the coefficient of education is not statistically significant. The coefficient of life expectancy is significant and by using the mortality rate as an instrument for life expectancy we have that the return is only different in Africa, where we have that an increase in one-year life expectancy increases the output per capita in Africa by approximately 0.7%, whereas in Europe this return is approximately 13.2%. The return to health in other regions is not statistically different from the return to health in Europe.

By not including dummies of the interaction between regions and considering the case where we have year dummies, in column (2), we can see that the return of education is almost the same as the return of education we have in column (4) of Table 3. The return of a one-year increase in life expectancy is almost 0.864% in the output per capita, which is lower than that of column (4) of Table 3. In the analysis of column (3) where we do not include year dummies, we have that the return of life expectancy is statistically different across regions, in Africa the return of life expectancy is almost 0.8%. This return is also low in Latin America if compared to the return in Europe and in Asia, where is a greater return. The results in column (4) are not slightly different from the results in column (4) of Table 4.

Table 5: Production function estimation for the whole sample by 2SLS using Mortality rate as Instrument

	1	2	3	4
	Dummies in time	Dummies in time	No dummies in time	No dummies in time
VARIABLES	logGDP_PPP	logGDP_PPP	logGDP_PPP	logGDP_PPP
log capital	0.0780***	0.0536**	0.0863***	0.0407
	(0.0252)	(0.0271)	(0.0259)	(0.0279)
log labor	0.0223	-0.137	0.0431	-0.0570
	(0.178)	(0.167)	(0.173)	(0.175)
schooling	-0.0993	0.0514***	-0.117	0.123***
	(0.0939)	(0.0167)	(0.0751)	(0.0131)
life expectancy	0.132*	0.00864	0.156***	0.0228***
	(0.0767)	(0.00542)	(0.0399)	(0.00486)
dummy africa * health	-0.125*		-0.148***	
	(0.0756)		(0.0401)	
dummy america * health	-0.112		-0.132***	
	(0.0687)		(0.0414)	
dummy asia * health	-0.0921		-0.110***	
	(0.0673)		(0.0409)	
dummy africa * education	0.138		0.178**	
	(0.145)		(0.0780)	
dummy america * education	0.203		0.237***	
	(0.126)		(0.0810)	
dummy asia * education	0.205*		0.231***	
	(0.117)		(0.0792)	
Constant	4.454*	8.572***	3.570***	6.649***
	(2.404)	(0.776)	(1.020)	(0.730)
Observations	638	638	638	638
Number of idcode	137	137	137	137

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.2 Results for the Africa Sub-Saharan

We begin by estimating equation (6) by pooling ordinary least squares for the Africa Sub-Saharan. The results we got are summarized in the table below:

Table 6: Production function estimation for Africa Sub Saharan by pooled OLS

	1	2	3	4
VARIABLES	Robust to heteroskedasticity Δy_{it}	Robust heteroskedasticity Δy_{it}	Robust to serial correlation Δy_{it}	Robust to serial correlation Δy_{it}
Δk_{it}	0.0892	-0.0249	0.0892	-0.0249
	(0.0812)	(0.0765)	(0.116)	(0.110)
Δl_{it}	-2.288***	-1.885***	-2.288***	-1.885***
	(0.232)	(0.273)	(0.396)	(0.427)
ΔE_{it}	0.322***	0.294***	0.322***	0.294***
	(0.0243)	(0.0229)	(0.0417)	(0.0388)
ΔH_{it}		0.0286***		0.0286**
		(0.00775)		(0.0113)
Constant	15.88***	13.08***	15.88***	13.08***
	(1.032)	(1.384)	(1.747)	(2.124)
Observations	121	121	121	121
R-squared	0.715	0.744	0.715	0.744

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

We did the estimations by using a variance matrix robust to heteroskedasticity in columns (1) and (2) and robust to serial correlation in columns (3) and (4). By analyzing the table above we can perceive that the coefficients estimations are the same either using variance robust to heteroskedasticity or to serial correlation.

Analyzing the results presented in columns (1) and (3) where we only include as the variable to measure the human capital the average years of schooling, we have that the value of the coefficient has the expected signal and is statistically significant. Without including the measure of health capital we can perceive that the value of the coefficient that measures education is not low, which highlights the importance of schooling in the output of Africa Sub Saharan countries and gives a direction that we can have other dimensions of human capital that were not included in the model. However, when we include health capital (life expectancy) in the estimation process, columns (3) and (4), we have that the inclusion of health capital produces coefficients with the expected signal and substantially reduces the marginal significance level of the coefficient of education, although this coefficient is still significant. This result is the same as presented in section 4.1.

Now the result we are going to analyze is the fixed effects estimation of the equation (9) where we have the analysis with year dummies and without year dummies. The results are summarized in Table 7.

By including year dummies for controlling the worldwide technological frontier, we have that in both cases the coefficient for schooling does not have the expected signal and is not statistically significant. Although, when we include health capital the measure of schooling decreases and the life expectancy in column (2) has the expected signal and is statistically significant, which means that an increase in one-year life expectancy increases the output per capita in Africa by approximately 0.933%. When we do not include year dummies, we have that

Table 7: Production function estimation for the Africa Sub-Saharan by fixed effects estimator

	1	2	3	4
VARIABLES	Dummies in time logGDP_PPP	Dummies in time logGDP_PPP	No dummies in time logGDP_PPP	No dummies in time logGDP_PPP
log capital	0.00803	-0.0162	0.0388	-0.00150
	(0.0396)	(0.0378)	(0.0335)	(0.0349)
log labor	-0.280	-0.371	0.0507	-0.0967
	(0.936)	(0.908)	(0.955)	(0.903)
schooling	-0.0163	-0.0247	0.0838**	0.0654*
	(0.0358)	(0.0380)	(0.0342)	(0.0325)
life expectancy		0.00933*		0.0116**
		(0.00461)		(0.00462)
Constant	8.816**	8.807**	6.963*	7.165*
	(3.924)	(3.787)	(4.027)	(3.817)
Observations	153	153	153	153
R-squared	0.255	0.295	0.140	0.209
Number of idcode	32	32	32	32

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

the estimation coefficients of schooling are significant and have the expected signal, with this coefficient reducing to 0.0654 when health capital is included. Given that, we have that increase in one year the average years of schooling in Africa Sub Saharan increases the output per capita by approximately 6.54%, whereas we have that increase in one-year the life expectancy, the output per capita increases by around 1%. In column (3) we have that the return of schooling is around 0.084, which corroborates the idea of Mankiw et al. (1990).

Now by making the empirical exercise where we use Infant mortality rate as an instrumental variable for life expectancy we have the results summarized in the table below.

When we make the estimation including year dummies we have that any of the coefficients have the expected signal and are significant, although the coefficient for life expectancy is significant at 1% and shows to us that an increase in one-year life expectancy increases the output per capita in Africa countries by approximately 1.58%. In the case where we do not include year dummies, we have that the coefficient of schooling is significant and means that a one-year increase in schooling increases the output per capita by approximately 4.57%. In turn, increasing life expectancy in one-year increases the output per capita in African countries by approximately 2.39%.

Table 8: Production function estimation for Africa Sub Saharan by 2SLS using Mortality rate as Instrument

	1	2
VARIABLES	Dummies in time logGDP_PPP	No dummies in time logGDP_PPP
log capital	-0.0329	-0.0447
	(0.0359)	(0.0390)
log labor	-0.435	-0.255
	(0.385)	(0.407)
schooling	-0.0305	0.0457*
	(0.0350)	(0.0235)
life expectancy	0.0158***	0.0239***
	(0.00537)	(0.00567)
Constant	9.003***	7.382***
	(1.655)	(1.689)
Observations	153	153
Number of idcode	32	32

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.3 Results for Latin America and the Caribbean

Estimating equation (6) by pooled ordinary least squares for Latin America and the Caribbean lead us to the results summarized in Table 9.

Table 9: Production function estimation for Latin America and the Caribbean by pooled OLS

	1	2	3	4
VARIABLES	Robust to heteroskedasticity Δy_{it}	Robust heteroskedasticity Δy_{it}	Robust to serial correlation Δy_{it}	Robust to serial correlation Δy_{it}
Δk_{it}	-0.285	-0.256	-0.285	-0.256
	(0.180)	(0.155)	(0.295)	(0.202)
Δl_{it}	-0.658	0.373	-0.658	0.373
	(0.581)	(0.405)	(1.042)	(0.657)
ΔE_{it}	0.115***	0.0725**	0.115*	0.0725
	(0.0316)	(0.0320)	(0.0579)	(0.0588)
ΔH_{it}		0.0614***		0.0614***
		(0.00861)		(0.0150)
Constant	11.60***	3.367*	11.60***	3.367
	(2.309)	(1.878)	(3.920)	(2.979)
Observations	87	87	87	87
R-squared	0.235	0.475	0.235	0.475

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results presented here are very similar to the previous analysis we already did about the pooled ordinary least squares estimation. Observe that the inclusion of health capital diminishes the marginal importance of schooling in explaining the economic growth of Latin America countries.

The next table shows the results for the fixed effect estimator for Latin America and the Caribbean.

By analyzing columns (1) and (2) we have that the capital and labor have the expected signal, although the only significant coefficients were the log of capital. Observe that by not including year dummies we have that in column (3) all coefficients are significant, observe as well that raising the average years of schooling by one year increases the output per capita in Latin America countries by approximately 14.5%. By putting the coefficient of health capital in the human capital and considering the result of column (4) we have that the importance of schooling is reduced, although the importance of schooling in the production function approach we are considering here is still big. Observe that in this case, we have that life expectancy is not significant in explaining the output per capita.

Now by considering the Infant mortality rate as an instrumental variable for life expectancy and using two-stage least squares we obtain the results in Table 11.

By observing the results we can see that in the case where we include year dummies, the only statistically significant and that has the expected signal is the log capital. The variable of labor also has the expected signal, although is not significant. When we do not include year dummies in our regression we have that all regressors are significant and have the expected signal, except the coefficient of health which is not significant but has the expected signal. In Latin America, by considering the result in column (2) of Table 11 we have that an increase in

Table 10: Production function estimation for Latin America and the Caribbean by fixed effects estimator

	1	2	3	4
VARIABLES	Dummies in time logGDP_PPP	Dummies in time logGDP_PPP	No dummies in time logGDP_PPP	No dummies in time logGDP_PPP
log capital	0.135**	0.142**	0.127**	0.121**
	(0.0576)	(0.0605)	(0.0544)	(0.0544)
log labor	0.320	0.380	1.043**	0.821
	(0.489)	(0.529)	(0.447)	(0.526)
schooling	-0.00576	-0.0112	0.145***	0.114**
	(0.0433)	(0.0438)	(0.0274)	(0.0418)
life expectancy		-0.0197		0.0169
		(0.0130)		(0.0130)
Constant	7.604***	8.825***	3.260*	3.229*
	(2.144)	(2.173)	(1.835)	(1.768)
Observations	110	110	110	110
R-squared	0.723	0.735	0.598	0.613
Number of idcode	23	23	23	23

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11: Production function estimation for Latin America and Caribbean by 2SLS using Mortality rate as Instrument

	1	2
VARIABLES	Dummies in time logGDP_PPP	No dummies in time logGDP_PPP
log capital	0.142**	0.124*
	(0.0580)	(0.0683)
log labor	0.385	0.914**
	(0.351)	(0.412)
schooling	-0.0116	0.127***
	(0.0309)	(0.0282)
life expectancy	-0.0211	0.00981
	(0.0135)	(0.0117)
Constant	8.913***	3.242**
	(1.690)	(1.473)
Observations	110	110
Number of idcode	23	23

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

one-year average schooling increases output per capita by approximately 12.7%.

This result highlights the importance of schooling in explaining the economic growth of Latin America countries if compared to the importance of health. Therefore, an extension of this article could be to analyze what other factor of human capital are contained in education that explains the economic growth in Latin America and the Caribbean.

4.4 Results for South Asia, Middle East, North Africa, East Asia, and Pacific

We begin by showing the pooled ordinary least squares for South Asia, the Middle East, North Africa, East Asia, and Pacific countries. This equation is an estimation of equation (5) and in order to control for the worldwide technological frontier year dummies were included. The results are in Table 12.

Table 12: Production function estimation for Asia by pooled OLS

	1	2	3	4
VARIABLES	Robust to heteroskedasticity Δy_{it}	Robust heteroskedasticity Δy_{it}	Robust to serial correlation Δy_{it}	Robust to serial correlation Δy_{it}
Δk_{it}	-0.524*	-0.812***	-0.524	-0.812**
	(0.282)	(0.243)	(0.403)	(0.301)
Δl_{it}	-0.619*	-0.378	-0.619	-0.378
	(0.342)	(0.299)	(0.593)	(0.501)
ΔE_{it}	0.282***	-0.0183	0.282***	-0.0183
	(0.0216)	(0.0317)	(0.0386)	(0.0560)
ΔH_{it}		0.162***		0.162***
		(0.0137)		(0.0242)
Constant	11.36***	2.157	11.36***	2.157
	(1.292)	(1.691)	(2.146)	(2.756)
Observations	149	149	149	149
R-squared	0.409	0.720	0.409	0.720

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The analysis of the results is quite standard compared to the analysis we already did in the previous pooled ordinary least squares regressions.

Now by making the empirical exercise with fixed effects we obtain the results summarized in Table 13.

By analyzing the results shown in columns (1) and (2) we have that schooling has the expected signal and it is statistically significant. In the first column, we can perceive that increasing the average years of schooling by one year increases the output per capita in Asian countries by around 10% and this effect diminishes to around 9.64% when we include health capital as one of the dimensions of human capital. In this case, which is displayed in column (2), we have that a one-year increase in life expectancy increases the output per capita by approximately 2.83%. When we do not control for the worldwide technological frontier, results displayed in columns (3) and (4), we have that the effects of schooling are around 22.4% in the case where we have only education as human capital. By putting life expectancy as a regressor, the effect of schooling diminishes to around 13%, and the effect of life expectancy increases by around 4.26%. This means that increasing life expectancy by one year increases the output per capita by around 4.26%.

The next empirical exercise we are going to show the result is estimating the production function by two-stage least squares using as an instrumental variable the Infant Mortality rate. The result is summarized in Table 14.

Observe that in column (1) we have the coefficients when we include year dummies. In

Table 13: Production function estimation for Asia by fixed effects estimator

	1	2	3	4
VARIABLES	Dummies in time logGDP_PPP	Dummies in time logGDP_PPP	No dummies in time logGDP_PPP	No dummies in time logGDP_PPP
log capital	0.0499	0.0351	0.0692	0.0479
	(0.0920)	(0.0837)	(0.0832)	(0.0695)
log labor	-0.860	-0.674	-0.652	-0.516
	(0.891)	(0.915)	(0.892)	(0.866)
schooling	0.102***	0.0964***	0.224***	0.130***
	(0.0308)	(0.0301)	(0.0213)	(0.0254)
life expectancy		0.0283**		0.0426***
		(0.0137)		(0.0104)
Constant	11.70***	9.095**	10.05***	7.233**
	(3.601)	(3.993)	(3.475)	(3.233)
Observations	185	185	185	185
R-squared	0.715	0.730	0.653	0.717
Number of idcode	42	42	42	42

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 14: Production function estimation for Asia by 2SLS using Mortality rate as Instrument

	1	2
VARIABLES	Dummies in time logGDP_PPP	No dummies in time logGDP_PPP
log capital	0.0725	0.0784
	(0.0538)	(0.0520)
log labor	-1.471***	-1.256***
	(0.406)	(0.395)
schooling	0.0759***	0.127***
	(0.0256)	(0.0271)
life expectancy	0.0253*	0.0380***
	(0.0150)	(0.0106)
Constant	12.72***	10.45***
	(2.206)	(1.731)
Observations	175	175
Number of idcode	40	40

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

this case, we have that a rising in one year of average years of schooling increases output per capita by around 7.59%, whereas increasing one-year life expectancy increases the output per capita by approximately 2.53%. When we do not control for the worldwide technological frontier, both coefficients increase and are still significant.

4.5 Results for Europe, Central Asia, and North America

By estimating the equation by pooled ordinary least squares we have the results in Table 15.

Table 15: Production function estimation for Europe by pooled OLS

	1	2	3	4
	Robust to heteroskedasticity	Robust heteroskedasticity	Robust to serial correlation	Robust to serial correlation
VARIABLES	Δy_{it}	Δy_{it}	Δy_{it}	Δy_{it}
Δk_{it}	1.017**	0.248	1.017	0.248
	(0.465)	(0.282)	(0.613)	(0.358)
Δl_{it}	-1.517**	-0.762**	-1.517	-0.762
	(0.726)	(0.354)	(1.293)	(0.608)
ΔE_{it}	0.120***	0.0812**	0.120	0.0812
	(0.0429)	(0.0343)	(0.0794)	(0.0611)
ΔH_{it}		0.157***		0.157***
		(0.0120)		(0.0212)
Constant	11.74***	-0.115	11.74**	-0.115
	(3.072)	(1.620)	(5.191)	(2.708)
Observations	159	158	159	158
R-squared	0.121	0.697	0.121	0.697

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results showed to support the idea of Mankiw et al. (1990), once we can see that by including the health capital, and life expectancy, the coefficient of education is reduced and that of health capital has the expected signal and is significant.

When we make the exercise by using fixed effects estimation we obtain the results summarized in Table 16.

One can note that when we include year dummies, columns (1) and (2), we have that schooling has the expected signal and its coefficient is reduced when we include life expectancy, although it is not significant in any of the regressions. Observe that in column (2) the coefficient of life expectancy is positive and significant, which means that an increase in one year in life expectancy increases the output per capita by approximately 7.72%, which is a result similar to the result we found in section 4.1 when we worked with dummies for the different regions. Observe as well that by including no-year dummies in order to control for the worldwide technological frontier we have that the coefficients of schooling have the expected signal as well as the coefficient of life expectancy, although in the last column we can perceive that the effect of life expectancy in output increases (e.g. an increase in one-year life expectancy increases the output per capita around 8.74%).

This result is in line with what we have already said about the fact that life expectancy is capturing some factor linked to productivity, since comparing the coefficients of life expectancy between the different regions we have that it is greater in the case of Europe and the countries which we defined belong to the Asia region. If this is true, then the result is in line with what we expected, the return of life expectancy must be greater in rich countries. Moreover observe that the coefficient of education is not significant once we are controlling for life expectancy, which can mean that the level of education in these countries is already so high that an increase in one more year has no substantial effect. Of course, by doing this analysis we are considering that education has decreasing returns to scale.

Table 16: Production function estimation for Europe by fixed effects estimator

	1	2	3	4
VARIABLES	Dummies in time logGDP_PPP	Dummies in time logGDP_PPP	No dummies in time logGDP_PPP	No dummies in time logGDP_PPP
log capital	0.427***	0.401***	0.459***	0.471***
	(0.0645)	(0.0734)	(0.0658)	(0.0723)
log capital	0.338	0.299	0.330	0.351
	(0.411)	(0.305)	(0.423)	(0.305)
schooling	0.00333	0.0143	0.176***	0.0157
	(0.0282)	(0.0287)	(0.0203)	(0.0294)
life expectancy		0.0772***		0.0874***
		(0.0193)		(0.0114)
Constant	7.369***	1.532	5.330***	0.289
	(1.781)	(2.301)	(1.778)	(1.541)
Observations	201	200	201	200
R-squared	0.617	0.694	0.463	0.671
Number of idcode	42	42	42	42

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Now consider the results in Table 17, where we present the estimation by two-stage least squares using Infant mortality rate as an instrumental variable.

Observe that the coefficient of life expectancy is almost the same whether we are controlling for year dummies or not and is around 9%, which gives room for what we said about the fact that life expectancy is capturing some factor linked to productivity. Also observe, that in either one of the cases the coefficient of schooling is not significant, which is in line with what we said that maybe in the countries that are in this region the level of education is already so high that one more year of education does not make a substantial difference in the output per capita.

Table 17: Production function estimation for Asia by 2SLS using Mortality rate as Instrument

	1	2
VARIABLES	Dummies in time logGDP_PPP	No dummies in time logGDP_PPP
log capital	0.392***	0.472***
	(0.0718)	(0.0646)
log labor	0.290	0.353
	(0.216)	(0.218)
schooling	0.0168	0.00418
	(0.0286)	(0.0315)
life expectancy	0.0973**	0.0937***
	(0.0395)	(0.0155)
Constant	0.0214	-0.0694
	(3.130)	(1.305)
Observations	200	200
Number of idcode	42	42

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5 Concluding remarks

Our model studied the economic growth by analyzing the growth of factor inputs - capital, labor, education, and health in four different regions of the world: Africa Sub Saharan; Latin America and the Caribbean; South Asia, Middle East, North Africa, East Asia, and Pacific; and Europe, Central Asia, and North America. Our main result, which is consistent with previous studies is that health has a positive and statistically significant effect on economic growth. For the whole world, it suggests that an increase in one-year life expectancy leads to a growth of output per capita in the countries of around 1.36% when we control for the worldwide technological frontier and about 2.10% when we do not control for this fixed effect in time.

The effect of schooling was also studied and we found that increasing one-year average schooling increases output per capita by approximately 5.52% once we control for the fixed effect in time and around 13% when we do not control for it.

By creating dummies of interaction between these different regions and the two variables we were more interested in - health and education - we obtained that the effect of health capital and education were not the same across different regions, being the effect of life expectancy larger in Europe, Central Asia, and North America, indicating a possible link between health and productivity. The effects of health capital in Africa Sub Saharan and in Latin America were not as expressive as the effects in Europe, Central Asia, and North America, whereas the effects on schooling for these two regions were greater than the effects found in Europe, Central Asia, and North America.

By studying the sample divided into regions and not the dummies interactions in the whole sample, we found results similar to what we found when we analyzed the whole sample with dummies. In Africa Sub Saharan and in Latin America the effects of an increase in one more year of schooling were more expressive in explaining the economic growth than the increase in life expectancy. In the regions identified as Asia and Europe the opposite happens and the result, we found for Europe was that schooling was not statistically significant in explaining economic growth. This indicates that the role of different forms of capital in the growth process change as income rise.

Our attention in this article was directed mainly to health and education, and because of this, we do not focus on the interpretation and study of the significance of the other inputs, which were serving more as control variables. One can argue that in some of the empirical exercises we showed, the coefficients of labor and capital were not either statistically significant and/or not had the expected signal. The bad behavior of these coefficients in some of the empirical exercises can be justified by the fact that in macroeconomic studies a central problem is the lack of degrees of freedom, which was the case in the article, mainly when we divided the sample. Moreover, we used aggregate data, which gives room for the problem of multicollinearity between the variables, mainly among the gross domestic product and the variable we used to proxy capital and labor.

Apart from these problems, the article highlighted the importance of health in the production function approach, which has some important policy implications, since it supports that investments in health are important not only on the grounds of enhancing the welfare of the population but as well because it can lead to a growth in output.

As we already pointed out some interesting extensions of this article can be done by including a variable related to experience in equation (1) and arguing that an experience is also a form of human capital, since we have that the wages also depend on the experience of the workers. One could also try to measure productivity and put it in the equation that measures human capital. Another extension can investigate how the education and health capital are distributed among the population of a country since in this article we were only worried about the average effect. By doing this one can estimate how the increase in one-year average schooling, for instance, affects the output per capita of different groups within a certain country.

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