Aggregate Threshold Effects in the Generation of Human Capital

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Resumo

Os níveis de desenvolvimento econômico diferem muito entre as nações. Explicar por que os países latino-americanos não conseguiram ultrapassar os países da Europa continua a ser um problema desafiador para a ciência econômica. Neste trabalho nosso principal objetivo é oferecer uma explicação para esse padrão desigual de desenvolvimento econômico. A explicação é baseada em uma teoria do capital humano que postula retornos crescentes de escala devidos à acumulação agregada de conhecimento. Os testes empíricos apoiam a nossa teoria.

Palavras-chave: Capital humano; efeito limiar; acumulação de conhecimento; retornos crescentes de escala; desenvolvimento econômico.

Abstract

Levels of economic development differ greatly across nations. Explaining why Latin American countries have not managed to overtake countries in Europe remains a challenging problem for economics. In this paper our main purpose is to offer an explanation for this uneven pattern of economic development. Our explanation is based on a human capital theory that posits increasing returns to scale due to aggregate knowledge accumulation. The empirical tests offer support for our theory.

Keywords: Human capital; threshold effect; knowledge accumulation; increasing returns to scale; economic development.

Área ANPEC: 5 – Crescimento, Desenvolvimento Econômico e Instituições

Classificação JEL: I28; O41; O47.

1 Introduction

Our purpose in this paper is to contribute to the debate about the importance of education in development by looking for a *threshold effect* that discontinuously raises the return to years of schooling.

Human capital is critical for economic development: without highly skilled workers, productivity remains low and technical progress is slow. Measuring human capital is a challenge, however, since we do not observe it directly, and do not know exactly how it is determined. Individual education and experience certainly seem to matter, but the economic and social environment in which learning takes place may also play an important role. We consider two hypotheses in this paper:

1. That the more highly educated is society, the higher the return to education for any individual.
2. This effect is discontinuous, and only kicks in after a certain level of education is achieved.

The two together are what we call the *aggregate threshold effect*.

A series of papers [e.g. Klenow e Rodríguez-Clare (1997); Hall e Jones (1999), Easterly e Levine (2002),and Bils e Klenow (2000)] have constructed measures of national human capital stocks for use in cross-country growth analysis. These studies use what has come to be known as the "macro-Mincer" approach. It works as follows. First, a return to education function is estimated using data on *individuals* who report their wage, education, and experience. Second, to calculate national, *aggregate* human capital, separate data on national educational attainment is found, and then combined with the estimated return function from the first step. Even though the return function was estimated for individuals, it is applied to aggregate data to find a measure of average human capital in a particular country.

If there are positive external effects of schooling, this approach will underestimate the return to education. Moreveover, if there exists a threshold, those countries with low secondary and tertiary education attainment currently may seriously underestimate the effect of significant increases in levels of schooling.

Using data on average teacher wages, we test for the threshold effect by incorporating indicator variables for average national schooling levels in the return to education function. , and use them to construct human capital series for various countries. We find clear support for the existence of an aggregate threshold effect. We use our estimated return function to construct series of human capital over time for several countries. This allows us to deconstruct output per capita at the national level into its three components: human capital, physical capital intensity, and productivity. We illustrate our results by contrasting Europe (and the OECD) with Latin America. One interesting result is that for the OECD most of the variation in output per worker is due to variation in human capital. For Latin America, variation in productivity is most important.

The paper is organized as follows. In Section 2, we illustrate our method for aggregating the data to estimate threshold effects. In Section 3 we estimate the size of these effects using panel data. In Section 4, we use the formula derived in Section 3 to construct human capital series across countries. In Section 5, we decompose output per worker into its three components. We use this to explain the variance in output per worker across groups of countries. We offer some conclusions in the Section 6.

2 The Return to Schooling

We explore the idea that the individual return to education depends, at least in part, on the educational level of *society*. We believe that there are aggregate threshold effects entering through positive externalities that accrue once a *critical mass* of educated people come into existence. This is not a new idea. It has long been noted that people that lack education may be reluctant to invest in schooling because the percieved return is low. One reason for the low return to education is precisely because no one else is educated.

The argument may be formalized as follows. Let e be an individual's level of education, E be the aggregate average level of education, and E_c be a critical level of aggregate education. Let $r(e, E)$ be the individual return to education, which depends non-negatively on both arguments. We assume that $r_e(e, E) > 0$ for all e and E, but that

$$r_E(e, E) \begin{cases} = 0 & if \quad E < E_c \\ > 0 & if \quad E \geq E_c \end{cases} \tag{1}$$

The critical level E_c is what we mean by the *aggregate threshold*.[1]

To see how this kind of environment can lead to stagnation, let ρ_j be the subjective rate of discount of person j. Define the critical level E_{Sj} implicitly by:

$$r(e_j, E_{Sj}) = \rho_j$$

Individual j will only attend school after E has surpassed E_{Sj}, because only then does the return justify the sacrifice in terms of present consumption. Generally, $E_c < E_{Sj}$ but is possible that $E_{Sj} = 0$ if ρ_j is very small, or the person has high aptitude.

2.1 Estimating Threshold Effects

In this section, we propose a strategy to estimate the effect of aggregate years of schooling on human capital. Consider the following wage equation.[2] Here, w_{jt} is a measure of average wages in Country j in time-period t:

$$\ln w_{jt} = \alpha + \gamma_1 E_{jt} + \gamma_2 \tau_{jt} (E_{jt} - E_c) + \eta_j + \upsilon_t + \epsilon_{jt} \tag{2}$$

In this expression, E_{jt} is the average amount of schooling in Country *j* in year *t*, E_c is the threshold amount of average education above which there is a critical mass of educated people, and τ_{jt} is an indicator variable for country *j* in year *t* defined as follows:

$$\tau_{jt} = \begin{cases} 1 & if \quad E_{jt} > E_c \\ 0 & otherwise \end{cases} \tag{3}$$

[1]There are several micro-level studies that investigate the existence of *sheepskin effects* [e.g. Heckman, Layne-Farrar e Todd (1996); Jaeger e Page (1996); and Hungerford e Solon (1987)]. According to this theory, wages rise discontinuously when degrees are awarded. It is not clear, however, whether the high wages reflect the acquisition of human capital, or are a signal of future effort.

[2]As is usual in studies of this kind, we assume that wages are strictly positively related to human capital.

The intercept α can be interpreted as the log of the wage associated with the minimum level of human capital. We also allow country effects η_j and time effects υ_t. The former captures the unique, unobservable characteristics of each country; and the latter captures the effect of the particular time period. Finally, ϵ_{jt} is a white-noise error term that contains all unobserved variables that influence wages.

According to the linear spline specification of equation (2), the *marginal effect* of education on the wage jumps from γ_1 to $\gamma_1 + \gamma_2$ as soon as the aggregate level of education in the country passes E_c. There is, however, no discrete change in the *level* of the wage.

Hall and Jones (1999) also use a human-capital-generating function that demonstrates a variable return to effort depending on a discrete number of years of schooling. Unlike our paper, however, they assume (based on micro studies from various countries) that the return to education *diminishes* at each successive step of the function ($\gamma_2 < 0$). Although we expect the opposite, form (2) allows the data to decide.

2.2 Other Specifications

We consider three alternative, but related, specifications.

First, we allow the level of the wage to jump along with slope:

$$\ln w_{jt} = \alpha + \gamma_1 E_{jt} + \beta_1 \tau_{jt} + \gamma_3 \tau_{jt} E_{jt} + \eta_j + \upsilon_t + \nu_{jt} \tag{4}$$

Again, the error is assumed to be white noise, and we retain the country and time effects.

Second, we replace the indicator τ_{jt} with the variable Π_{jt}, which is defined as the proportion of the population over 25 that has a high school or college diploma. This yields the following estimating equation:

$$\ln w_{jt} = w_b + \gamma_1 E_{jt} + \beta_2 \Pi_{jt} + \gamma_4 \Pi_{jt} E_{jt} + \eta_j + \upsilon_t + \epsilon_{jt} \tag{5}$$

This allows for increasing returns in a different way. Now the return to education is $\gamma_1 + \gamma_4 \Pi_{jt}$. The return depends on the proportion of people with a high school or university diploma.

In a third formulation, we include a quadratic term in in place of the interaction term. That is:

$$w_{jt} = w_b + \gamma_1 E_{jt} + \gamma_5 {E_{jt}}^2 + \eta_j + \upsilon_t + \eta_{jt} \tag{6}$$

In this case, the return to education is $\gamma_1 + 2\gamma_5 E_{jt}$.

2.3 Schooling

To measure the national average years of schooling we use the data provided by Barro e Lee (2001). Their estimates of the fraction of the population that has attained some primary, secondary, or higher education, coupled with the duration in years of each level of education, allow them to construct a measure of E. We use the variable they call $Tyr25$, the *average years of schooling for the population over 25 years old* as our measure of E. This data has been used in many studies of human capital and growth in recent years. It is reported for every half-decade from 1960 to 2000 for most countries.

In the regressions below we set $E_c = 6$, so that τ takes the value 1 when average schooling exceeds 6 years. Although an $E_c = 6$ may appear low for an individual threshold effect, at the aggregate level it is fairly high: a nation whose average education level exceeds 6 years will have a significant proportion of high-school and college graduates in its workforce.

The proportion of the population that has completed secondary school or higher, which corresponds to our Π variable, is the sum of the variables called LSC and LHC in the Barro and Lee (2000) data.

2.4 Wages

To construct our dependent variable $\ln w_{jt}$, we use the log of the *average wage of primary school teachers* as a proxy for the average wage of the population in general. The teacher salary data was collected by Barro e Lee (2001) and is measured in real international dollars, so it is comparable over time and country. There is considerable cross-country variation in this data, which was collected for 98 countries and 7 five-year intervals.

There are both good and bad aspects of using this series as a proxy. It may be a good proxy because the education industry is a sector that is relatively labor intensive, so the wage of teachers reflects the amount of human capital in this sector and is relatively free of influence of new technology or machinery. On the other hand, we must assume that the variation in primary school teacher wages is similar to that of the general population, whose years of schooling we are measuring.[3]

3 Results on the Return to Schooling

We use a panel data set consisting of five-year periods. To estimate the return to education, we use data that goes from 1960 to 1990 (the wage data ends in 1990). The results are presented in Table 1.

The eight regressions in Table 1 show the random-effects and fixed-effects estimates for each of the four specifications.[4] Columns (1) and (2) present the base spline specification equation (2). Columns (3) and (4) show the results of the more general specification equation (4). In Columns (5) and (6), we use Π, the proportion of the population with a high school or college degree according to equation (5). The last two columns show the results of dropping both Π and τ and adding the quadratic term E^2 as in equation (6).

The overall fit of each regression is quite good, in the sense that all of them easily pass an F-test or χ^2-test for the joint significance of all of the independent variables. The R^2 values are between 20% and 45% depending on whether we look at the random-effects model or the fixed-effect model.[5] And all of them support the existence of some kind of increasing returns.

The RE spline model in Column (1) implies that the rate of return to schooling jumps from 12.2% to 23.6% after the nation passes the $E_c = 6$ threshold. The FE specification shows a much smaller initial return – essentially zero – but one that jumps to 16.8% for schooling above $E_c = 6$. The

[3]There is also an aggregation problem. We use the *log of the average* (teacher) wage on the left-hand side of all of our regressions, but the correct variable is the *average of the log* of the wage. The smaller the variation in the wages of the population, however, the closer the two measures will be. Using the teacher-wage proxy may help the aggregation problem, since within countries the individual wage variation should be relatively small since it pertains only to the teaching profession.

[4]The RE technique assumes that the country effect η is *not* correlated with the explanatory variable E. The FE technique assumes the opposite.

[5]The R^2 for the random-effects model is not a true R^2.

Table 1 – Return to Education

Dependent Variable is Log of Wage								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	RE	FE	RE	FE	RE	FE	RE	FE
E	0.122**	-0.029	0.105**	-0.052	0.151**	0.013	0.016	-0.212**
	[0.00]	[0.55]	[0.00]	[0.30]	[0.00]	[0.80]	[0.71]	[0.00]
$\tau (E-6)$	0.114**	0.168**						
	[0.01]	[0.00]						
τ			-0.412	-0.743*				
			[0.15]	[0.02]				
τE			0.096*	0.153**				
			[0.02]	[0.00]				
Π					-0.021+	-0.032*		
					[0.10]	[0.02]		
ΠE					0.003*	0.004**		
					[0.01]	[0.00]		
E^2							0.014**	0.021**
							[0.00]	[0.00]
Constant	7.957**	8.536**	7.991**	8.591**	7.940**	8.491**	8.106**	8.849**
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
N	509	509	509	509	499	499	509	509
Countries	102	102	102	102	99	99	102	102
Overall R^2	0.44		0.45		0.45		0.44	
Adj. R^2		0.27		0.27		0.28		0.29

Notes: Robust p values in brackets. **significant 1%; * at 5%;

more general specification of Equation (4) that is estimated in Columns (3) and (4) shows similar magnitudes, depending on whether we use fixed- or random-effects.[6]

When we substitute the proportion of high-school graduates Π for the indicator τ, as in Columns (5) and (6), the return to schooling remains high and significant and, as the theory predicts, rises with the proportion of graduates. The coefficients on $\Pi_{jt}E_{jt}$ are significant in both specifications.

In the last two columns, we show the quadratic specification. For the RE version – Column (7) – the rate of return appears to be nearly proportional to the amount of schooling in the country, since the coefficient on E_{jt} is low and insignificant, but the coefficient on ${E_{jt}}^2$ is positive and very significant at 0.014. Curiously, in the FE specification, the return is *negative* at low levels of education. This is not realistic, and probably indicates that this specifications is not correct.

We conclude that there is substantial evidence favoring some degree of threshold effects. It appears that a threshold effect operates at the aggregate level. After the population reaches a certain

[6]There is also a discrete upward jump in the *level* of $\ln w$ after $E_c = 6$ is passed in this model.

average level of schooling, further schooling raises every individual's human capital at a greater (but constant) rate. In the coming section, we use the results in Column (1) of Table 1 to construct a series of human capital for the countries in our sample.

4 Constructing Human Capital

The results above suggest that threshold effects and increasing returns are important in the generation of human capital at the national level. Of the different regressions that we ran in the previous section, we prefer that in Column (1) of Table 1, the spline form – represented by Equation (2) – using the random-effects (RE) estimate. For the first 6 years of school, the rate of return is 12.2% ($\gamma_1 = .091$). After that, it rises to 23.6% ($\gamma_1 + \gamma_2 = 0.236$).

These figures imply the following equation to construct a series for human capital across countries:

$$\ln H_{jt} = \ln H_0 + .122 \left[\tau_{jt} 6 + (1 - \tau_{jt}) E_{jt}\right] + .236 \tau_{jt} (E_{jt} - 6) \tag{7}$$

We follow Hall e Jones (1999) and assume that the base level of human capital is 1, so that $\ln H_0 = 0$. To construct an empirical measure for human capital, the only data we need are the values of E_{jt} for different countries and time periods. We end up with a panel of 967 observations for average years of schooling; it comprises 125 countries distributed over five-year intervals between 1960 and 2000 (nine 5-year periods). We have gaps for some countries, and others start late or end early.

In Table 2, we show average human capital per person h by region of the world for our first year 1960 and our last year 2000.[7] We also show human capital *relative* to the US for those two years. We call this h_r. The last two rows shows the data for the US.

Every region has made progress: h has grown everywhere. In Western Europe and the other OECD countries, it grew by 90%. In Latin America, it grew, but not as strongly, by 60%. Even in Sub-Saharan Africa, there was an increase in h of 25%. However, nowhere did it grow more strongly than in the US, where it stood 133% greater at the end of our period when compared to the beginning.

In spite of the real progress around the world, all of the regions fell behind the US in the accumulation of h over time. We see this most clearly by looking at the h_r series. The region with the highest relative human capital in 2000 was Western Europe, and it was only 55% of the US level. Latin America fell from a relative level of 39% to one of 26% over this period. Sub-Saharan Africa in 2000 had human capital only 18% of that in the US. South Asia was even worse, with 17%.

5 Decomposing Output

In this section, we show how output across countries and regions may be decomposed into the contributions of its underlying elements. Human capital plays a significant part in explaining cross-country variation.

We assume that output is produced using a conventional neoclassical production function:

$$Y = K^{\alpha} (AH)^{1-\alpha} \tag{8}$$

[7] The regions are those defined by the World Bank. In this classification, the US, Japan, and Canada are put in the group with Western Europe.

Table 2 – Human Capital By Region

(1)	(2)	(3)	(4)	(5)	(6)
Region	*Year*	h	*% change*	h_r	*% change*
West Europe & OECD	1960	2.47		0.67	
West Europe & OECD	2000	4.70	90.46%	0.55	-18.37%
East Asia & Pacific	1960	1.35		0.37	
East Asia & Pacific	2000	2.16	59.84%	0.25	-31.49%
East Europe & C. Asia	1960	2.11		0.58	
East Europe & C. Asia	2000	4.01	89.92%	0.47	-18.60%
Latin America & Carr.	1960	1.44		0.39	
Latin America & Carr.	2000	2.24	54.94%	0.26	-33.59%
Mid. East & N. Africa	1960	1.09		0.30	
Mid. East & N. Africa	2000	1.85	69.53%	0.22	-27.34%
South Asia	1960	1.16		0.32	
South Asia	2000	1.45	25.43%	0.17	-46.24%
Sub-Sahara Africa	1960	1.17		0.32	
Sub-Sahara Africa	2000	1.50	28.71%	0.18	-44.84%
United States	1960	3.67		1.00	
United States	2000	8.56	133.32%	1.00	0.00%

where Y is total output, K is the capital stock, A is productivity, and H is total human capital. Assume that $H = hL$, where h is average human capital per persion and L is the number of workers. As in Hall e Jones (1999), output per worker $y \equiv \frac{Y}{L}$ can be decomposed in the following way:

$$y = Ak^{\rho}h \tag{9}$$

where $k \equiv \frac{K}{Y}$ is the *capital intensity* and $\rho \equiv \frac{\alpha}{1-\alpha}$.

To decompose output per worker into each of its components in (9), we need independent measures for three of the four variables. We have already constructed the series for h: it is recorded for regions in Table 2. Our data for y comes from the Penn World Table v. 6.2 (HESTON; SUMMERS; ATEN, 2006)) – we use the $RGDPWK$ series. We construct a capital series using the perpetual inventory method.[8] To get capital intensity, we divide our capital series by $RGDPL$ from the Penn World Table. We set $\alpha = .33$, which is a standard value. Last, productivity A is found as the residual once the other series in (9) have been constructed.

In Table 3 we show the decomposition for a sample of countries in Western Europe and the OECD, and in Latin America, *relative to the United States*. In column (3) we see that many countries in Europe are gaining ground on the United States in terms of income per worker. In Latin America, the record is not as good: Brazil and Chile have managed to keep pace, and grow about as fast as the US, but Argentina, Venezuela, and Mexico have fallen behind.

[8] We constructed K as follows. First, we found the initial capital stock: $K_0 = \frac{I_a}{g+\delta}$. In this expression, I_a is the average of the first four observations of investment in each country, g is technology growth and δ is depreciation. We assume $g = .02$ and $\delta = .06$ in all countries. Second, we applied the recursive formula $K_{t+1} = (1-\delta)K_t + I_t$ to fill out later values of K. We use the earliest observation possible, which is 1960 in most cases.

Those countries that are catching up, like France, Ireland, and Portugal, have done so primarily through gains in productivity A. Their human capital, as we saw above at the regional level, has not kept up. This is also true of Brazil and Chile: productivity has increased markedly in both countries, but human capital growth has been a disappointment. Physical capital intensity has stayed about the same in Europe and Latin America, although Chile has seen a decided drop in its capital intensity relative to that in the US.

Table 3 – Decomposition of Output per Worker

(1)	(2)	(3)	(4)	(5)	(6)
Country	*Year*	y	k^ρ	h	A
Western Europe and Industrialized					
France	1965	0.69	1.15	0.46	1.30
France	2000	0.73	1.10	0.40	1.65
Ireland	1965	0.41	1.03	0.52	0.77
Ireland	2000	0.73	0.90	0.47	1.73
Portugal	1965	0.32	1.06	0.30	0.98
Portugal	2000	0.50	1.04	0.20	2.39
UnitedKingdom	1965	0.75	1.02	0.61	1.19
UnitedKingdom	2000	0.72	0.97	0.50	1.47
UnitedStates	1965	1.00	1.00	1.00	1.00
UnitedStates	2000	1.00	1.00	1.00	1.00
Latin America and Caribbean					
Argentina	1965	0.56	1.01	0.43	1.30
Argentina	2000	0.33	0.93	0.41	0.86
Brazil	1965	0.21	1.07	0.32	0.59
Brazil	2000	0.21	0.96	0.19	1.12
Chile	1965	0.34	1.40	0.40	0.60
Chile	2000	0.33	0.94	0.36	0.99
Mexico	1965	0.28	1.00	0.31	0.90
Mexico	2000	0.24	0.93	0.27	0.93
Venezuela	1965	0.45	1.07	0.31	1.34
Venezuela	2000	0.21	0.93	0.22	1.05

In Table 4 we decompose the variance of y into the variance explained by each of the three components.[9] We do this for the world as a whole, for the OECD (mostly Europe, North America, and Japan), and for Latin America, separately, pooling the data from all nine time periods.

The most surprising result concerns the results for the OECD. Of the variation in y, the great majority is explained by variation in human capital, h. One might think this is due to the influence of the US, which we have seen has experienced growth in h far in excess of its European partners. This, however, is not the case. Even without the US (column 4), the majority of the variation in y is accounted for by variation in human capital.

[9]To do this we run three separate regressions of the form $\ln Z_{jt} = \alpha + \beta \ln y_{jt} + \epsilon_{jt}$, where Z_{jt} is variously k^ρ , h, or A. Table 4 reports the β coefficients from these three regresssions in the different regions.

Table 4 – Variance Decomposition

Variance of y explained by:	*Region*			
	World	*OECD*	*OECD no USA*	*Latin America*
k^ρ	0.19	0.10	0.12	0.12
h	0.38	0.67	0.63	0.38
A	0.43	0.23	0.25	0.50
Total	1.00	1.00	1.00	1.00
N	739	182	174	178

6 Conclusion

In this paper we have investigated the idea that a critical mass of educated people raises the return to schooling discontinuously. That is, we tested for a threshold effect at the aggregate level. All four of our specifications supported that idea, and we used one of them – the RE version of a linear spline function – to construct a series of human capital for several countries around the world and over time.

One conclusion was that the US has experienced considerably more growth in human capital than the average of any other *region*. This is not to say that some countries did not increase their education as fast or faster than the US, but there were not many. Notably, however, Norway, Sweden, Finland, Romania, Bulgaria, Malaysia, and South Korea were able to do so.

Combining our human capital construct with a measure of capital, we were able to decompose output per worker into its three components: capital intensity, human capital, and productivity. In comparing Europe with Latin America, we saw that Europe tended to have much greater productivity, but we did not test this stastitically. We looked, finally, at the fraction of the variance in output per worker that was explained by the three components. We did it for the world, for the OECD region, and for Latin America. Remarkably, we found that in the OECD region the majority of the variance of output per worker was due to differences in human capital.

If there is indeed a threshold effect, it becomes quite important to make efficient investments in human capital. Within-country and micro studies, moreover, may not detect any evidence of a threshold because it operates as a critical-mass externality and because at the aggregate level they have not reached the level where it begins to operate.

References

BARRO, R. J.; LEE, J.-W. International data on educational attainment: Updates and implications. *Oxford Economic Papers*, v. 53, n. 3, p. 541–63, July 2001. Http://ideas.repec.org/a/oup/oxecpp/v53y2001i3p541-63.html.

BILS, M.; KLENOW, P. J. Does schooling cause growth? *American Economic Review*, v. 90, n. 5, p. 1160–1183, December 2000. Disponível em: <http://ideas.repec.org/a/aea/aecrev/v90y2000i5p1160-1183.html>.

EASTERLY, W.; LEVINE, R. ItÂ´s not factor accumulation: Stylized facts and growth models. In: LOAYZA, N. et al. (Ed.). *Economic Growth: Sources, Trends, and Cycles*. Central Bank of Chile, 2002, (Central Banking, Analysis, and Economic Policies Book Series, v. 6). cap. 3, p. 061–114. Disponível em: <http://ideas.repec.org/h/chb/bcchsb/v06c03pp061-114.html>.

HALL, R. E.; JONES, C. I. Why do some countries produce so much more output per worker than others? *The Quarterly Journal of Economics*, v. 114, n. 1, p. 83–116, February 1999. Http://ideas.repec.org/a/tpr/qjecon/v114y1999i1p83-116.html.

HECKMAN, J.; LAYNE-FARRAR, A.; TODD, P. Human capital pricing equations with an application to estimating the effect of schooling quality on earnings. *The Review of Economics and Statistics*, v. 78, n. 4, p. 562–610, November 1996. Disponível em: <http://ideas.repec.org/a/tpr/restat/v78y1996i4p562-610.html>.

HESTON, A.; SUMMERS, R.; ATEN, B. *Penn World Table Version 6.2*. [s.n.], 2006. Disponível em: <http://pwt.econ.upenn.edu/php_site/pwt_index.php>.

HUNGERFORD, T.; SOLON, G. Sheepskin effects in the returns to education. *The Review of Economics and Statistics*, v. 69, n. 1, p. 175–77, February 1987. Disponível em: <http://ideas.repec.org/a/tpr/restat/v69y1987i1p175-77.html>.

JAEGER, D. A.; PAGE, M. E. Degrees matter: New evidence on sheepskin effects in the returns to education. *The Review of Economics and Statistics*, v. 78, n. 4, p. 733–40, November 1996. Disponível em: <http://ideas.repec.org/a/tpr/restat/v78y1996i4p733-40.html>.

KLENOW, P.; RODRÍGUEZ-CLARE, A. The neoclassical revival in growth economics: Has it gone too far? In: *NBER Macroeconomics Annual 1997, Volume 12*. National Bureau of Economic Research, Inc, 1997, (NBER Chapters). p. 73–114. Disponível em: <http://ideas.repec.org/h/nbr/nberch/11037.html>.