

# The Kuznets Curve of Education: A Global Perspective on Education Inequalities 1870-2010\*

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## Abstract

This paper describes global trends in average educational attainment and in education inequality since 1870, improving the database released by Morrisson-Murtin (2009). Inequality in years of schooling is found to be rapidly decreasing, a direct consequence of the decline in illiteracy. Then, we turn to human capital inequality, and focus, among several other alternatives, on a Mincerian production function of human capital that accounts for diminishing returns to schooling. Within countries, we find evidence of an inverted U-shape curve for human capital inequality, namely a Kuznets curve of education. At the world level, human capital inequality has followed a similar pattern, first increasing from 1870 to 1970, then decreasing.

**JEL classification:** D31, E27, F02, N00, O40.

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# 1 Introduction

Education is recognized to be a key factor of economic development, not only giving access to technological progress as emphasized by the Schumpeterian growth theory, but also entailing numerous social externalities such as the demographic transition (Murtin, 2009) or democratization (Murtin and Wacziarg, 2010). If the evolution of world distributions of income and longevity over the last two centuries have been described by Bourguignon and Morrisson (2002), changes in the world distribution of education have remained unexplored until now, despite their major importance.

How has global education inequality evolved over the twentieth century? How should it be measured? Up to now, existing studies on education inequality have had limited spatial and time coverage. For example, Castello and Domenech (2002) and Thomas et al. (2001) provide a descriptive analysis of years of schooling inequality for a broad panel of countries, but their study starts only in 1960. Also, they remain at the country level and do not consider the world distribution of years of schooling, which takes into account educational differences both within and between countries.

In contrast, this paper depicts the world distribution of education over 140 years, improving and extending the database recently released by Morrisson and Murtin (2009), which focuses on average years of schooling. We provide both average years of schooling and the distribution of education as summarised up by four quantiles<sup>1</sup> in each country. Importantly, this new database is cross-validated by historical data on illiteracy rates. Then, we describe average stocks of primary, secondary and tertiary schooling by region since 1870, and estimate world inequality in years of schooling, which has been dramatically reduced since 1870.

Focusing on the measurement of education inequality, this paper raises an important methodological issue. We show that a substantial share of inequality in years of schooling can be mechanically explained by a single component of the distribution of

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<sup>1</sup>individuals with no schooling, with only primary schooling, with primary and secondary schooling, and those having received higher education.

education, namely the population that has not attended school, subsequently called the illiterate population. Actually, we find that the observed decrease in inequality in years of schooling over the XXth century is almost entirely explained by the decline in illiteracy. We believe that this result, derived both theoretically and empirically, could help to reconsider an empirical fact discussed in the literature on education inequality (see Berthelemy (2006)), namely the cross-country negative correlation between the average of and the inequality in years of schooling. This correlation mainly reflects the negative and mechanical correlation between average schooling and the illiteracy rate.

In line with a recent macroeconomic literature (see for instance Hall and Jones (1999)), we then turn to human capital as defined by Mincer (1974), in order to confer a monetary dimension to education. We propose estimates of the world inequality in human capital, examining several definitions for human capital. We focus on one functional form in particular, which accounts for the existence of diminishing returns to schooling. It is the only one that can account for the cross-country negative correlation between Mincer returns to schooling and average years of schooling, as described by Psacharopoulos and Patrinos (2004). At the national level, we find that that human capital inequality within countries has increased then stabilized or even decreased in most regions of the world. When plotted against average years of schooling, human capital inequality within countries has clearly followed an inverted U-shape curve, namely a “Kuznets curve of education”. At the global level, we also find that human capital inequality has increased from 1870 to approximately 1970, then has decreased. We interpret these findings as a consequence of mass education and the existence of diminishing returns to schooling.

Section 2 introduces the methodology and the data. Section 3 examines the world distribution of education since 1870. Section 4 focuses on global inequality in education, while Section 5 looks at global human capital inequality. In Section 6 we describe human capital inequality within countries, while last section concludes.

## 2 Methodology and data

For the sake of comparability with income inequality data provided by Bourguignon and Morrisson (2002), we have selected a sample of large countries and merged countries of smaller size. For GDP per capita and population, we updated the data from the latter authors using last estimates from Maddison (2008). As regards education, we have built an original database on national distributions of education for 78 countries since 1870, extending the recent database constructed by Morrisson and Murtin (2009) who display only average years of schooling. Country-level data has been averaged to obtain a final sample of 32 macro-countries, which correspond to at least 90% of world population at any period. Each country or country group represents at least 1 per cent of world population or world GDP in 1950. In order to facilitate the presentation of results, these macro-countries have been aggregated into eight blocks, defined geographically, historically or economically: Africa, Latin America excluding Argentine and Chile, Eastern Europe, Western Europe (including Austria, Czechoslovakia and Hungary) and its offshoots in America (Argentina, Chile, Canada and the US) and in the Pacific (Australia and New-Zeland), China, India (including Bangladesh and Pakistan), Japan and Korea, as well as some other Asian countries.

We improve educational data from Morrisson and Murtin (2009) in several ways. As described in details in an extensive annex that also displays the underlying data, we take into account differential mortality across educational groups to correct the educational distributions after 1960 originally borrowed from Cohen-Soto (2007). Before 1960, we account for immigration, which has been intense in some countries over the XIXth and early XXth centuries (for the US, see Murtin and Viarengo, 2010). Most importantly, we have built a secondary database on illiteracy rates, containing 179 observations mainly taken from Unesco (1957), to cross-check our data and correct implausible figures. We have proceeded as follows. Given the calculated stocks  $H^{P,S,H}$  of primary, secondary and tertiary schooling and assumptions on average du-

ration at school<sup>2</sup>, we can infer the percentage  $p^P$  of the population displaying only primary schooling, the percentage  $p^S$  of the population displaying primary and secondary schooling, the percentage  $p^H$  of the population displaying primary, secondary and tertiary schooling, and the complementary part, the percentage  $p^I$  of the population that has not attended school. These percentages are given by

$$\left\{ \begin{array}{l} H^P = h^P p^P + 6 (p^S + p^H) \\ H^S = h^S p^S + 6 p^H \\ H^H = h^H p^H \\ p^P + p^S + p^H + p^I = 1 \end{array} \right. \quad (1)$$

where  $h^{P,S,H}$  are equal to average durations. Based on these equations, the implicit percentage of non-scholarized population  $p^I$  can be compared with the country-level observed illiteracy rate over the period 1870-1950. As shown by Figure 1, the resulting correlation is equal to 0.98, and there is no significant outlier. We do not expect the two variables to match perfectly. Indeed, we acknowledge the fact that illiteracy and school non-attendance are two distinct issues. For instance, pupils who have attended school for a few years could still be technically illiterate, while people who have never attended school could have received some literacy within the household or at some unreported church-based school. However, Figure 1 suggests that they do compare well with each other and this confers some consistency and credibility to our database.

Lastly, inequality indices are computed on the distribution of the educational quantiles (4 groups x 32 macro-countries = 128 groups). All groups are pooled and ranked according to the number of years of education and then the cumulative function and

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<sup>2</sup>As Morriison and Murtin (2009) we have assumed that completed primary and secondary were lasting a maximum of six years. This assumption is a rough estimate that we have to use because there is no detailed information on the duration of primary and secondary schooling in each country from 1870 to 2000. Obviously durations vary by country and over time. For instance, France currently has five years in primary and seven in secondary. But until 1950, the pupils engaged in secondary schooling left primary school after five years, but the others - who represented a large majority - remained in primary school for seven years. Tertiary is assumed to last a maximum of four years. These assumptions ensure comparability across time and countries of education distributions, in spite of the many international reforms of schooling systems over that period.

the Lorenz curve of the world distribution of education are computed. We assumed no heterogeneity in years of schooling inside each group, without any loss in generality<sup>3</sup>.

### **3 Global Trends in Educational Achievement since 1870**

Table 1 presents the distribution of years of schooling at the world level since 1870. In the mid-twentieth century, the world was divided into two classes: Those who have attended school, and those who have not. Over the whole period, Figure 2 clearly shows a huge reversal, as illiterates and educated individuals are roughly in reverse proportions in 1870 and in 2010. What explains this result is clearly the development of primary schooling, whose attendance involved 20% of the world population in 1870 and 82% in 2010. Moreover, 45% of the world population attended secondary education in 2010, but this development is quite recent since this proportion was about 20% in 1960. In a sense, higher education is the contemporary equivalent of secondary schooling in 1950: 11% of the world population attained higher education in 2010, which represents about a third of the population displaying only secondary education. In contrast, in 1950, the latter group amounted to 13% of the world population or about a third of the population with only primary schooling. Lastly, the overall level of schooling has been multiplied by 6, this increase being inequally spread over the period. Indeed, the absolute increase was less than 3 average years of schooling between 1870 and 1960, but equal to 3.5 years over the last fifty years. However, the increase in schooling attainment has slowed down over the last decade.

The global rise in schooling attainment has been unequally distributed across countries. Table 2 provides a geographical overview of education attainment, together with total average years of schooling, average years of primary and secondary schooling, as well as the illiteracy rate. There were three distinct groups in 1870. In Western Europe

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<sup>3</sup>As the number of grades used to describe the schooling distribution could influence the resulting inequality levels, we have compared our results with those obtained from a smoothed schooling distribution. The main conclusions of the paper remain the same.

and offshoots, schooling exceeded 3 years. In Latin America, Eastern Europe, Japan, Korea and China, it was comprised between 0.6 and 1 year. In Africa, South Asia (India, Bangladesh and Pakistan) and other Asian countries, average schooling was less than 0.15 years. The illiteracy rate was about 36% in the first group, 80% in the second one, and above 95% in the third one. These figures highlight the huge gap between Western Europe and the third group. Another important point is the advance of China and Japan with respect to other Asian countries, the Indian empire and Africa. In the former two countries average schooling was about one year (education was higher in Japan than in Korea). Actually this means that around 40% of men and 10% of women could read and write 2000 graphic signs, which requires about 4 years of schooling. A small minority knew several thousand signs after 6 or 8 years of schooling. As the average educational attainment in China and Japan was approximatively the same at the beginning of the eighteenth century, these countries were the only ones in the world that had the same average schooling than Western Europe three centuries ago.

In 2010, the group of less advanced countries is only composed of Africa and South Asia, because average schooling in other Asian countries has increased much more than in India, Bangladesh and Pakistan. Moreover, Japan and Korea, as well as Eastern Europe to a lesser extent, have caught up with Western Europe. In the intermediate group, we find Latin America, China, and other Asian countries with average schooling being around 8 years. The difference between Western Europe and this group are about five average years of schooling, which roughly decompose into one year of primary schooling, three years of secondary schooling, and one year of higher education. Figure 3 illustrates clearly the process at work. It is striking that no global convergence in average educational levels has been observed in the postwar period.

Illiteracy, which was a common rule in 1870 with rates exceeding 80% everywhere except in Western Europe, is now a regional problem. It remains substantial only in Africa, more precisely in Sub-Saharan Africa, and in South Asia with rates around

40% in 2010.

Changes in the world distribution of education since 1870 are revealed by Table 3 that shows the regional composition of two world quantiles, namely the bottom 80% and the 10th decile (the first line indicating the population distribution). The main factors explaining the time variations are the differences in the growth rates of average education and of population.<sup>4</sup> Between 1870 and 1910, Western Europe and its offshoots had an edge on the rest of the world. Indeed, the share of Western Europe in the top decile reached almost 60%. It was equivalent to the share of the same region in the top income decile, 64%. If we consider that secondary schooling was the condition of access to technology, in 1910, Western Europe had in some respect the quasi-monopoly of advance in knowledge and technology. Today this monopoly has disappeared. The share of Western Europe in the top decile is equal to 41% in 2010, which represents a loss of 20% within a century. In contrast, the share of Asia (including China, Japan, Korea, South Asia) has reached 43% of the top decile, an increase of 15% with respect to 1910. The world distribution of education is therefore less polarized today than it was a century ago.

Africa is on the other side of the distribution. Firstly, it is today the poorest region in the world, but this handicap is not new. In 1870, the share of Africa in the top decile was about 0.6%. This is partly a legacy of the past. At the beginning of the XIXth century nearly all African population was illiterate, except the Arab population in Northern Africa, while in Asia nearly 40% of Chinese and Japanese men could read and write. Even if the situation remains unfavourable, education is growing in Africa, although at a lower pace than in other regions of the world. But one shall remember the situation over the XIXth century in order to understand its current lag.

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<sup>4</sup>For instance, the shares in world population of Latin America and Africa respectively, have been multiplied by 3 and 2 between 1870 and 2000, whereas the shares of Western Europe and Eastern Europe have decreased.



## 4 Inequality in years of schooling

In this section we analyse global inequality in years of schooling. Table 4 reports the observed trends for the coefficient of variation, the Gini and the Theil indices<sup>5</sup>. Table 4 shows an exceptionally high level of inequality in 1870 with a Gini coefficient reaching 0.82 and a Theil index of 1.56. The world in 1870 was characterized by a huge gap between the literate and illiterate populations, which is inconceivable by current standards. Throughout the period, years of schooling inequality has decreased continuously so that the Gini coefficient has been divided by more than two, while the Theil index amounts to less than a quarter of its original level.

It is meaningful to draw a comparison between illiteracy and extreme poverty (less than 1 dollar a day). Between 1870 and 1990, the illiteracy rate has decreased from 76% to 27% and extreme poverty from 75% to 24%. Therefore, the evolutions of these two essential indicators, namely the percentages of people who do not have access to education or to a minimum income are parallel and illustrate an unprecedented improvement.

The decomposition of schooling inequality into two components is instructive, as it shows that both the within and the between components of schooling inequality have decreased dramatically between 1870 and 2010. For the period 1960-2000 our estimates are consistent with those of the World Bank (2005), which do not take into account the weighting by population. Despite this difference, we observe a comparable decrease of the Theil Index (-60% according to the World Bank, 2005, versus -76% for our estimate). In total inequality, the contribution of the between component is small in 2010, as it represents only 23% for the Theil index, a figure in agreement with the World Bank estimate (less than 20%). It is the exact opposite for income inequality between countries, which represented two thirds of total income inequality in 1992 (Bourguignon-Morrisson, 2002). Similarly, the gap between the poorest region,

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<sup>5</sup>the mean logarithmic deviation was not reported since it is only defined over strictly positive outcomes.

Africa, and Western Europe for average schooling is only 1 to 3, instead of 1 to 12 for average income.

However, computing inequality in years of schooling raises a couple of comments and criticisms, that we enumerate now. Firstly, we observe opposite trends in income and years of schooling inequalities, as mentioned above. How to reconcile those trends, if not by reconsidering the relevance of years of schooling as the appropriate educational factor of production ?

Second, inequality indices might be “excessively” sensitive with respect to individuals endowed with zero years of schooling<sup>6</sup>. As reported in Table 4, if we exclude the illiteracy group and compute a Gini index on educated individuals only, we find a Gini equal to 0.24 in 1870, 0.28 in 1950, and 0.23 in 2010. It is disturbing that the bulk of inequality in years of schooling captures illiteracy, and that variations in schooling inequality reflect mainly illiteracy’s decrease. Some studies (Castello and Domenech, 2002, or Berthélemy, 2006) have already pointed at the negative correlation between years of schooling inequality and average years of schooling, offering various explanations. The following proposition shows that there is a mechanical link between illiteracy and years of schooling inequality.

**Proposition 1.** *Let  $f$  be the distribution of a random variable  $X$  taking values over a domain  $[m, M]$  with  $0 \leq m < +\infty$  and  $M \leq +\infty$ . Assume that this distribution can be decomposed as the mixture*

$$f(x) = p\delta_{x=m} + (1 - p)g(x) \quad (2)$$

where  $\delta_{x=m}$  is a mass point in the minimum value and  $g$  the distribution of the population for which  $X > m$ . Let  $\mu(f)$  be the mean outcome for a distribution  $f$ ,  $G(f)$  the corresponding Gini index, and  $I_{GE}^\alpha(f)$  the Generalized-Entropy index. The Gini index

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<sup>6</sup>For instance, if we remember that the Gini index is twice the area situated below the Lorenz curve, then illiteracy should have a huge impact on this index by shifting away the origin of the curve from zero to the percentage of illiterates in the population.

can be decomposed as follows

$$G(f) = p \frac{\mu(f) - m}{\mu(f)} + (1 - p) \frac{\mu(f) - pm}{\mu(f)} G(g)$$

and similarly for the Generalized-entropy indices  $I_{GE}^\alpha(f)$ , with  $\alpha \neq 0$ <sup>7</sup>

$$I_{GE}^\alpha(f) = (1-p)^{1-\alpha} \left( \frac{\mu(f) - pm}{\mu(f)} \right)^\alpha I_{GE}^\alpha(g) + \frac{1}{\alpha^2 - \alpha} \left( (1-p)^{1-\alpha} \left( \frac{\mu(f) - pm}{\mu(f)} \right)^\alpha + pm^\alpha \mu(f)^{-\alpha} - 1 \right)$$

*Proof.* see in annex □

An application to years of schooling follows immediately. Taking  $m = 0$ , the proposition shows that the Gini index computed on the whole population is a linear combination of the illiteracy rate and the Gini index computed on the educated population. Formally  $G(f) = p + (1 - p)G(g)$ , and as a particular case, the Theil index decomposition is obtained when  $\alpha \rightarrow 1$ , so that  $\text{Theil}(f) = \text{Theil}(g) - \ln(1 - p)$ .

The above proposition shows that variations in illiteracy explain *almost all* of years of schooling inequality variations over the period. Indeed, let us assume that inequality among the educated population remains equal to 0.25, its grand average. According to the latter formula, an illiteracy level of 76% should set the Gini index calculated for the whole population at a value of 0.82, while an illiteracy level of 18% would bring it at 0.39. These figures are extremely close to the actual values of the Gini index calculated on the whole population (0.82 in 1870 and 0.37 in 2010), showing that *all* of the decrease of the latter index between 1870 and 2010 is encompassed into illiteracy's decline. Consequently, the cross-countries negative correlation between average schooling and schooling inequality depicted in the literature simply reflects the negative correlation between average schooling and illiteracy, which is mechanical.

Moreover, there is a profound reason to worry about the calculation of inequality in schooling. The issue is the non-monetary dimension of years of schooling. The

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<sup>7</sup>the proposition is still valid for the Mean Logarithmic Index, i.e. when  $\alpha = 0$ , if  $m > 0$ .

marginal cost or the marginal benefit of an additional year of higher education is not equal to those of an additional year of primary schooling. The crucial issue in the measurement of inequality in education is certainly the search for a equivalence scale for years of schooling. Focusing on human capital is one solution to that problem, and we hold next section as the main methodological contribution of our paper.

## 5 Inequality in Human Capital

### 5.1 Defining human capital

The macroeconomic literature has gradually moved away from considering average years of schooling as a factor of production, as in Mankiw et al. (1992), to focus on the Mincerian definition of human capital as proposed by Hall and Jones (1999). For an educational group  $j$  in a country  $i$  at date  $t$  let us define human capital  $h_{i,j,t}$  as:

$$h_{i,j,t} = e^{r_{i,j,t} S_{i,j,t}}$$

where  $S_{i,j,t}$  is average years of schooling of quantile  $j$  and  $r_{i,j,t}$  the return to schooling.

For the sake of simplicity, it is convenient to rule out any heterogeneity in the return to schooling across time, countries and quantiles<sup>8</sup>. This simplification will tell us how the exponential functional form modifies the results on years of schooling inequality. Thus, we first set  $\forall i, j, t, r_{i,t} = r$ , while considering an average world return to schooling of 10% following Psacharopoulos and Patrinos (2004).

As a second step, we argue that the return to schooling declines with the level of educational attainment. In other words, schooling has diminishing returns. As described extensively by Psacharopoulos and Patrinos (2004)<sup>9</sup>, the returns to schooling

<sup>8</sup>We also rule out any externality of education.

<sup>9</sup>see their Table 1 and 2 on returns to investments in education. As the latter include tuitions and taxes, they are slightly different from Mincer returns as emphasized by James J. Heckman et al. (2005), who point at the higher returns of some *specific* years of schooling such as graduation years. We could not include these refinements in our historical framework.

are higher for primary schooling than for secondary or higher education, whatever the level of development and the geographical zone of the country. In order to account for that pattern, we follow Mincer (1974) and Card (2001) among others and consider the Mincer equation with a quadratic function of schooling for each country  $i$  at time  $t$

$$\log y_{i,j,t} = a + \rho S_{i,j,t} - \frac{1}{2} k S_{i,j,t}^2 + u_{i,t} \quad (3)$$

where  $y$  is income. Once the above equation is derivated with respect to schooling, one obtains the following return to schooling

$$r_{i,j,t} = \rho - k S_{i,j,t} \quad (4)$$

Then, we need to estimate some plausible values for coefficients  $\rho$  and  $k$ . If the latter equation is valid for all educational groups  $j$  - in particular if  $\rho$  and  $k$  do not depend on the educational group  $j$ , are constant across countries and throughout time - one can simply estimate these two coefficients by regressing the observed, national, Mincerian return to schooling on average years of schooling. As shown by Figure 4, we have matched the returns to schooling of 59 countries taken from Psacharopoulos and Patrinos (2004) with our data on average schooling attainment at corresponding dates (around 1990), and estimated the following OLS regression:

$$r_i = 0.125 - 0.0040 S_{i,,t} + u_i \quad (5)$$

(0.009)      (0.0017)

Interestingly, we have found microeconomic evidence that cross-validates our choice of the structural parameters  $\rho$  and  $k$ . Using IUPMS Census data that depict 1% of the US population since 1940, we estimated Mincer equations (5) every 10 years since 1940, while adding extra controls for experience. Table 5 shows that from 1940 to 1980, the quadratic function for schooling is found to be concave as expected. For

1990 and 2000, it turns out to be convex, but the schooling variable upon which this result relies is less accurate<sup>10</sup>. Importantly, the average microeconomic estimates for the US over the period 1940-1980 are  $\rho = 11.1\%$  and  $k_{=2} * 0.00155 = 0.0031$ , which are fully consistent with the macroeconomic estimates drawn from the cross-country analysis. These findings suggest that the negative correlation between returns to schooling and average education highlighted by Psacharopoulos and Patrinos (2004) stems from a *composition effect*, as more educated cohorts display a lower return to schooling. As a result, our benchmark definition of human capital of educational group  $j$  in country  $t$  is as follows:

$$h_{i,j,t} = e^{0.1254S_{i,j,t} - 0.002S_{i,j,t}^2} \quad (6)$$

from which average human capital in country  $i$  can be deduced by averaging over all educational quantiles.

The choice of a particular functional form is important because the rest of the paper relies on it. The one we focus on is widely used in applied microeconomic studies, and has the important property of exhibiting diminishing returns to education. But there is another functional form, mostly used in theoretical studies<sup>11</sup>, with such a property. This alternative form is the power function which states that human capital is equal to

$$h_{i,j,t} = (\theta + S_{i,j,t})^\alpha \quad (7)$$

For comparability purposes with the Mincer function it is convenient to set  $\theta = 1$  so that uneducated workers receive one unit of human capital. The power function has diminishing returns to schooling equal to  $\alpha/(1 + S_{i,j,t})$ . For each country in 1990, we have computed the average return to schooling implied by the national distributions of education, choosing  $\alpha = 0.8$  as a convenient value. We found that this functional form entails a world distribution of returns to schooling that is not entirely supported

<sup>10</sup>IUPMS data display a detailed version of grades achieved until 1980, then years of schooling have to be reconstructed from a categorial variable.

<sup>11</sup>e.g. Matthias Doepke and David de la Croix (2003)

by the data. Indeed, for a range of values of  $\alpha$ , we either find much too high returns on the right tail of the world distribution of returns, or much too low returns on the left tail<sup>12</sup>. Hence, we present the results obtained with the power function for the sake of exhaustivity. But it should be borne in mind that our benchmark functional form given by (6) is the only one that delivers plausible returns to schooling, accounts for diminishing returns at the micro-economic level and fits at the same time the observed negative correlation between returns and average schooling.

## 5.2 Results

Table 6 provides estimates of human capital inequality for these three specifications ( $r = 10\%$ , diminishing returns and power function). Firstly, the contrast between schooling inequality and human capital inequality is striking, since their trends appear to be opposite until the second half of the XXth century. Indeed, while schooling inequality has always decreased, the Gini index of human capital inequality has increased by respectively 0.14 points ( $r = 0.10$ ), 0.08 points (diminishing returns) and 0.03 points (power function) between 1870 and 1970. After 1970, in any simulation and for any inequality index we find that inequality has fallen over time. In other words, global human capital inequality has followed an inverted U-shape curve that has peaked in the second half of the XXth century.

The initial increase in human capital inequality does not reconcile so well with declining schooling inequality and constant or decreasing returns to education. The explanation stems from the exponential transformation that magnifies inequality in years of schooling as the average level increases. To see this, let us consider for illustrative purposes that schooling has a normal distribution with mean  $m$  and coefficient of variation  $s$ . Laplace transformation of a normal variable simply provides the coefficient of

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<sup>12</sup>with  $\alpha = 0.8$  the smallest equivalent Mincer return is the US with 5.5% and the highest is Bangladesh-Pakistan with 25.7%; with  $\alpha = 1$  those values are respectively 6.8% and 31.5%.

variation of human capital  $h$  and a first-order approximation yields

$$s(h) = \sqrt{e^{r^2 m^2 s^2} - 1} \simeq r m s \quad (8)$$

where  $r$  stands for the return to schooling. Now it is clear that human capital inequality depends positively on inequality in years of schooling ( $s$ ), positively on the return to education ( $r$ ), and also positively on the average level of schooling ( $m$ ). Due to the convexity of the exponential function, inequality in human capital has increased throughout the century simply because countries have become more educated on average. Initially, this convexity effect has overcome the equalitarian effect induced by decreasing returns to education and more equal distribution of years of education. On a second step, the equalitarian effect has dominated and inequality in human capital has started decreasing.

The Mincer functional forms deserves a quick discussion. There are of course some limitations to the above framework. Most importantly, we have selected time constant parameters  $\rho$  and  $k$  and ruled out country-specific returns. But the goal of this paper is not to account for recent developments on the labour market, in particular the observed rise in the return to schooling<sup>13</sup>. It rather aims to propose a general framework where education is rescaled along a monetary dimension over 140 years. We believe that further refinements on the definition of the return to schooling would be more suited to case-studies. Besides, one important property of the Mincerian functional form is that inequality in human capital increases with average schooling as described above. This feature has a large influence as human capital inequality can increase even if inequality in years of schooling decreases significantly. Lastly, empirical studies generally use Mincer regressions in the context of wage-earner income. However, wage-earners do not necessarily constitute the bulk of the active population in developing countries. In

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<sup>13</sup>See among others Berman et al. (1998), Machin and Van Reenen (1998) and Machin (2004). Actually, we have tested the effect of introducing country-specific, autocorrelated, shocks on the return to schooling, while running a bootstrap experiment. All results were qualitatively unchanged.



a sense, it is not certain that our simplistic Mincerian framework would be sufficient, or even appropriate, to depict the labour market in rural areas. As underlined by Banerjee and Duflo (2007), many market failures affect very poor populations, so that marginal productivity and wages do not necessarily match over such imperfect markets (such as those having prevailed among socialist countries). From that perspective, our equivalence scale of education does not reflect *actual* human capital (income), but rather *potential* human capital in a counter-factual, well-functioning, labour market.

So far, the findings of the paper are as follows: i) inequality in years of schooling has declined dramatically because of illiteracy's decline; ii) the observed, aggregate, negative cross-country correlation between Mincer returns to schooling and average years of schooling can be accounted for by a human capital function with decreasing returns to schooling; iii) the convexity effect associated with the retained exponential functional form generates an unequalitarian effect that was initially larger than the equalitarian effect of falling schooling inequality; iv) from the second half of the XXth century onwards the equalitarian effect has dominated and global human capital inequality has unambiguously started falling. In the next section, we analyse the trends of human capital inequality within countries.

## **6 The Kuznets Curve of Education**

Figure 6 describes human capital inequality within countries in the eight geographical areas, in other words, it displays the regional average of human capital inequality within countries. The benchmark definition of human capital with decreasing returns to schooling is retained. Several facts emerge. Firstly, Western Europe and offshoots are the only place in the world where human capital within inequality has been continuously falling since 1870. In all other regions, inequality has increased sharply at least until the mid-XXth century. Secondly, in all regions of the world, human capital within inequality has stagnated or has started decreasing in the second half of the

XXth century. The timing of that reversal in trends varies across regions. In Japan and Korea, it took place around 1950, around 1970 in Eastern Europe and after 1980 in Latin America, Africa and Other Asian Countries. Human capital within inequality has stagnated in China, India, Bangladesh and Pakistan since 1980, and one can expect such a decrease to take place in a close future.

These patterns deeply echo with the well-known Kuznets (1955) hypothesis of an inverted U-shaped curve for income inequality within countries. Kuznets argued that because of sectoral shifts of workers and other reasons, income inequality may rise on a first step but would decline afterwards. This hypothesis has received much scrutiny in the empirical literature and is discussed by Lindert (2000) and Morrisson (2000) from a historical perspective. In our setting, we can make the same kind of hypothesis than Kuznets, namely that human capital inequality within countries follows an inverted U-shape curve along educational development.

Figure 6 plots human capital within inequality with respect to average years of schooling for the various macro-countries over the period 1870-2010.<sup>14</sup> As a result, we do find strong evidence of a “Kuznets curve of human capital inequality” over the period 1870-2010. Actually, human capital inequality culminates when countries reach a level of about 3-4 average years of schooling, which roughly corresponds to half of the population being illiterate, 40% receiving primary schooling and 10% secondary schooling (e.g. the world in 1950). It is fairly intuitive that human capital inequality is maximal when the transition from illiteracy to literacy is exactly at mid-course. This is actually what we observe.

A further issue focuses on the factors behind convergence in schooling among societies and the building of mass education. It is fairly beyond the scope of this paper to review all effects induced by, for instance, tax-funded public school systems, the introduction of compulsory years of schooling, decreasing returns to schooling, reli-

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<sup>14</sup>Same results would be obtained with other definitions of human capital, and by choosing human capital rather than schooling on the x-axis.

gion or ethical motivations. However, two powerful forces seem to emerge. One is the complementarity between education and technology, which has provided strong incentives to increase the educational level over time (e.g. Galor and Moav, 2006, Goldin and Katz, 2008). Another is the existence of a convex cost of schooling, or said differently, of decreasing returns to schooling, which arise from biological limitations and contribute to the homogenization of educational attainment. In that respect, Murtin and Viarengo (2010) have shown that the latter convergence effect and trade openness were the two major determinants of compulsory years of schooling among Western European countries after 1950.

## **7 Conclusion**

This paper presents the first estimates of the world distribution of years of schooling and of human capital over the last 140 years. An original database on average years of schooling and the distributions of schooling have been built for that purpose, extending past work by Morrisson and Murtin (2009). We have shown that the educational comparative advantage of Western Europe has decreased rapidly since the beginning of the twentieth century. As a consequence the context of the two globalization processes, the first in 1860-1914, the second starting in the late 1970s, are very different. In world economic competition, education is a crucial advantage at least because it enables access to technological progress. Over the twentieth century, the lead of Western Europe in world education has continuously decreased, whereas Asia has increased its educational share substantially.

Furthermore, we have shown that computing inequality in years of schooling raises some important methodological issues. From a practical and empirical perspective, we advise disentangling in a systematic way the impact of illiteracy from that of education inequality among educated individuals; otherwise, the former will cancel the latter if both are aggregated into a single index of education inequality. In the context of growth

regressions for instance, it might generate misleded interpretations.

To solve that problem, we have studied human capital inequality. Evidence on diminishing returns to schooling at both the macro and the micro levels led us to choose a convenient functional form for human capital. The observed empirical regularity of diminishing returns with respect to years of schooling explains the negative cross-country correlation between Mincer returns to schooling and average schooling. As a result, we find that world human capital inequality has increased, peaked in the second half of the XXth century, then started to decrease.

The major empirical finding of this paper takes place at the country level. We have exhibited an inverted-U shape curve of human capital inequality within countries along the process of educational development, namely “a Kuznets curve of education”. It happens that human capital within inequality is maximal when the share of illiterate population is close to 50% of national population, an observation that fits well with Kuznets’ original motivation for his hypothesis.

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## A Figures

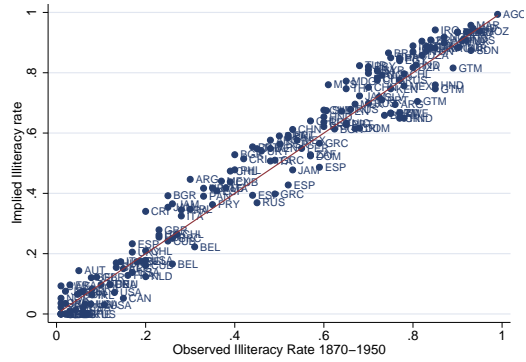


Figure 1: Comparison of Implied and Observed Illiteracy Rates 1870-1950

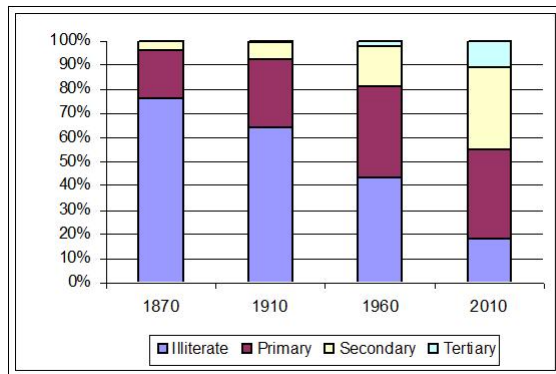


Figure 2: The World Distribution of Education 1870-2010



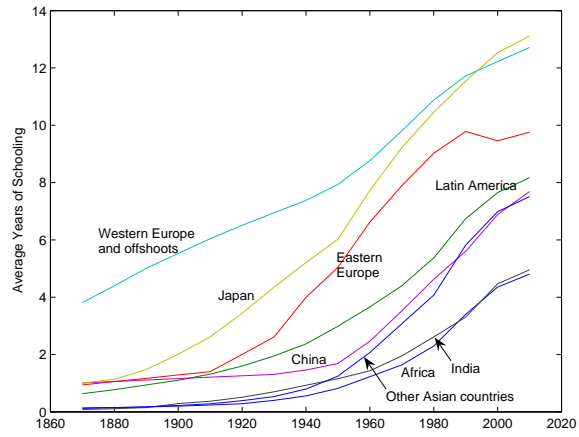


Figure 3: Average Years of Schooling by Region 1870-2000

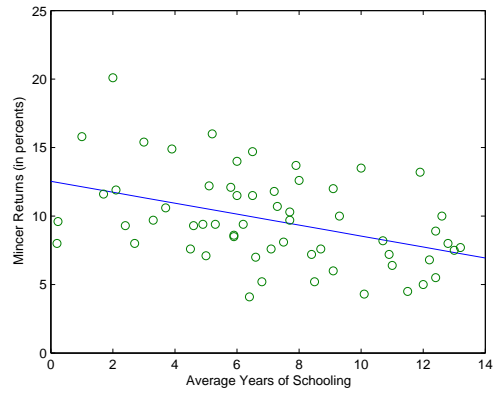


Figure 4: The Return to Schooling and Average Schooling in 59 Countries around 1990

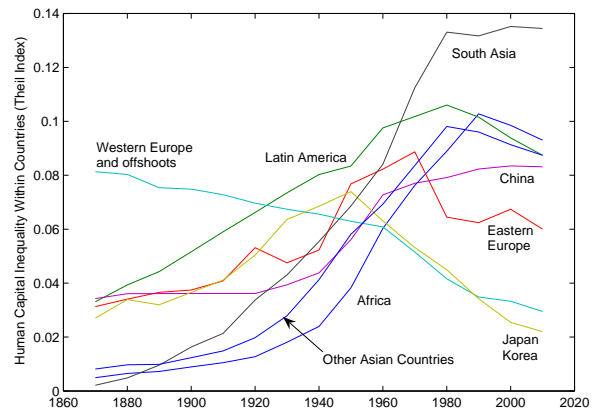


Figure 5: Inequality in Human Capital Within Countries by Geographical Zone 1870-2010 - Theil Index

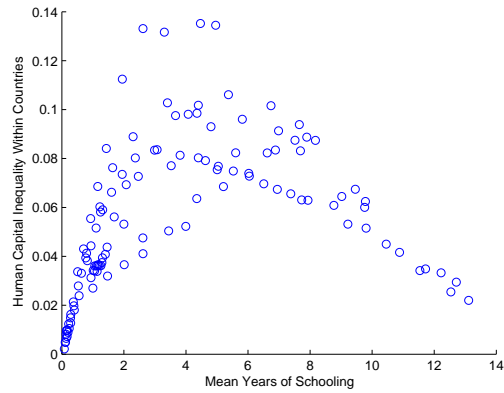


Figure 6: The Kuznets Curve of Human Capital 1870-2010 - Theil Index

## B The impact of illiteracy on education inequalities

*Depending on editors' preferences, the following piece could be moved to the companion annex paper*

We consider here a continuous outcome  $x$  that can take values greater or equal to  $m$ .

For a fraction  $p$  of total population we have  $x = m$ . Then the distribution  $f$  of the outcome can be viewed as the mixture

$$f(x) = p\delta_{x=m} + (1-p)g(x)$$

where  $\delta_{x=m}$  is a mass point in  $m$  and  $g$  the distribution of the outcome in the population with an outcome strictly greater than  $m$ . For the Gini index we use its mean-differences definition. Writting  $\mu(f)$  as the mean outcome for a distribution  $f$  and  $G(f)$  the corresponding Gini index we have

$$\begin{aligned} G(f) &= \frac{1}{2\mu(f)} \int \int |x - x'| f(x)f(x') dx dx' \\ &= \frac{p^2}{2\mu(f)} \int \int |x - x'| \delta_{x=m}\delta_{x'=m} dx dx' + \frac{p(1-p)}{\mu(f)} \int \int |x - x'| \delta_{x=m} g(x') dx dx' \\ &\quad + \frac{(1-p)^2}{2\mu(f)} \int \int |x - x'| g(x)g(x') dx dx' \end{aligned}$$

by symetry. The first term cancels out. Since  $m$  is the minimum value of the outcome the above expression simplifies into

$$\begin{aligned} G(f) &= \frac{p(1-p)}{\mu(f)} \left( \int \int x' \delta_{x=m} g(x') dx dx' - \int \int x \delta_{x=m} g(x') dx dx' \right) \\ &\quad + \frac{(1-p)^2}{2\mu(f)} \int \int |x - x'| g(x)g(x') dx dx' \\ &= \frac{p(1-p)}{\mu(f)} (\mu(g) - m) + \frac{(1-p)^2}{\mu(f)} \mu(g)G(g) \end{aligned}$$

The means  $\mu(f)$  and  $\mu(g)$  are simply related by  $\mu(f) = pm + (1-p)\mu(g)$ , which yields

$$G(f) = p \frac{\mu(f) - m}{\mu(f)} + (1-p) \frac{\mu(f) - pm}{\mu(f)} G(g)$$

or alternatively

$$G(f) = G(g) + \frac{pm}{\mu(f)} \left[ \frac{\mu(f)}{m} - 1 - G(g) \left( \frac{\mu(f)}{m} + 1 - p \right) \right]$$

Similarly, the GE-index is given by

$$\begin{aligned}
I_{GE}^\alpha(f) &= \frac{1}{\alpha^2 - \alpha} \int \left[ \left( \frac{x}{\mu(f)} \right)^\alpha - 1 \right] f(x) dx \\
&= \frac{1}{\alpha^2 - \alpha} \int \left( \frac{x}{\mu(f)} \right)^\alpha f(x) dx - \frac{1}{\alpha^2 - \alpha} \\
&= \frac{p}{\alpha^2 - \alpha} \int \left( \frac{x}{\mu(f)} \right)^\alpha \delta_{x=m} dx + \frac{1-p}{\alpha^2 - \alpha} \int \left( \frac{x}{\mu(f)} \right)^\alpha g(x) dx - \frac{1}{\alpha^2 - \alpha} \\
&= \frac{1-p}{\alpha^2 - \alpha} \left( \frac{\mu(g)}{\mu(f)} \right)^\alpha \int \left( \frac{x}{\mu(g)} \right)^\alpha g(x) dx + \frac{pm^\alpha}{\alpha^2 - \alpha} \mu(f)^{-\alpha} - \frac{1}{\alpha^2 - \alpha} \\
&= \frac{(1-p)^{1-\alpha}}{\alpha^2 - \alpha} \left( \frac{\mu(f) - pm}{\mu(f)} \right)^\alpha \left[ I_{GE}^\alpha(g) + \frac{1}{\alpha^2 - \alpha} \right] (\alpha^2 - \alpha) + \frac{pm^\alpha}{\alpha^2 - \alpha} \mu(f)^{-\alpha} - \frac{1}{\alpha^2 - \alpha} \\
&= (1-p)^{1-\alpha} \left( \frac{\mu(f) - pm}{\mu(f)} \right)^\alpha \underbrace{I_{GE}^\alpha(g) + \frac{1}{\alpha^2 - \alpha} \left( (1-p)^{1-\alpha} \left( \frac{\mu(f) - pm}{\mu(f)} \right)^\alpha + pm^\alpha \mu(f)^{-\alpha} - 1 \right)}_A
\end{aligned}$$

which achieves the decomposition. Let us examine now the case when  $\alpha = 1$  (for the Theil index). We use Taylor expansions

$$\begin{aligned}
A &= \frac{1}{\alpha^2 - \alpha} \left[ (1-p)^{1-\alpha} \left( 1 - \frac{pm}{\mu(f)} \right)^\alpha - \left( 1 - \frac{pm^\alpha}{\mu(f)^\alpha} \right) \right] \\
&\simeq \frac{1}{\alpha^2 - \alpha} \left[ \left( 1 - \frac{pm}{\mu(f)} \right)^\alpha + \left( 1 - \frac{pm}{\mu(f)} \right)^\alpha (1-\alpha) \log(1-p) - \left( 1 - \frac{pm^\alpha}{\mu(f)^\alpha} \right) \right] \\
&= -\frac{1}{\alpha} \log(1-p) \left( 1 - \frac{pm}{\mu(f)} \right)^\alpha + \frac{1}{\alpha^2 - \alpha} \left[ \left( 1 - \frac{pm}{\mu(f)} \right)^\alpha - \left( 1 - \frac{pm^\alpha}{\mu(f)^\alpha} \right) \right]
\end{aligned}$$

$$\begin{aligned}
A &\simeq -\frac{1}{\alpha} \log(1-p) \left( 1 - \frac{pm}{\mu(f)} \right)^\alpha \\
&\quad + \frac{1}{\alpha^2 - \alpha} \left[ \left( 1 - \frac{pm}{\mu(f)} \right) + \left( 1 - \frac{pm}{\mu(f)} \right) (\alpha - 1) \log \left( 1 - \frac{pm}{\mu(f)} \right) - \left( 1 - \frac{pm^\alpha}{\mu(f)^\alpha} \right) \right] \\
&= -\frac{1}{\alpha} \log(1-p) \left( 1 - \frac{pm}{\mu(f)} \right)^\alpha + \frac{1}{\alpha} \left( 1 - \frac{pm}{\mu(f)} \right) \log \left( 1 - \frac{pm}{\mu(f)} \right) - \frac{1}{\alpha^2 - \alpha} \frac{pm}{\mu(f)} \left( 1 - \left( \frac{m}{\mu(f)} \right)^{\alpha-1} \right) \\
&\simeq -\frac{1}{\alpha} \log(1-p) \left( 1 - \frac{pm}{\mu(f)} \right)^\alpha + \frac{1}{\alpha} \left( 1 - \frac{pm}{\mu(f)} \right) \log \left( 1 - \frac{pm}{\mu(f)} \right) + \frac{1}{\alpha} \frac{pm}{\mu(f)} \log \left( \frac{m}{\mu(f)} \right)
\end{aligned}$$

Then taking the limit  $\alpha \rightarrow 1$  we have

$$\text{Theil}(f) = \text{Theil}(g) + A - \frac{pm}{\mu(f)} \text{Theil}(g)$$

$$\text{where } A = -\log(1-p) \left( 1 - \frac{pm}{\mu(f)} \right) + \left( 1 - \frac{pm}{\mu(f)} \right) \log \left( 1 - \frac{pm}{\mu(f)} \right) + \frac{pm}{\mu(f)} \log \left( \frac{m}{\mu(f)} \right)$$

Table 1 - The World Distribution of Schooling

	1870	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
Illiteracy rate	75.92	73.14	70.13	66.45	64.06	60.06	56.79	50.96	48.73	44.08	36.98	35.03	27.52	20.50	18.22
Share Having Only Primary	20.13	22.15	24.28	27.20	28.41	31.40	33.33	37.85	37.59	37.88	39.57	35.17	37.14	37.99	36.92
Share Having Only Secondary	3.77	4.48	5.38	6.17	7.08	8.01	9.25	10.63	12.84	16.75	20.84	24.83	28.84	32.78	34.61
Share Having Tertiary	0.19	0.25	0.25	0.40	0.55	0.73	0.91	1.13	1.75	2.45	3.74	5.21	7.00	9.23	10.89
Mean Years of Schooling	1.24	1.41	1.62	1.86	2.08	2.34	2.62	2.98	3.37	4.02	4.77	5.52	6.33	7.13	7.51
Mean Years of Primary Schooling	1.01	1.14	1.30	1.48	1.64	1.82	2.02	2.29	2.49	2.87	3.27	3.67	4.10	4.49	4.61
Mean Years of Secondary Schooling	0.22	0.26	0.31	0.36	0.42	0.48	0.56	0.65	0.81	1.06	1.36	1.66	1.97	2.31	2.50
Mean Years of Tertiary Schooling	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.04	0.07	0.09	0.14	0.19	0.26	0.34	0.40

Table 2 - Mean Years of Schooling and Illiteracy Rate by Geographical Area 1870-2010

	Africa	Latin America	Eastern Europe	Europe and offshoots	China	Japan-Korea	South Asia	Other Asian Countries
<b>1870</b>								
Total MYS	0.12	0.63	0.94	3.81	1.01	1.00	0.08	0.14
Primary	0.11	0.53	0.84	2.89	0.91	0.98	0.08	0.11
Secondary	0.01	0.09	0.10	0.90	0.09	0.02	0.00	0.02
Illiteracy rate	97.52	86.47	77.62	36.36	75.16	79.77	98.08	97.17
Population (in millions)	66.0	32.4	94.9	229.5	358.0	44.2	257.6	72.9
<b>1910</b>								
Total MYS	0.24	1.31	1.40	6.04	1.21	2.61	0.37	0.28
Primary	0.21	1.06	1.24	4.41	1.10	2.52	0.30	0.24
Secondary	0.02	0.24	0.16	1.56	0.10	0.08	0.07	0.04
Illiteracy rate	95.13	73.37	67.26	13.11	69.86	47.95	93.42	94.01
Population (in millions)	96.2	64.0	148.9	349.3	423.0	59.6	305.0	109.5
<b>1950</b>								
Total MYS	0.82	2.99	5.04	7.93	1.69	6.02	1.16	1.25
Primary	0.68	2.36	4.07	5.35	1.45	4.66	0.87	1.01
Secondary	0.14	0.59	0.86	2.41	0.21	1.25	0.26	0.22
Illiteracy rate	86.46	45.72	2.44	5.20	61.19	15.88	82.70	76.29
Population (in millions)	175.9	140.2	194.4	482.0	546.8	104.7	444.1	192.3
<b>1980</b>								
Total MYS	2.30	5.37	9.02	10.88	4.63	10.45	2.61	4.07
Primary	1.72	3.99	5.69	5.89	3.82	5.77	1.73	3.23
Secondary	0.54	1.20	3.01	4.35	0.78	4.31	0.79	0.76
Illiteracy rate	67.25	28.42	1.15	0.88	31.44	2.96	68.08	39.86
Population (in millions)	366.9	309.4	284.5	636.6	981.2	154.9	852.2	399.2
<b>2010</b>								
Total MYS	4.81	8.17	9.76	12.71	7.69	13.11	4.96	7.51
Primary	3.43	5.31	5.81	5.97	5.07	5.99	3.35	5.14
Secondary	1.26	2.48	3.50	5.41	2.43	5.91	1.38	2.10
Illiteracy rate	34.21	6.35	0.06	0.10	11.58	0.00	37.67	8.14
Population (in millions)	772.1	504.4	157.2	769.2	1339.0	175.8	1509.8	676.3

Table 3 - Regional Distribution of World Quantiles of Education

	Africa	Latin America	Eastern Europe	Europe and offshoots	China	Japan-Korea	South Asia	Other Asian Countries
<b>1870</b>								
Total	5.7	2.8	8.2	19.9	31.0	3.8	22.3	6.3
Bottom 80	6.6	3.0	8.5	13.3	31.5	3.9	25.9	7.3
Decile 10	0.6	1.5	6.8	57.7	27.8	3.3	1.6	0.7
<b>1910</b>								
Total	6.2	4.1	9.6	22.5	27.2	3.8	19.6	7.0
Bottom 80	7.6	4.5	10.2	12.2	29.6	3.5	23.9	8.6
Decile 10	0.8	2.8	7.3	61.3	18.3	5.1	3.6	1.0
<b>1960</b>								
Total	8.0	6.7	8.4	19.6	24.3	4.3	19.7	8.9
Bottom 80	10.9	7.0	5.9	8.2	28.5	2.2	26.3	11.0
Decile 10	1.9	4.9	11.6	54.6	8.0	9.5	6.9	2.6
<b>2010</b>								
Total	13.1	8.5	2.7	13.0	22.7	3.0	25.6	11.5
Bottom 80	15.7	8.5	2.3	6.4	23.5	1.4	29.9	12.3
Decile 10	3.2	8.6	3.3	41.4	13.9	9.0	12.9	7.7

Table 4 - Global Inequality in Years of Schooling

	1870	1890	1910	1930	1950	1970	1990	2010
<b>World population</b>								
Coefficient of variation	2.134	1.850	1.624	1.422	1.246	1.005	0.793	0.664
Gini coefficient	0.818	0.776	0.732	0.683	0.631	0.540	0.439	0.370
Theil coefficient	1.557	1.339	1.151	0.970	0.806	0.588	0.411	0.292
Theil coefficient between countries	0.613	0.597	0.526	0.433	0.335	0.205	0.113	0.067
Average years of schooling	1.24	1.62	2.08	2.60	3.31	4.68	6.29	7.47
Illiteracy rate	75.9	70.1	64.0	56.8	48.7	37.0	27.5	18.3
<b>Educated population</b>								
Coefficient of variation	0.582	0.569	0.557	0.554	0.555	0.516	0.424	0.422
Gini coefficient	0.244	0.253	0.257	0.267	0.281	0.270	0.225	0.229
Theil coefficient	0.135	0.133	0.131	0.132	0.138	0.126	0.089	0.090
Average years of schooling	5.13	5.43	5.77	6.02	6.45	7.42	8.68	9.14

Table 5 - Estimated Mincer Regressions for Males in the United States 1940-2000

	Coefficient of Schooling	Coefficient of Squared Schooling
1940 <sup>1</sup>	10.1** (0.1)	-
	11.3** (0.2)	-0.070** (0.009)
1950 <sup>1</sup>	6.4** (0.1)	-
	11.9** (0.3)	-0.298** (0.016)
1960 <sup>1</sup>	8.4** (0.0)	-
	13.6** (0.1)	-0.256** (0.007)
1970 <sup>1</sup>	7.6** (0.0)	-
	8.1** (0.1)	-0.023** (0.006)
1980 <sup>1</sup>	7.2** (0.0)	-
	10.4** (0.2)	-0.130** (0.006)
1990 <sup>2</sup>	8.8** (0.0)	-
	4.8** (0.2)	0.169** (0.006)
2000 <sup>2</sup>	9.5** (0.0)	-
	0.8** (0.1)	0.366** (0.005)

<sup>1</sup> years of schooling variable: highest grade achieved (detailed version).

<sup>2</sup> years of schooling variable constructed with educational attainment variable (degrees): 14 years for some years of college but no degree or an associate degree, 16 years for a bachelor's degree, 17 years for a professional degree, 18 years for a master degree and 21 for a Doctorate.

source: IUPMS Census Data 1% samples.

Table 6 - Global Inequality in Human Capital

	1870	1890	1910	1930	1950	1970	1990	2010
<b>World population</b>								
<i>Constant return equal to 10%</i>								
Coefficient of variation	0.39	0.43	0.47	0.50	0.53	0.54	0.52	0.49
Gini coefficient	0.131	0.159	0.188	0.212	0.241	0.272	0.273	0.264
Theil coefficient	0.057	0.070	0.085	0.097	0.113	0.129	0.124	0.115
Theil coefficient between countries	0.019	0.029	0.040	0.046	0.049	0.052	0.044	0.034
Average human capital	1.18	1.25	1.32	1.41	1.54	1.80	2.13	2.38
<i>Human capital with diminishing returns</i>								
Coefficient of variation	0.30	0.32	0.34	0.35	0.36	0.36	0.33	0.30
Gini coefficient	0.116	0.138	0.157	0.173	0.188	0.197	0.184	0.164
Theil coefficient	0.037	0.044	0.051	0.056	0.061	0.064	0.058	0.047
Theil coefficient between countries	0.014	0.021	0.026	0.029	0.030	0.027	0.020	0.013
Average human capital	1.17	1.22	1.28	1.35	1.44	1.61	1.81	1.95
<i>Power function</i>								
Coefficient of variation	0.89	0.88	0.87	0.83	0.79	0.70	0.59	0.51
Gini coefficient	0.352	0.384	0.404	0.409	0.408	0.381	0.328	0.280
Theil coefficient	0.282	0.301	0.309	0.301	0.288	0.251	0.199	0.150
Theil coefficient between countries	0.114	0.145	0.158	0.152	0.137	0.099	0.062	0.038
Average human capital	1.77	2.01	2.28	2.59	3.00	3.78	4.68	5.33
<b>Educated population</b>								
<i>Constant return equal to 10%</i>								
Coefficient of variation	0.39	0.39	0.40	0.41	0.42	0.42	0.39	0.39
Gini coefficient	0.154	0.164	0.174	0.185	0.202	0.214	0.202	0.209
Theil coefficient	0.062	0.064	0.067	0.071	0.078	0.082	0.072	0.075
Theil coefficient between countries	0.007	0.009	0.014	0.018	0.018	0.023	0.019	0.018
Average human capital	1.76	1.82	1.89	1.95	2.05	2.27	2.56	2.69
<i>Human capital with diminishing returns</i>								
Coefficient of variation	0.22	0.22	0.22	0.22	0.23	0.22	0.19	0.19
Gini coefficient	0.094	0.100	0.104	0.110	0.119	0.118	0.099	0.101
Theil coefficient	0.022	0.022	0.022	0.023	0.025	0.025	0.018	0.018
Theil coefficient between countries	0.003	0.004	0.006	0.008	0.008	0.008	0.005	0.004
Average human capital	1.69	1.72	1.77	1.80	1.85	1.97	2.12	2.16
<i>Power function</i>								
Coefficient of variation	0.37	0.37	0.37	0.37	0.38	0.36	0.31	0.31
Gini coefficient	0.158	0.166	0.172	0.180	0.193	0.191	0.163	0.167
Theil coefficient	0.059	0.059	0.059	0.061	0.066	0.063	0.046	0.048
Theil coefficient between countries	0.009	0.010	0.015	0.020	0.019	0.020	0.012	0.011
Average human capital	4.20	4.36	4.55	4.68	4.90	5.41	6.08	6.30