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Education Inequality, Human Capital Inequality and the Kuznets Curve

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Summary – This paper develops an improved measure of human capital. Using a Mincer specification of human capital, the improved measure takes into consideration rates of returns to schooling, education quality, and school dropouts. The paper applies the improved measure to evaluate national and global human capital inequality and compares them with education inequality. Human capital Kuznets curves are evident when relative inequality measures are used while education Kuznets curves are found when absolute inequality measures are used. It is also found that while global education inequality has been declining over the past four decades, global human capital inequality remains largely steady.

Key words: education, human capital, inequality, Kuznets curve

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1. INTRODUCTION

One of the issues confounding modern growth economists is the search for a suitable proxy for human capital. In fact, a substantial part of the empirical literature in growth has been devoted to attempting to quantify the contribution of human capital, particularly the capital derived from investments in education e.g. Mankiw, Romer and Weil (1992), Barro (2001) and Krueger and Lindahl (2000). After the initial explosion of literature discussing the *average* quantity of human capital, recent research has begun to focus on the importance of the *distribution* of human capital in affecting growth. Studies by Thomas, Wang and Fan (henceforth TWF) (2000) and by Castelló and Doménech (henceforth CD) (2002), which measure human capital by the cumulative years of schooling, used Gini coefficients to highlight the negative relationship between human capital inequality and GDP growth. Checchi (2001) and De Gregorio and Lee (2002) employed similar measures to investigate the relationship between human capital inequality and income inequality.

Using education – be it measured by years of schooling or enrolment rates – as a proxy of human capital, however, has been criticized as inaccurate at best (Wößmann 2000). Conceptually, education is a means of human capital accumulation but is not in itself conceptually equivalent to human capital. Using it as a proxy for human capital therefore implicitly assumes a linear "production function" that transforms education inputs measured by enrolment rates or years of schooling into education outputs, i.e. knowledge embodied in people. There is empirical evidence, however, indicating that education exhibits diminishing marginal return properties (Psacharopoulos & Patrinos 2004), which speaks against the assumption of a linear transformation from education attainment to human capital accumulation. More importantly, under the conventional education measure, a person with no formal schooling would be classified as having no human capital at all. This result is clearly misleading since it completely ignores the accumulation of human capital through informal education at home or workplace.

In this paper, we propose a specification of human capital acquired from formal schooling, using an exponential transformation in the tradition of Jacob Mincer (1974). Furthermore, we weight the years of schooling with education level specific rates of return in order to capture the non-linearity in human capital accumulation via schooling. These modifications to the conventional specification of human capital not only have a substantial impact on the average measure of human capital and its distribution individually, but also alter the relationship between them. Indeed, contrary to the findings from previous studies, we find that our adjustments lead us to conclude that human capital inequality is *low* when the average years of schooling are low.

Yet another problem arises when multinational data is used; as is often the case in empirical growth studies. In such instances, using years of schooling as a proxy of human capital implies that a student who finishes six years of primary schooling in a less developed country will accumulate the same amount of human capital as if she had finished her schooling in an OECD country. This is equivalent to assuming a uniform "production technology" in the education sector across countries. This assumption clearly contradicts empirical evidence that education quality varies substantially across countries (e.g. Hanushek & Kimko 2000; Hanushek & Luque 2003). The second contribution of this paper is to take into account of cross country differences in education quality when measuring human capital. Extending on Hanushek & Kimko (2000), we construct a measure of relative national schooling quality and incorporate it into the human capital measure.

The third contribution of this paper is to investigate the change of global education and human capital inequalities over the last four decades. While previous studies have focused on national education and human capital inequalities, we are not aware of any attempts made to investigate these inequalities at the world level. Since human capital is a key determinant of income and human capital stock evolves only gradually, measurements of global human capital inequality will give us a reference for the approximate state of global income inequality in both the short and medium terms.

Last but not least, the paper contributes to the literature by re-examining the existence of human capital Kuznets curves. Given the close linkage between human capital and income, the existence of income Kuznets curves logically call for the search for education or human capital Kuznets curves. However, the evidence in the literature thus far is not very consistent. Ram (1990) and Londoño (1990) report some indications of education Kuznets curves while TWF (2000) show the opposite. In this paper we find that whether one can observe education Kuznets curves or human capital Kuznet curves is critically dependent on the use of absolute or relative measures of inequality.

The rest of the paper is organized as follows. In the next section, we review the literature on measuring average human capital and its inequality. Section 3 details the methodology employed to estimate our human capital measures. Section 4 explains the construction of a cross country education quality measure. Section 5 reports the empirical findings on education and human capital inequality and Section 6 concludes.

2. LITERATURE REVIEW

(a) Specifying human capital

Early cross-country growth regressions considered the inclusion of adult literacy rates as a human capital proxy e.g. Azariadis and Drazen (1990). Since literacy rates measure the proportion of a population with basic reading and writing abilities, they can only represent a small part of the total human capital stock.

School enrolment ratios, which measure the number of students enrolled in a particular grade level relative to the total population of the corresponding age group, are another proxy used in the literature, e.g. Barro (1991) and Mankiw, Romer and Weil (1992). A caveat of this proxy is that enrolment ratios are *flow* variables while human capital is a *stock* variable. Children currently enrolled in schools are by definition not yet part of the labor force, so that the human capital they are accumulating through schooling cannot yet be used in production. In fact, it has not been established that there exists an immediate and stable relationship between current school enrolment ratios and the stock of human capital embodied in the current productive labor force of a country (Barro & Lee 1993; Wößmann 2000). In a survey of recent literature on human capital, Wößmann (2000) criticized the use of school enrolment ratios, like that of literacy rates, as due mainly to the availability of data rather than to theoretical underpinnings.

Given that human capital represents a stock concept, education attainment which takes into account the total amount of formal education received by the population, appears to be a suitable specification. As such, an abundance of literature including research by Barro (1997), Islam (1995) and Krueger and Lindahl (2000) have specified the average years of schooling as a proxy for human capital stock. Nevertheless, using merely the average years of schooling ignores a gamut of microeconometric literature on wage rate differentials which shows evidence of decreasing returns to schooling. Recent studies like Hall and Jones (1999), and Gundlach et al. (1998) weight the average years of schooling in each level, by level-specific rates of return. While these specifications are a marked improvement over previous specifications, they still ignore country differences in the quality of schooling.

Thus far, Wößmann (2000) appears to be the only study which attempts to adjust for differences in schooling quality on top of adjusting for differences in rates of return to schooling. The author combined quality measures from Hanushek and Kimko (henceforth HK) (2000) and world average rates of return to education at the different education levels with the average years of schooling for each level of schooling in a Mincer-type specification of human capital for a country. Nonetheless, his measure is plagued by another misspecification. If the human capital of individual *i* is given by: $hc_i = \exp(ed_i)$, then the average human capital of population with size *N* will be equal to:

$$HC = (1/N)\sum_{i}^{N} hc_i = (1/N)\sum_{i}^{N} \exp(ed_i) \tag{1}$$

Nevertheless, Wößmann specifies the average human capital of the population as:

$$\exp\left((1/N)\sum_{i}^{N} ed_i\right) \tag{2}$$

which is equal to (1) only either by coincidence or when there is perfect education equality within the population, i.e. $ed_i = ed_j, \forall i, j \in N$. Therefore, in general cases, it is rather difficult to interpret Wößmann's measure of average human capital. Our measure rectifies this misspecification and thus can be used to measure both average human capital and its inequality properly.

(b) Human Capital Inequality

TWF (2000) argued that an asset such as education attainment is not perfectly tradable; hence its marginal product across individuals is not equalized. This gives rise to aggregation problems and thus aggregate output no longer depends merely on the average level of the human capital, but also on its distribution.

Earlier, Mincer (1974) suggested that the distribution of human capital is determined by individual ability and investment financing opportunities, and that this distribution is an approximate determinant of the distribution of earnings. Thus, if a population's abilities are normally distributed, a skewed distribution of education services would potentially cause great welfare losses. Given the potential implications of the distribution of human capital on the distribution of income, and the subsequent implications of the distribution of income on growth, researchers have begun to focus not only on the *level* of human capital, but also on its *distribution*.

Ram (1990), Londoño (1990) and De Gregorio and Lee (2002) used the standard deviation of schooling to measure education dispersion. They all revealed the existence of an education Kuznets curve[1]. On the other hand, Checchi (2001), CD (2002), TWF (2000) used Gini coefficients to calculate education inequality, and they all found a negative correlation between the average educational achievement and educational inequality.

A limitation of Checchi and CD's studies is that only four levels of education: no schooling, primary schooling, secondary schooling and higher schooling, were considered in their Gini coefficient calculations. Subsequently, the studies ignore the distinction between those who actually completed a level of education and those who did not. This issue was partially addressed by TWF (2000). Using schooling distribution data from the Barro and Lee (henceforth BL) 1996 data set and schooling cycle[2] data from Psacharopoulos and Arriagada (1986), the authors defined seven levels of education: no schooling, partial primary, complete primary, partial secondary, complete secondary, partial tertiary and complete tertiary in their cross-country analysis of education inequality. Students who only partially completed a level of schooling were assumed to have received *half* the total duration of that level of education. The study finds that inequality in education attainment for most countries has been declining over the 1960 to 1990 period.

Our analysis will use a seven category disaggregation such as that used by TWF, but with a different treatment of those who did not complete a level of education. The BL data set counts those who have received at least one year of schooling in a particular level to have partial education. Thus, it is incorrect to assume that all those who have partial education have completed half the duration of that education level. We seek to improve TWF's measure by separately calculating the average years of education for dropouts.

A common drawback of the inequality studies reviewed above is that, once again, the authors did not account for decreasing returns to education or for cross-country differences in schooling quality. A more recent paper by TWF (2002) used a Mincer-type formulation of human capital to incorporate rates of return to schooling in their estimation of human capital inequality. However, by using a constant average rate of return, the authors ignore the findings in the microeconometric literature on decreasing returns to schooling. The study also ignored cross-country differences in schooling quality.

Table 1 summarizes the specifications of human capital in the literature. In short, when measuring either average human capital or its distribution, previous studies have mis-specified their measures in a number of ways: directly using education attainment as a proxy of human capital; omitting decreasing returns to education; neglecting cross-country differences in education quality; ignoring the difference between those who completed a certain level of schooling and those did not. While some studies rectify one or two problems, none have covered all of them, as what this paper sets out to do.

3. CONSTRUCTING THE HUMAN CAPITAL MEASURE

(a) Data

Data on years of schooling are drawn from the widely used datasets developed by BL (1993) and subsequently updated in BL (2000). Data on rates of return to education are drawn from Psacharopoulos & Patrinos (2004). Data on countries' schooling cycles are drawn from the UNESCO Institute for Statistics Database. The limitation on certain data restricts our dataset to 99 countries, covering countries from all continents. These countries represent at least 84 percent of the world population. There are totally 9 time periods starting 1960 till 2000, with a five-year gap between every consecutive pair of periods.

(b) Computing the Number of Years of Schooling for Dropouts

To estimate the average years of schooling received by dropouts of each level of education in each country, we combine the information from the BL 2000 data set with schooling cycle data from UNESCO. The average years of a level of schooling, say, primary schooling, can be defined as the weighted average of the number of years of primary education received by students who completed and those who did not complete primary schooling. We use the population proportions of people with the respective education levels as weights. The proportion of students who did not complete primary education can be calculated by simply taking the difference between the proportion of those who attained the level and those who completed the level. Thus the average number of years of primary education may be expressed as:

$$pyr = (lpc + ls + lh) * yp + (lp - lpc) * ypd \tag{3}$$

where *pyr* is average years of primary schooling in the total population; *lp*, *ls* and *lh* are the percentages of the population who attained primary, secondary and higher level schooling, respectively; *lpc* is the percentage of the population who completed primary level schooling; *yp* is the number of years of primary schooling; and *ypd* is average years of primary schooling attained by those who did not complete primary schooling.[1]

Since the values of all variables except *ypd* are known, the value of the latter can be computed using equation (3). For example, in 2000, the average years of primary schooling received by dropouts in the United States and Japan are calculated to be 3.02 and 3.00 respectively. Given that the countries' durations of primary schooling were 6 years, TWF's procedure provides a very good approximation for the average years of schooling of drop-outs. However, the average years of schooling for drop-outs in Thailand and the Netherlands, which also have a 6 year primary schooling cycle, are 5.03 and 4.13 respectively. These figures are substantially different from the 3 years assumed by TWF. These examples thus illustrate the need to consider the average years of schooling of dropouts for each country individually.

The average number of years of schooling for secondary and tertiary school dropouts can be obtained using analogous equations:

$$syr = (lsc + lh) * ys + (ls - lsc) * ysd \tag{4}$$

[1] Those who attained secondary and higher level schooling are assumed to complete primary schooling.

$$hyr = lhc * yh + \left(lh - lhc\right) * yhd \tag{5}$$

where *syr* and *hyr* are average years of secondary and higher schooling, respectively, in the total population; *lsc* and *lhc* are the percentages of the total population who completed secondary and higher level schooling, respectively; *ys* and *yh* are number of years of secondary and higher level schooling, respectively; *ysd* and *yhd* are average years of secondary and higher schooling, respectively, attained by those who did not complete that level of schooling.

(c) Human Capital Specification

Based on the Mincer formulation, we specify the human capital stock of an individual with y years of schooling as:

$$hc = Qe^{\phi(y)}; \quad \phi(y) = \begin{cases} r_1 y & \text{if } 6 \geq y \\ r_1 6 + r_2(y-6) & \text{if } 12 \geq y > 6 \\ r_1 6 + r_2 6 + r_3(y-12) & \text{if } y > 12 \end{cases} \tag{6}$$

Q is a country-specific measure of education quality and will be explained in detail in the next section. The function $\phi(y)$ reflects the efficiency of a person with y years of schooling relative to one with no schooling. The derivative of this function is equal to the marginal rate of return to education i.e. $\phi'(y) = r$. r_1, r_2, and r_3 being the rates of return to the first six years of education, next six years of education, and further education, respectively. We do not use the terms primary, secondary and higher level schooling here because of differences in schooling cycles between countries. For instance, the primary and secondary schooling cycles of Ireland are eight and five years, respectively, while Italy has the opposite numbers. If we apply r_1 to primary education and r_2 to secondary education *regardless* the schooling cycles, then high school graduates from Ireland and Italy will have different levels of human capital even though they are of equally 13 years of schooling.

The values of r_i are drawn from the world social rates of return from Psacharopoulos and Patrinos (2004), with $r_1 = 18.9$, $r_2 = 13.1$ and $r_3 = 10.8$. Social rates of return take into account of both private and public spending on education. These rates have yet accounted for the externality or spillover effects due to a more educated populace, which is seen as a key source of endogenous growth. Nevertheless, this externality effects are accounted for in the quality measure discussed later. Psacharopoulos and Patrinos (2004) also provide country-specific rates of return. However, country-specific rates are constructed under the assumptions that global labor markets are perfectly competitive, that labor is perfectly mobile, and that employers have perfect information on the human capital quality of workers. Wößmann (2000) contends that these assumptions generally do not hold, and data on country-specific rates suffers from a high degree of measurement error. Considering these limitations, we decided to use the world rates of return.

With the specification in (6), those who have no formal schooling possess one (normalized) unit of human capital rather than none. The non-zero human capital specification can be justified by the fact that almost everyone receives some sort of informal education, especially through family education or learning-by-doing at the workplace. This simple transformation holds the key to some important results in Section 5.

(d) Education and Human Capital Inequality

Some previous studies have considered education and human capital to be synonymous and have therefore referred to the distribution of education as the distribution of human capital. We are careful to make the distinction between the two concepts in the following analysis. We consider the distribution of education and human capital analogously to income. The Gini coefficient is used as the main measure of education and human capital dispersion. Other measures of inequality will be examined later.

The general expression for the Gini coefficient using education is:

$$G = \frac{1}{2\mu} \sum_{i=1}^{7} \sum_{j=1}^{7} n_i n_j \, | x_i - x_j | \tag{7}$$

where *i* and *j* are indices of the level of education; μ is the average years of schooling in the population; n_i is the proportion of the population in education level *i*; x_i is the cumulative years of schooling at education level *i*, defined as $x_1 \equiv 0$, $x_2 \equiv ypd$, $x_3 \equiv yp$, $x_4 \equiv yp + ysd ... x_7 \equiv yp + ys + yh.$

Applying the above formula to each country for the nine time periods available provides education Ginis from 1960 to 2000. The distribution of human capital can be similarly computed by redefining μ to be the average human capital in the population, and x_i to be the amount of human capital cumulated through schooling up to education level *i*. Alternative inequality measures such as standard deviation, coefficient of variation and Theil index will also be computed and presented later.

5. EDUCATION QUALITY MEASURE

Accounting for education quality is important in measuring human capital when cross-country data are used. This is because one year of education in Bangladesh is unlikely to generate the same amount of human capital as that in Switzerland for the same person. We therefore incorporate a country-specific education quality measure, Q, in our human capital specification.

We recognize that quality differences in schooling exist not only between countries, but also between and within levels of schooling and even across time. However, available data only allows for the measurement of different schooling quality between countries but not within countries. Also, given the available data, we are unable to evaluate the differences in education quality over time. In this aspect, HK (2000) argued that education quality changes only slowly over time due to the static nature of teaching technology and the slow turnover of teaching personnel. Moreover, since Q is uniformly applied to everyone within a country, including those with no formal education, it means that we assume the relative qualities of informal education between countries are the same as those of formal education. This is partly to reflect the fact that formal education could spillover to informal education and partly to simplify the specification.

We use the QL measure drawn from the HK data set as a proxy for education quality.[3] QL is derived from the score of a number of international mathematics and science test over a number of years starting from 1965 through 1991. However, data for "true" values of QL is only available for 38 countries. Therefore, we adopt the regression method in HK (2000) to generate predicted test scores for countries with missing values for quality measures but which have data on the right-hand-side variables. Since the purpose is to obtain a predicted test score for countries that did not participate in international tests, the direction of causality between the explained and explanatory variables is not an issue. Instead, we should aim for a model which results in a high R-squared. The model is set up as follows:

$$QL_k = \alpha_0 + \mathbf{X}_k \alpha + \mathbf{Z}_k \delta + \varepsilon_k \tag{8}$$

where k is a country index, **X** a vector of explanatory variables and their higher power terms, **Z** a vector of regional dummies, and ε the error term.

The components of **X** and **Z** and their expected signs are depicted in Table 2. In particular, the inclusion of average year of schooling for the population with age 25 or above (*SCHOOL*) in **X** provides a means to account for the potential externality effects of individuals' education on the population's human capital stock. All the above variables except *HTX* are sourced from the 1994 update of the BL (1993) dataset. *HTX* is derived from the WDI database.

(Table 2 here)

Given the diversity of our sample, we expect the error term to exhibit heteroskedasticity. A White Heteroskedasticity test with no cross terms performed on the residuals confirms our expectations. We therefore adjust the standard errors using the White heteroskedasticity consistent coefficient covariance method.

Table 3 presents the results of three resulting regressions with *QL* as the dependent variable. Model 1 is run with the same explanatory variables as in HK (2000). Only the recurring government expenditure on education to GDP ratio (*GEEREC*) has an unexpected sign. This may be because of the coexistence of the total government expenditure on education to GDP ratio (*GEETOT*) in the regression. The addition of two variables, average pupil/teacher ratio in secondary school (*TEASEC*) and high-technology exports as a percentage of manufactured exports (*HTX*) to the regression increased our R-squared to 0.81 (Model 2). Model 3 drops population (*P*) and one regional dummy (*ASIA*), while incorporating the squared and cubed terms of *HTX*. Almost all variables are significant individually. The externality effect variable *SCHOOL* becomes insignificant individually, but it is jointly significant with other variables. A Ramsey RESET test does not reject the null hypothesis that Model 3 is of correct specification. Model 3 is also the one with the highest R-squared of 0.88, which makes it a suitable model for prediction purposes. Thus, Model 3 is chosen as our preferred prediction model.

(Table 3 here)

The actual observations of *QL* range between 20 and 60. Some of the predicted values however fall out of these bounds and their accuracy could be a concern. Instead of dropping those countries from sample as HK did, we use the average scores of two countries in the same region; one with a GDP per capita higher than the country in concern, and another with a lower per capita GDP. In doing so, we assume that countries in the same region with similar per capita income have similar spending behavior on education. The predicted and actual *QL* scores are shown in Table A1 of the appendix.

Directly applying the raw *QL* scores as *Q* in the human capital specification implies that a Japanese student has 24 percent more human capital than a Finland student with the same years of schooling and three times that of a Uruguay student, since Japan's score is 60.65, Finland 48.76 and Uruguay 20.62. These figures seem to be rather large. Since *QL* scores come from very infrequent international tests over a long period of time, there could be substantial sampling errors. To balance between accounting for quality difference between national education systems on the one hand, and potential sampling errors on the others, we apply a logarithmic transformation to the *QL* scores, i.e. $Q = \ln(QL)$. Using this transformation, the Japanese student now has 6 percent more human capital than the Finland student, and 36 per percent more than that of the Uruguayan.

It may be argued that the logarithm transformation is ad hoc. However, the same can be said to directly using *QL* as a measure of education quality or any other monotonic transformations. The difficulty here is that it is not known how the international test score is quantitatively related to the rate of returns to schooling. Notwithstanding, studies that compare earnings of native and migrant workers can shed some light on the order of magnitude of human capital differences across different countries. Kee (1995) finds that wage differentials between migrant workers from less developed countries and native workers in the Netherlands differ by an order of 10 to 50 percent. Similarly, Baker & Benjamin (1994) show that the same years of schooling will give native Canadian workers 50 percent higher wages than their migrant counterparts.[4] Since migrant workers may face labor market discrimination, differences in labor quality will account for an even smaller portion of the observed wage differentials. If the order of wage differentials between migrant and native workers is a guide to go by, it is clear that ln(QL) is preferred to QL as a cardinal measure of education quality. In addition, since ln(QL) is a time-invariant variable in this study and Gini coefficient is invariant to rescaling, our measures of national education and human capital inequality are independent of the education quality measure.

4. EMPIRICAL RESULTS

(a) Average education versus average human capital

Figure 1 shows a plot of our measure of average human capital against average education for 99 countries over nine five-year periods starting from 1960 to 2000. As expected, there is clear evidence of a positive relationship between average education and average human capital. Nonetheless, the average human capital can take a range of values for a given level of average years of schooling, and this phenomenon is especially pronounced towards the 'middle' of the curve. For example, average human capital values corresponding to an average of six years of schooling, can fall between 10 to 15 units. This large margin suggests that using average years of schooling measures to proxy average human capital may incur large specification errors. The result is due to the fact that (a) the return rates of education vary between different levels of schooling and therefore the average human capital level of a country is determined by the distribution of education as well as the average years of schooling, and (b) countries with the same distribution of education may still differ in schooling equality.

(Figure 1 here)

(b) Education inequality and human capital inequality

The essentially linear relationship between education and human capital breaks down when we examine inequality rather than average levels. Figure 2 depicts a slightly left skewed, but otherwise unmistaken inverted-U shaped relationship between education Ginis and human capital Ginis. When education Ginis are low, the two Ginis are positively related. This is because when education is close to perfectly equally distributed amongst the population, naturally so will be human capital. On the other hand, when education Ginis are high, the two Ginis are negatively related. For instance, in 1960, Nepal's education Gini is close to 0.99, but its human capital Gini is below 0.16. The high education Gini is due to the fact that 98.3 percent of the population did not attain any schooling, and the remaining 1.7 percent of population attained, on average, 1.9 years of schooling. Even if the minority had on average less than two years of primary schooling, they nevertheless possessed *all* the formal education in the nation and this leads to a large measure of education inequality. In contrast, under the Mincer specification, a person who has no formal education is assumed to have one unit of human capital and a person who attained 1.9 years of schooling would have 3.6 units of human capital.[5] As a result, the distribution of human capital is much more even.

The Nepal example clearly illustrates that using formal education as a proxy of human capital is particularly problematic when average years of schooling are low, because in such a situation informal education will constitute a significant part of human capital. The exponential transformation in equation (6) provides a simple means to acknowledge those immeasurable components of human capital.

Furthermore, the points in Figure 2 are closely clustered towards the left hand side. This is expected because if education is perfectly equally distributed, human capital should also be perfectly equally distributed, after excluding individual ability and experience. However, the points are increasingly dispersed as they move towards the right. This is, again, because of the changing return rates to education with the level of schooling.

(Figure 2 here)

(c) Education inequality and average years of schooling

Figure 3 shows a plot of average years of schooling against education Gini and it is clear that the two are negatively related. The result arises because when the average years of schooling of a nation are low, typically a small part of the population have all the years of schooling in the nation rather than every one sharing a small but equal amount of schooling. The result is the same as those found by Checchi (2001) and TWF (2000).

(Figure 3 here)

(d) Human capital inequality and average human capital

A plot of human capital Gini against average human capital in Figure 4 gives a very different result from the last figure. Figure 4 shows a concave relationship between the two, strongly suggesting the existence of a human capital Kuznets curve. This is not unexpected given the results in Figures 1 to 3. Since it has been established that human capital is one of the most important factors in determining income, finding a human capital Kuznets curve provides a 'natural' explanation of the income Kuznets curve that was first suggested by Simon Kuznets back in 1955 (Kuznets 1955).

(Figure 4 here)

A point of interest about the Kuznets curve is obviously its turning point at which inequality attains its maximum value. The fact that human capital does not have a natural unit of measurement makes it is rather difficult to interpret the turning point level of human capital. Given the strong positive correlation[6] between average human capital and average years of schooling, we can plot human capital Gini against the average years of schooling instead (Figure 5) and find the turning point in terms of the latter rather than average human capital.

(Figure 5 here)

To estimate the turning point in Figure 5, we fit the data with a right skewed concave function of the form:

$$\textit{Human capital Gini} = \alpha_0 S^{\alpha_1} \exp(\alpha_2 S);\ \alpha_1 > 0,\ \alpha_2 < 0 \qquad (9)$$

where S is average years of schooling. The results are reported in Table 4.

(Table 4 here)

The turning point of (9) occurs when S equal to $-\alpha_1/\alpha_2$. Using Theorem 4 of Mood et al (1974, p. 181),[7] the expected value of $-\alpha_1/\alpha_2$ is estimated to be 4.165

years and its variance to be 0.0016. Given the small variance, the point estimate is highly accurate for our dataset. Moreover, this estimated average years of schooling figure ties closely with that calculated by De Gregorio and Lee (2002). The corresponding human capital Gini at the turning point is 0.36.

By 2000, a substantial number of Sub-Saharan African countries still have average years of schooling well below 4.2; for example, Gambia (1.9), Liberia (2.3), Mali (0.76), Mozambique (1.2), Niger (0.82), Rwanda (2.0), and Sierra Leone (2.0). In other regions, there are also many low income countries being far away from passing the turning point level of average education, for instance, Papua New Guinea (2.4), Pakistan (2.5), Bangladesh (2.5), Afghanistan (1.1), Nepal (1.9), Haiti (2.7), and Guatemala (3.1).

The evidence of a human capital Kuznets curve and the position of its turning point have important implications for education policy, such as the United Nations' second Millennium Development Goal (MDG). The second MDG is to ensure that by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling. If the UN successfully achieves its target, we should then observe average years of schooling in the least developing countries to increase. However, if a nation's starting average years of schooling is well below the threshold level of 4.2, one may observe human capital inequality, and thus possibly income inequality, to increase rather than to decrease as the nation achieves universal primary education. Furthermore, due to the fact that part of the adult population may have little or zero formal schooling, even if universal primary education is achieved by 2015, the average years of schooling for the workforce may remain below the threshold level for many years to come. Therefore, policymakers should be cautious in expecting falling income inequality in the society as an incentive of accomplishing the MDG. Nevertheless, it is equally unwarranted to advocate that, if a nation falls below the 4.2 year threshold level, an educational expansion will definitely be accomplished with raising inequality. For example, expenditure inequality may not link to income inequality if there is resource sharing within households. Accordingly, households with uneducated parents could still benefit if their children can receive education even if that mean inter-generational income equality to increase. To put all these arguments into perspective, it is useful to consult the findings of a recent survey by Hannum & Buchmann (2004) on the impact on socio-economic development of educational expansion. The survey finds that decades of sociological studies give no evidence that educational expansion necessarily reduce socio-economic inequality.

As a way to round up this section, we summarize the inter-relationships between the level and distribution of education and human capital a simple four-quadrant diagram in Figure 6.

(Figure 6 here)

(e) Other measures of inequality

The discussion on inequality so far is based on a relative measurement of inequality – the Gini coefficient. Nevertheless, there is an array of inequality measures, ranging from other relative measures like the Theil entropy measure and the coefficient of variation (CV), to absolute measures like the standard deviation (SD) and the mean absolute deviation (MAD). Since policymakers may use multiple measures of inequality, it is important to know how robust the human capital Kuznets curve is with respect to different measures of inequality. Figure 7 shows how the use of other inequality measures alters the results in Figures 3 and 4, respectively. Theil measure is not calculated for education inequality because it is undefined when a portion of the population has zero year of schooling.

(Figure 7 here)

In Figure 7, we observe an education Kuznets curve when SD and MAD are used but not when CV is used.[8] Londoño (1990), Ram (1990) and De Gregorio and Lee (2002) found similar education Kuznets curves using SD as an inequality measure. In addition, we observe a clear human capital Kuznets curve when Theil and CV are used. When SD and MAD are used, although human capital inequality and average human capital display a slightly concave relationship, there are insufficient observations on the far right of panels (b) and (d) to confirm a Kuznets curve. In general, the human capital Kuznets curves in panels (f) and (g) as well as in Figure 3 appear to be much more pronounced than the education Kuznets curves in panels (a) and (c).

The fact that we cannot observe education Kuznets curves when we use relative measures of inequality are used is not by chance. Relative measures of education inequality are essentially some absolute measure of education inequality divided by average years of schooling. When average years of schooling tend to zero, even if absolute measures of education inequality are small, relative measures of education inequality will tend to the upper bound (i.e. 1 for Gini coefficient and infinity for CV), resulting in a downward sloping relationship between the relative measures of education inequality and average years of schooling. In the case of human capital, due to the Mincer specification, average human capital is bound to be bigger than one and therefore prevent the relative measures of human capital inequality from reaching their upper bound values. Our findings thus not only highlight the sensitivity of education and human capital to different measures of inequality but also explain why there is inconsistent evidence of education and human capital Kuznet curves in the literature.

(f) World education and human capital inequality

Since the dataset covers at last 84 percent of the world population, it can be used to construct a measure of world education and human capital inequality. Country population size is accounted for in constructing these inequality measures. The result is shown in Figure 8. Country-specific measures of education quality are static over years. Thus, the changes in world human capital inequality are due largely to changes in the quantity of education (its total and distribution) amongst nations over time.

(Figure 8 here)

Over the 40 year period, there has been a steady decrease in education Ginis across the world, and the pace of it increased since 1975. During the period, average years of schooling for the world, as expected, also increased steadily from 3.5 years in 1960 to 6.3 years in 2000.[9] On the contrary, the world human capital Gini exhibits a slightly concave trend with a peak at about 0.43 Gini points in 1980. Therefore, the inter-relationships between the world education and human capital resemble those described in the four-quadrant diagram in Figure 6. Furthermore, the evolution path of the world's human capital stock resembles a Kuznets curve, and it reaches the turning point in 1980. In that year, the world average years of schooling are equal to 4.4, which is very close to the previously estimated 4.2 years using national data.

6. CONCLUSION

Human capital measures are widely used in many branches of economic literature, especially growth and development studies. However, the measures used as a proxy of human capital are most often poor justified by human capital theory. The misrepresentation of human capital will lead to errors in empirical research and may adversely affect policy makers' decisions. Hence the main objective of this paper was to improve on existing measures of human capital stock. Our improved measure of human capital was then applied in an analysis of inequality both on a national and on a global scale.

Our findings highlighted the importance in distinguishing between education and human capital. Although average education and average human capital exhibited a strong positive correlation, the use of average education to proxy for human capital is subject to a large margin of error. Most importantly, due to their concave relationship, using education inequality as a proxy of human capital inequality could lead to completely misleading findings.

It was found that while there was a positive relationship between average years of schooling and average human capital, the relationship between education and human capital inequality measured by Gini coefficients was concave. These led to the evidence of a human capital Kuznets curve with a turning point at about 4.2 years of schooling where the human capital Gini was about 0.36. This result had particular implications for policymakers in that promoting universal primary education as set out in the UN's second MDG, may lead to an increase rather than a decrease in human capital inequality. Policymakers should be cautious in expecting a fall in income gap in the society as a consequence of their education campaigns.

The evidence of a human capital Kuznets curve provided a natural explanation for the occurrence of the income Kuznets curve. However, the human capital Kuznets was only observed when we used relative measures of inequality. On the contrary, an education Kuznets curve is observed only when absolute measures of inequality are used, such as the coefficient of variation. These findings thus explain why there is inconsistent evidence in the literature about the existence of education or human capital Kurznets curves when different inequality measures were used.

On a global scale, human capital Ginis have remained rather static throughout the past four decades even though education Ginis trended downwards. It is interesting to read this result along side with that of Dowrick & Akmal (2005). They found that global income inequality, when measured by a Gini coefficient using true Afriat income, was largely stable over the 1980s and 1990s.

As mentioned in previous sections that, a limitation of the human capital measure constructed in this paper is the lack of reliable measures of education quality that allow us to account for quality inequality between countries and within countries, at a point in time and overtime. This is likely to a very fruitful (but data demanding) research area. Lastly, as labor and education markets are increasingly globalized, the flows of foreign and migrant workers and international students will be increasingly important in defining the human capital content of the labor force of a country. Another item on the research agenda, therefore, is how to account for these global flows of human capital in the construction of national human capital stock.

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Table 1: Methodological Improvements in the Measurement of Human Capital

Measure	Earlier approach	Later approach
Average Levels	Literacy rates or enrollment rates (Azariadis and Drazen 1990; Barro 1991; and Mankiw, Romer and Weil 1992).	Attainment rates (Barro 1997; Islam 1995; and Krueger and Lindahl 2000)
	Constant returns to education (Azariadis and Drazen 1990; Barro 1991; and Mankiw, Romer and Weil 1992)	Diminishing returns to education (Hall and Jones 1999; Gundlach et al. 1998)
	Homogenous education production function (equal schooling quality) (Hall and Jones 1999; and Gundlach et al. 1998)	Adjust for differences in schooling quality on top of adjusting for differences in rates of return to schooling (Wößmann 2003)
Inequality	Four levels of education used to calculate inequality (Checchi 2001; and CD 2002)	Seven Levels of education used to calculate inequality (TWF 2000; Ram 1990)[10]
	Students who have not completed an education level are assumed to have received half the total human capital endowment. (TWF 2000)	Calculate average years of education for dropouts (the current paper).

Table 2: Explanatory Variables in Prediction Models for Schooling Quality

Variable	Definition	Expected sign
X		
P	Primary school enrolment ratio	+
SCHOOL	Average years of schooling in the population aged 25 and above	+
GEETOT	Average ratio of total nominal government expenditure on education to nominal GDP	+
GEEREC	Average ratio of recurring nominal government expenditure on education to nominal GDP	+
GPOP	Average growth rate of population	–
HTX	1986 series of high-technology exports as a percentage of manufactured exports	+
TEAPRI	Average pupil/teacher ratio in primary school over the period 1950 to 1980	–
TEASEC	Average pupil/teacher ratio in secondary school over the period 1950 to 1980	–
Z		
ASIA	Equal to one if a country lies in the Asian region	
LATIN	Equal to one if a country lies in the Latin America and Caribbean region	
AFRICA	Equal to one if a country lies in Africa	

Table 3: Prediction Models for Schooling Quality, QL Scores

	Dependent Variable, *QL*		
	(1)	(2)	(3)
C	28.97	22.82	11.13
	(11.98)**	(13.53)	(9.62)
P	14.95	7.37	
	(12.79)	(7.94)	
SCHOOL	1.77	2.42	1.21
	(0.66)**	(1.11)**	(1.08)
TEAPRI	0.15	0.19	0.35
	(0.14)	(0.16)	(0.09)***
TEASEC		0.40	0.47
		(0.34)	(0.27)*
GEEREC	-1616.72	-1551.21	-1135.99
	(473.40)***	(554.22)**	(570.23)*
GEETOT	1277.27	1204.43	916.41
	(453.49)***	(529.09)**	(489.62)*
GPOP	-827.38	-717.67	-407.19
	(234.54)***	(308.01)**	(151.86)**
HTX		0.11	3.32
		(0.13)	(0.91)***
HTX^2			-0.16
			(0.04)***
HTX^3			2.02E-03
			(4.32E-04)***
ASIA (= 1)	9.77	5.63	
	(6.04)	(6.56)	
LATIN (= 1)	-10.00	-12.19	-11.92
	(4.47)**	(6.11)*	(3.88)***
AFRICA (= 1)	13.07	10.42	9.27
	(9.34)	(8.22)	(3.87)**
Observations	32	27	27
R-squared	0.76	0.81	0.88
Adjusted R-squared	0.66	0.67	0.80

Note: White Heteroskedasticity-Consistent Standard Errors are in parentheses below coefficients.
*** indicates significance at 1 percent level, ** 5 percent level, * 10 percent level.

Table 4: Human Capital Inequality Function

(a)

	Dependent variable: human capital Gini
C	-1.34 (-0.01)***
Ln(S)	0.75 (0.01)***
S	-0.18 (-4E-03)***
R-squared	0.75
No. Observations	891

Note: White Heteroskedasticity-consistent standard errors are in parentheses below coefficients.

*** indicates significance at 1 percent level.

(b)

Coefficient Covariance Matrix			
	α0	α1	α2
α0	9.22E-05	-2.31E-05	-8.00E-06
α1	-2.31E-05	0.00021	-5.35E-05
α2	-8.00E-06	-5.35E-05	1.65E-05

Figure 1: Average Human Capital versus Average Years of Schooling

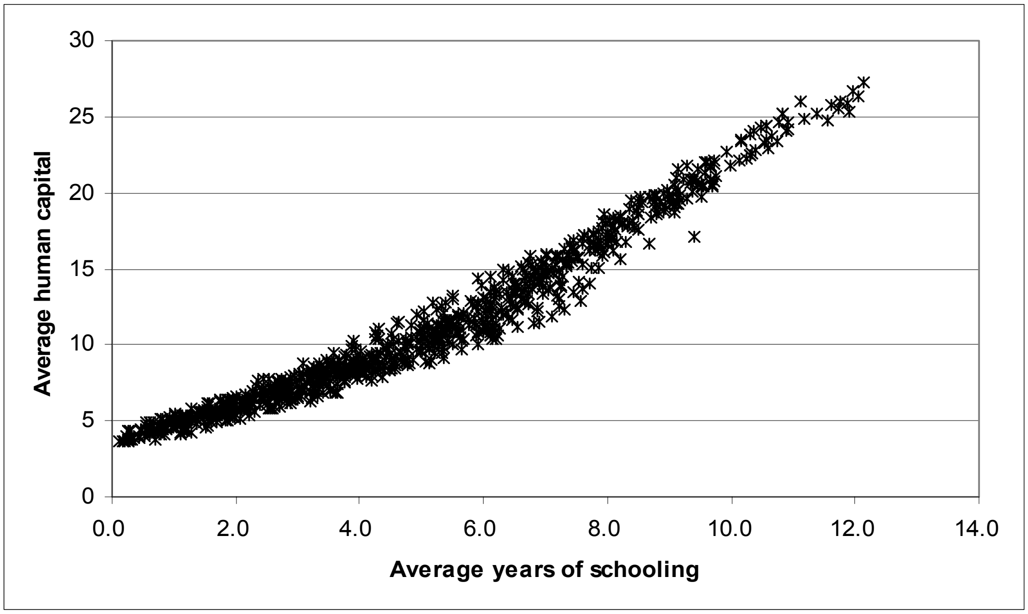


Figure 2: Human Capital Gini versus Education Gini

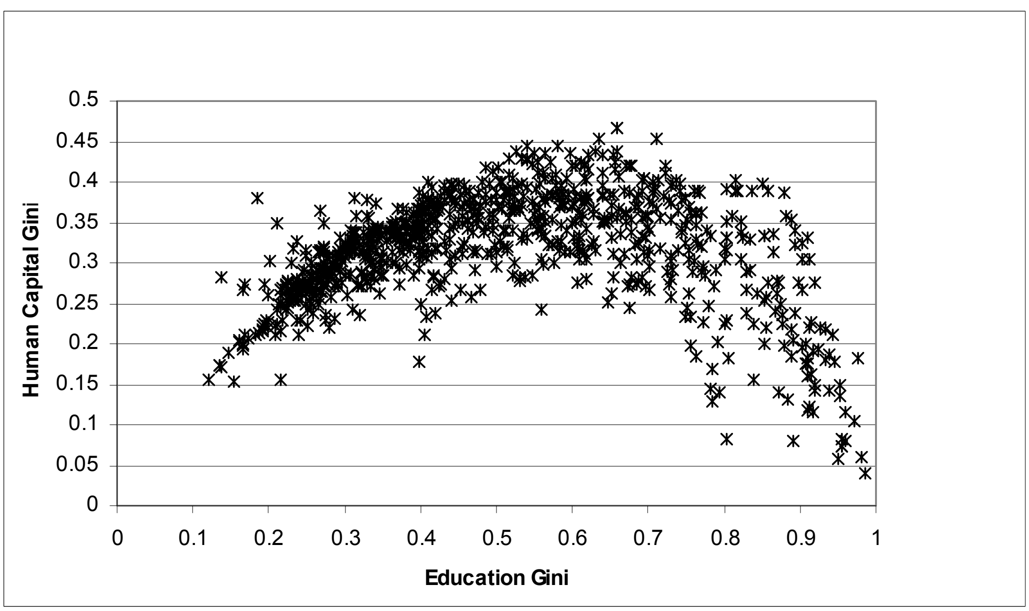


Figure 3: Education Gini versus Average Years of Schooling

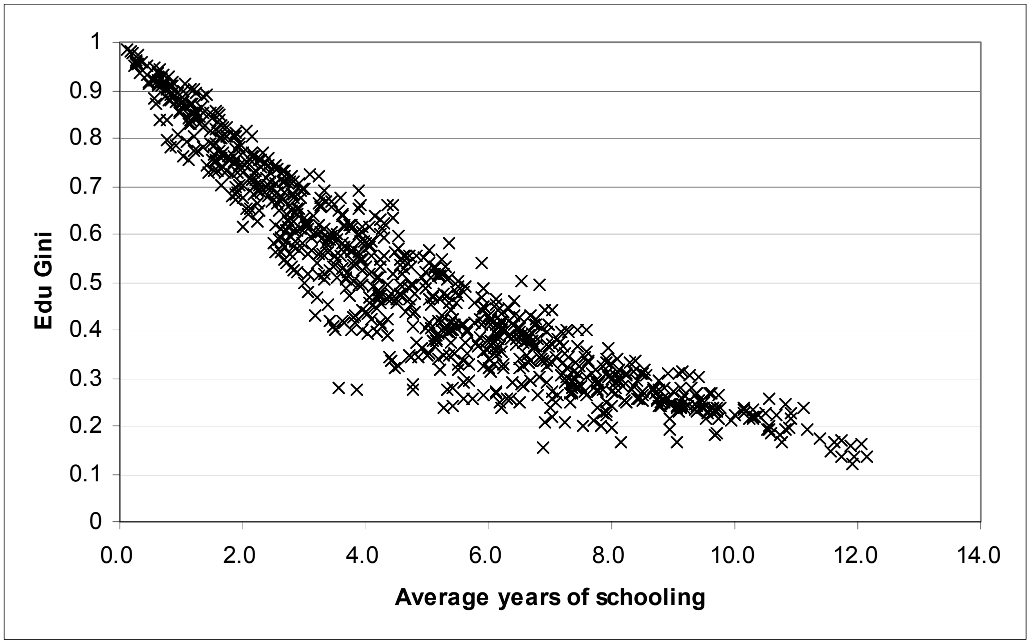


Figure 4: Human Capital Gini versus Average Human Capital

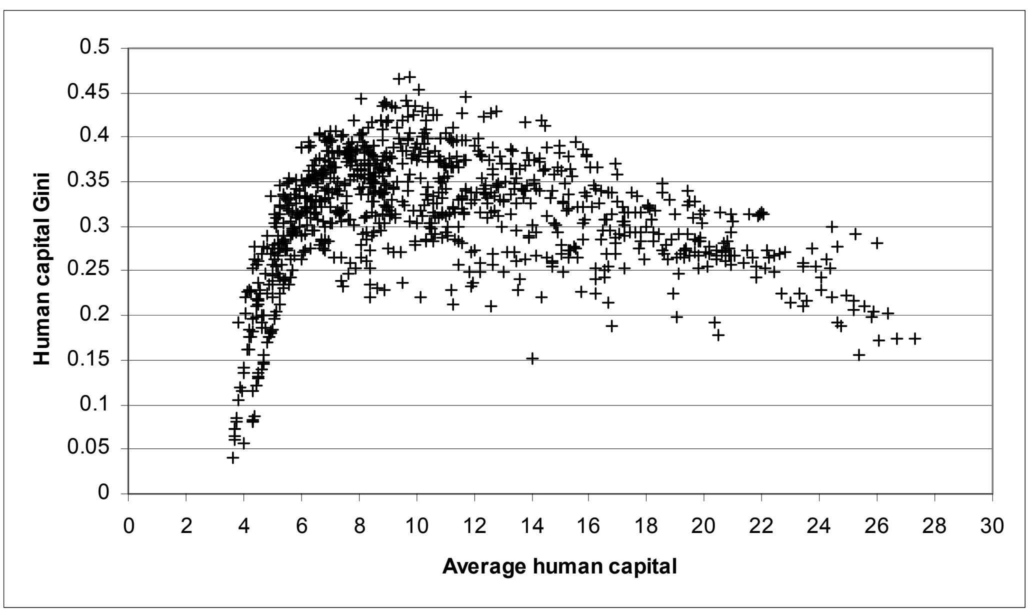


Figure 5: Human Capital Gini versus Average Years of Schooling

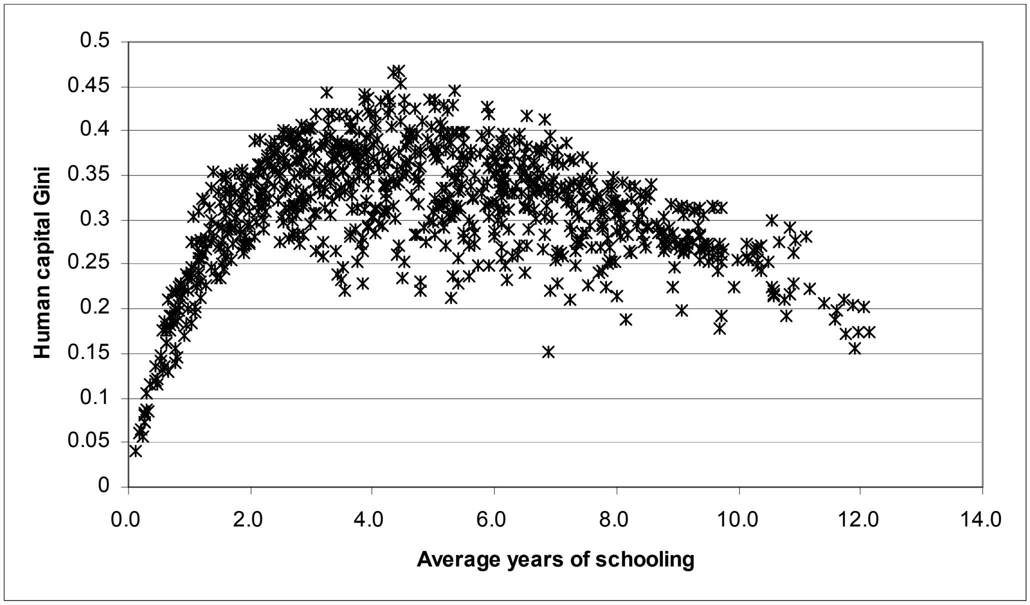


Figure 6: Summary of Relationships

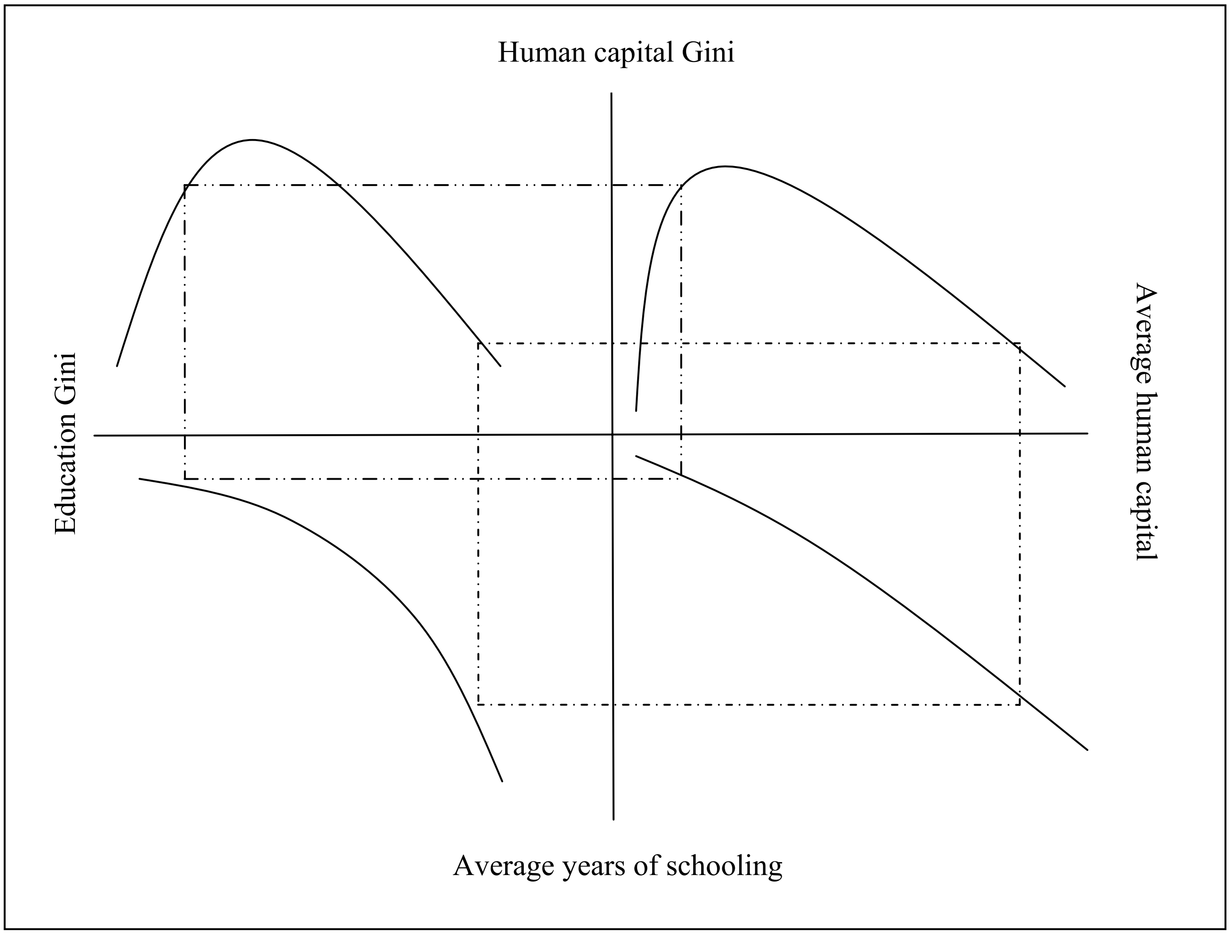
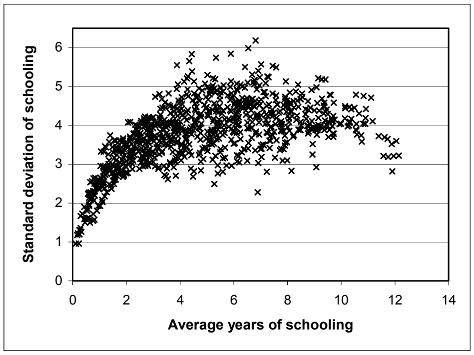
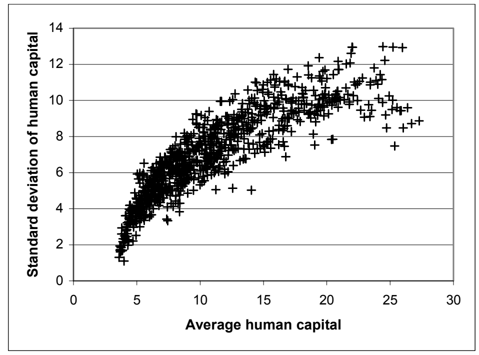


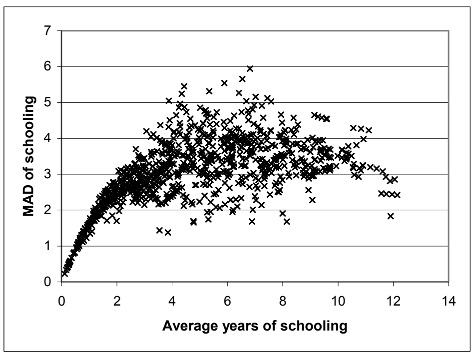
Figure 7: Other measures of inequality



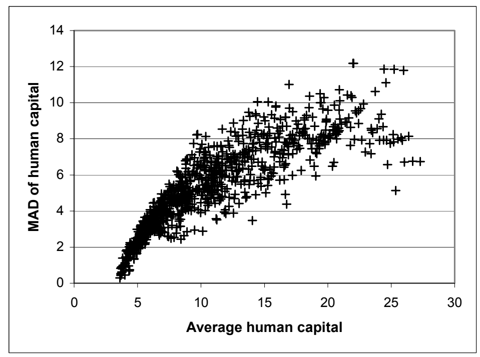
Panel (a)



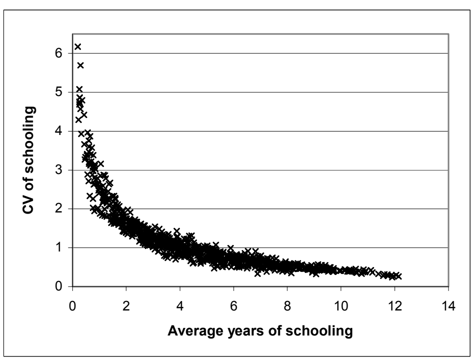
Panel (b)



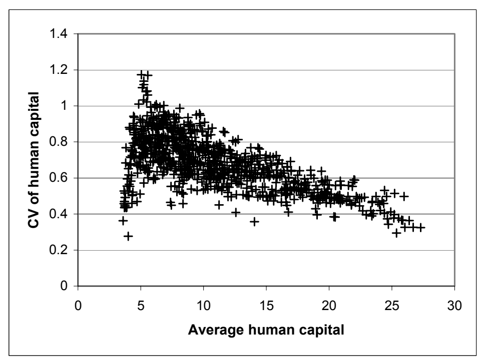
Panel (c)



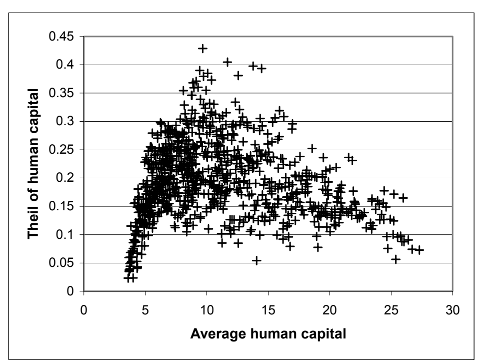
Panel (d)



Panel (e)

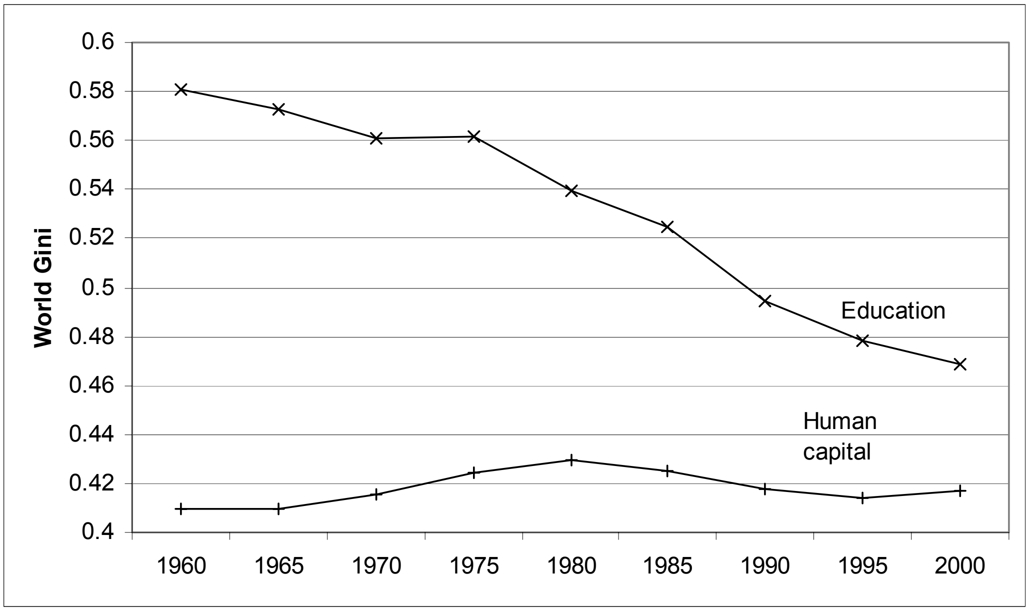


Panel (f)



Panel (g)

Figure 8: Historical Trends in World Education and Human Capital Gini's



APPENDIX

Table A1: Schooling Quality Data

COUNTRY	TEST[a]	QL
Afghanistan	*	29.98
Algeria	0	43.19
Argentina	0	37.72
Australia	1	48.13
Austria	0	49.88
Bahrain	0	29.63
Bangladesh	0	32.02
Barbados	0	46.18
Belgium	1	50.41
Bolivia	0	22.83
Botswana	0	33.97
Brazil	1	33.91
Cameroon	0	46.44
Canada	1	47.57
Central Africa Rep.	0	53.52
Chile	1	26.30
China	*	30.11
Colombia	0	26.70
Costa Rica	0	34.15
Cyprus	0	45.53
Denmark	0	54.33
Dominican Rep.	0	23.29
Ecuador	0	22.83
El Salvador	0	28.41
Fiji	0	26.17
Finland	1	48.76
France	1	54.15
Germany, West	1	59.03
Ghana	0	31.55
Greece	0	47.44
Guatemala	0	27.55
Guyana	0	29.45
Haiti	0	22.38
Honduras	0	22.83
Hong Kong	1	56.93
Hungary	1	53.85
Iceland	0	51.58
India	1	21.63

Indonesia	0	42.31
Iran	1	20.79
Iraq	%	29.63
Ireland	1	47.59
Israel	1	51.29
Italy	1	44.59
Jamaica	0	22.94
Japan	1	60.65
Jordan	0	44.86
Kenya	0	32.29
Korea	0	58.58
Kuwait	0	29.63
Lesotho	%	35.34
Liberia	%	40.21
Malawi	0	44.17
Malaysia	0	38.77
Mali	0	30.55
Mauritius	0	38.21
Mexico	0	34.40
Mozambique	1	24.26
Myanmar	*	35.19
Nepal	0	31.77
Netherlands	1	56.84
New Zealand	1	52.44
Nicaragua	0	27.55
Niger	0	53.20
Norway	1	49.60
Pakistan	0	28.19
Panama	0	34.15
Papua New Guinea	0	21.89
Paraguay	0	22.83
Peru	0	24.80
Philippines	1	34.35
Poland	1	50.28
Portugal	1	44.09
Senegal	0	36.82
Sierra Leone	%	31.58
Singapore	1	56.51
South Africa	*	35.97
Spain	1	49.40
Sri Lanka	0	25.85
Sudan	0	31.61
Swaziland	0	33.74
Sweden	1	47.41

Switzerland	1	57.17
Syria	0	27.89
Taiwan	1	56.28
Tanzania	0	36.33
Thailand	1	39.83
Togo	0	43.11
Trinidad & Tobago	0	29.25
Tunisia	0	41.56
Turkey	0	31.36
Uganda	0	48.72
United Kingdom	1	53.98
United States	1	43.43
Uruguay	0	20.62
Venezuela	0	37.72
Zaire	%	47.14
Zambia	0	44.70
Zimbabwe	0	29.12

Note:
"1" denotes countries with actual value of *QL*. "0" denotes countries with computed value of *QL* from the regression model 3. "*" denotes countries for which data on the explanatory variables was not available. "%" denotes countries for which data on *HTX* was not available. For countries in the last two categories, *QL* scores are imputed from the score of their neighbouring countries with similar income per capita.

Source: Hanushek and Kimko (2000) and author's calculations.

[1] The Kuznets curve is due to Simon Kuznets' theory that inequality increases over time as average income rises but then at a critical point begins to decrease as average income rises further.

[2] Schooling cycle means the maximum duration (in year) of schooling pertains to a given level of education. For instance, in most countries, the schooling cycles for primary, secondary, and tertiary education are six, six and four years, respectively.

[3] HK has two series of *QL*, namely *QL*1 and *QL*2. Nevertheless, the two series are highly correlated. *QL*1 is used in our estimation.

[4] See the coefficients for "year of schooling" in the earnings function in Table A2 of Baker & Benjamin (1994).

[5] Since the rate of return to primary education is 18.9, so if a person has attained 1.9 years of primary education, the amount of human capital he has accumulate is equal to exp(18.9*1.9) = 3.58.

[6] The correlation between average human capital and average years of schooling was at least 0.97 for all years.

[7] According to the theorem, $\mathrm{E}\left[\frac{\alpha_1}{\alpha_2}\right] \approx \frac{\mu_{\alpha 1}}{\mu_{\alpha 2}} - \frac{1}{\mu_{\alpha 2}^2}\operatorname{cov}\left[\alpha_1, \alpha_2\right] + \frac{\mu_{\alpha 1}}{\mu_{\alpha 2}^3}\operatorname{var}\left[\alpha_2\right]$, and

$$\operatorname{var}\left[\frac{\alpha_1}{\alpha_2}\right] \approx \left(\frac{\mu_{\alpha 1}}{\mu_{\alpha 2}}\right)^2 \left(\frac{\operatorname{var}\left[\alpha_1\right]}{\mu_{\alpha 1}^2} + \frac{\operatorname{var}\left[\alpha_2\right]}{\mu_{\alpha 2}^2} - \frac{2\operatorname{cov}\left[\alpha_1, \alpha_2\right]}{\mu_{\alpha 1}\mu_{\alpha 2}}\right).$$

[8] Theil index is undefined for education as every population has people of no formal schooling.

[9] Hannum & Buchmann (2004) provide the most recent survey on the impacts of global educational expansion on socio-economic development.

[10] Ram (1990) use the data from Psacharopoulos & Arriagada (1986). Due to the unavailability of that dataset, we are not able to comment on the treatment of dropouts in the dataset.