INEQUALITY IN INCOMES AND ACCESS TO EDUCATION. A CROSS-COUNTRY ANALYSIS (1960-95)†

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Abstract

In the current debate on the relationship between inequality in income distribution and growth one of the possible links works through the access to education. Starting from on optimal demand for education, where the years of education depend on family income among other things, we derive two testable predictions in the analysis of aggregate data on school enrolments: a negative (linear) dependence on Gini concentration index on incomes distribution; and a positive dependence on public resources invested in education and/or on skill premium in the labour market. These predictions are tested on a (unbalanced) panel of 108 countries for the period 1960-95. The main findings of this analysis are that, once we control for the degree of development with the (log of) per capita output, financial constraints seem mainly relevant in limiting the access to secondary education. However, when considering gender differences, there is evidence that female participation in education is more conditioned by family wealth, in some cases starting from primary education. Finally, there is weak evidence that public resources spent on education raise the enrolment rates.

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1. Introduction

In recent years there has been a revival of interest in studying the relationship between inequality and growth. After the works by Kuznets in the 50s (for example Kuznets (1955)), where the stages of growth were shaping the degree of inequality in society, the issue was neglected for almost 30 years, to reappear again at the beginning of the current decade. Starting with the empirical finding of a negative relationship between income inequality and growth of per capita income observed in different samples of countries in the last 30 years, several studies have proposed alternative explanations. Without any claim to completeness, one could group existing explanations into two main lines of research.[1] The first one invokes political economy actions, in a context of asset markets completeness. Greater inequality raises the demand for fiscal redistribution and introduces distortions that hamper private investment decisions.[2] An empirical variant of the same idea is that (wealth) inequality makes turmoil more likely (e.g. the lack of land reform), increases political instability, makes investors' horizons more shaky and eventually reduces output growth.[3] In both cases it is the increasing threat of reduction in the return of invested capital (or even the risk of expropriation), that reduces the agents' willingness to invest in physical capital, thus depressing the potential for growth.

The second line of research considers the borrowing constraints in financing access to education as the main explanation for the negative correlation between inequality and growth.[4] The poorest parts of the population do not possess resources to access education and cannot find financial markets where they can borrow these resources to send their children to school.[5] In this case fiscal redistribution is efficient because it shifts resources from individuals with low rates of return to liquidity constrained agents with very high rates of return.[6]

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[1] A good survey of the recent literature is contained in Benabou 1996c.

[2] See Alesina and Rodrick 1994, Persson and Tabellini 1994, Perotti 1993, Bertola 1993 and 1994.

[3] An additional variant is Mauro 1995, where inequality fosters corruption and depresses investment.

[4] See Galor and Zeira 1993, Banerjee and Newman 1993, Torvik 1993, Benabou 1996a and 1996b.

[5] Piketty 1997 claims that it is impossible to create financial markets to finance education, since (future) work effort is unobservable and contracts contingent on it are not enforceable.

[6] Redistributing incomes among agents is not the only way to increase efficiency. A scheme of education subsidies financed through taxation of future incomes (intertemporal redistribution) recreates the missing market, and allows the achievement of the first best. See Banerjee and Newman 1993.

Empirical tests of these two lines of research are still inconclusive. Almost everyone accepts the idea of negative correlation,[7] but it is not yet clear through which variables it operates. The political economy explanation suffers the lack of evidence of a negative relationship between redistribution and growth.[8] Alesina and Perotti (1996) find evidence of a negative relationship between inequality and growth via a variable measuring political instability (first principal component extracted from numbers of riots, assassination, coups); but their analysis has no predictive power, and the possibility of measuring political instability is questionable.[9] It is more difficult to test the second line of research in the absence of information at the individual level about income and educational choices of the family. Using aggregate data Perotti (1994) finds that a subjective qualitative measure of credit market rationing is statistically significant in explaining growth only when interacted with income inequality. However the most convincing piece of evidence in this respect comes from the comparison between Far Eastern countries and Latin American ones. The former are characterised by lower inequality and greater access to school, whereas the latter exhibit the reverse situation; possibly for these different patterns, the first area experienced sustained growth during the 70s and the 80s, while the second area underwent stagnation.[10] Using household surveys for 35 countries, Filmer and Pritchett (1998) show that asset poverty (as measured by the first principal component extracted from information on ownership of durable goods and quality of the housing) reduces school attainment in the poorest 40% of the population.

The present study provides additional support to this second line of research. It starts with a log-linear optimal demand for education, where the number of years of schooling is proportional to family income. Even if directly derivable from a micro-founded model of overlapping generations, this demand can be obtained by several other models. In particular, optimal demand for schooling could

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[7] Benabou 1996c states that one standard deviation reduction in inequality increase GNP per capita of about 0.5-0.7%. Perotti 1996 finds that a GNP 1% increase in middle incomes (proxied by 3° and 4° quartile in income distribution) yields an increase in GNP per capita growth rate in the order of 0.2%. Persson and Tabellini 1994 provides a higher estimate (in the order of 0.7%).

[8] Which actually is positive and significant, as found in Perotti 1996. The same author, when acting as a discussant of Benabou 1996c, suggest a reverse causation: fast growing economies have more resources available for redistribution. Alesina 1998 points out that most of the redistributive policies in developing countries benefit rather the middle class than the poorest.

[9] The relationship between inequality and political instability can be read in a reverse way: harsh social conflict (for example during coups) may cause high number of killings but, if successful, introduces regressive policies that increase income inequality (e.g. the Chilean case).

[10] Bourguignon (1994) finds an overall negative relationship between inequality and growth on a sample of 35 developing countries of small-medium size. His results are mainly driven by the sub-sample of Asian countries, which experienced early land redistribution and more compressed income distribution, combined with government effort to encourage higher education. He also points out that a positive relationship between inequality and growth could apply to Latin America countries, via financing of investment (more inequality implies greater profits and therefore more financing opportunities for investment). Brandolini and Rossi (1998) make an effort to strengthen data comparability in a sample of 17 countries, and do not find a persistent relationship between household incomes inequality and growth (even if they speak of *social institutions*, where the link could be either positive or negative depending on the country area).

be positively associated with unobservable ability. If ability is intergenerationally transmitted, we could get positive correlation between family income and children's schooling even without imperfection in financial markets. Then, under the assumption of log-normality in the distribution of incomes, school enrolment and Gini concentration index on incomes are linearly related. Following the liquidity constraints explanation, the Gini coefficient should come out significant and negative each time missing financial markets create a barrier to accessing education for the poorest families. On the contrary, if the intergenerational transmission of talent is a valid explanation, educational attainments and family incomes should be positively correlated at any stage of education. Since our empirical estimates prove a robust negative correlation at the secondary level for all the population, and at primary and tertiary for the female component only, we believe that these results bring support to the view that poor families are prevented from accessing school by their low incomes. Thus, greater income inequality reduces access to school. As long as cumulated human capital affects income growth,[11] we strengthen the second line of interpretation of the negative relationship between inequality and growth.

The paper is organised as follows. The next section studies the relationship between individual demand for schooling and aggregate distribution of income. Section 3 describes the data-set and section 4 presents the estimates of school enrolment rates at different level (primary, secondary and tertiary) in an unbalanced panel of 108 countries for the period 1960-95. The final section contains concluding remarks.

2. Individual demand for education and aggregate income distribution

In the line of Becker (1993) and Card (1994) the optimal demand for schooling is derived by equating decreasing marginal benefits (because lengthening school time reduces working time) and increasing marginal cost (because of direct cost of higher stages of education and opportunity cost of foregone incomes). With homogeneous agents, the demand for schooling decreases with the intertemporal discount rate and with direct costs of schooling, and increases with the return to education and the resources publicly invested in education (as long as they increase the production of human capital). When agents are heterogeneous in ability, better talented children obtain more human capital (because they benefit more from schooling and they stay longer at school) and therefore earn more. When agents are heterogeneous in family income and financial markets are imperfect, children from poor families obtain less education because they face higher costs and earn less in the labour market.

[11] This proposition that is not tested in the present paper, but finds support in the literature. Cf. Barro 1991 and 1997.

These two polar cases of heterogeneity, respectively named "elitist" and "equalitarian" by Becker (1993), rather then being mutually excluding, rather they usually coexist. If we assume intergenerational persistence of talent,[12] we obtain intertemporal persistence in inequality. Thus when we take a snapshot picture of income distribution, we are unable to distinguish whether the poor are so because they are less talented or because they are the descendants of poor families.[13] Unless you have access to individual data with reasonable proxies for unobservable ability, the two cases are observationally equivalent. The debate between supporters of a "natural" explanation and defender of the "imperfect market" explanation of inequality has not yet reached a definite conclusion, given the lack of natural experiments to discriminate between the twos, and we suspect it *never* will.[14] Since individual data-set containing proxy variables for ability do not exist for a sufficient number of countries, we cannot proceed further in considering this question, and therefore we will limit our analysis to the assumption of identical individuals.

Let us start with considering a log-linear version of the optimal demand for schooling of a generic individual *i*, $i = 1,\ldots,n$ belonging to generation *t* [15]

$$s_{it} = \alpha_0 + \alpha_1\eta_{it} + \alpha_2 x_{it} + \alpha_3 w_{t+1} + \alpha_4 b_t + \alpha_5 e_t + \alpha_6 k_t \quad (1)$$

where s_{it} is the number of years of schooling aspired to by individual *i* in generation *t*, η_{it} is her endowment of unobservable ability, x_{it} is her family income. The remaining are aggregate variables: w_{t+1} is the wage rate for educated worker that is expected to prevail when entering the labour market, b_t is the direct cost for accessing education, e_t is a measure of the public resources invested in education and k_t is some proxy for the stage of development. Sign expectations are as follows. Individual ability raises the optimal demand for education because talented people have more success in school, drop out less and stay in school longer ($\alpha_1 > 0$). Family income can limit the access to

[12] We do not need to resort to "genetic" theories of talent transmission. If we take talent as meaning whatever capability you do mechanically acquire within your family, without intentional investment, then talent can be intergenerationally transmitted as verbal ability, role models, and so on. See the discussion in Mulligan 1997.

[13] Or any possible combination of the two cases. If for example expected future income is a positive function of talent, randomly distributed in each generation, poor individuals are the less talented children of both rich and poor families. See Chiu 1998.

[14] See Ichino and Winter-Ebmer 1999 about the problems arising when trying to discriminate among the two explanations.

[15] A formal derivation of this demand in a framework of overlapping generations, where individual invest in education in the first period and work in the second one, is contained in the working paper version of the present work (UN-Wider Working paper n.158 – April 1999).

education when financial markets are imperfect or even absent ($\alpha_2 \geq 0$); under perfect financial markets α_2 is expected to become nil. *Cæteris paribus*, an education premium raises the expected return from investing in education and thus the optimal demand for schooling ($\alpha_3 > 0$). Lower costs of accessing education and/or greater public resources invested ease educational attainments in the population (respectively $\alpha_4 < 0$ and $\alpha_5 > 0$). Finally we want to capture the rising trends in school participation: the richer the country and the better endowed it is in cultural facilities, the more likely is school participation at later stages ($\alpha_6 > 0$).

If schooling is rewarded in the labour market (and this must be the case, otherwise there is no monetary incentive to acquire education) and talent is intergenerationally transmitted, it must be correlated with family income

$$\eta_{it} = \beta_0 + \beta_1 x_{it} + \varepsilon_{it}, \quad \varepsilon_{it} \sim (0, \sigma_\varepsilon^2) \tag{2}$$

By replacing equation (2) into (1) we get

$$s_{it} = (\alpha_0 + \alpha_1\beta_0) + (\alpha_1\beta_1 + \alpha_2)x_{it} + \alpha_3 w_{t+1} + \alpha_4 b_t + \alpha_5 e_t + \alpha_6 k_t + \alpha_1 \varepsilon_{it} \tag{3}$$

From an observational point of view, individuals are identical except for family of origin incomes (or inherited wealth when it is proportional to earned incomes). However looking at the coefficient of $\partial s_{it} / \partial x_{it}$ we can discriminate between two cases: when $\partial s_{it} / \partial x_{it} > 0$ either talent transmission or liquidity constraints cannot be rejected; on the contrary $\partial s_{it} / \partial x_{it} = 0$ implies random distribution of talent and absence of liquidity constraints. Under the assumptions implied by equation (3) the distribution of s_{it} will reflect the distributions of x_{it} and ε_{it}, all the other variables being shifting parameters for the entire distribution. Equation (3) can be re-expressed more concisely as

$$\begin{gathered} s_{it} = \gamma_0 + \gamma_1 x_{it} + \gamma_2 \varepsilon_{it}, \\ \gamma_0 = \alpha_0 + \alpha_1\beta_0 + \alpha_3 w_{t+1} + \alpha_4 b_t + \alpha_5 e_t + \alpha_6 k_t, \; \gamma_1 = \alpha_1\beta_1 + \alpha_2, \; \gamma_2 = \alpha_1 \end{gathered} \tag{4}$$

If we accept the rather plausible assumptions that family incomes X are log-normally distributed and the random component ε_{it} is normally i.i.d., then $\log(X) = x \sim N(\mu_x, \sigma_x^2)$, $\varepsilon \sim N(0, \sigma_\varepsilon^2)$ and

$s \sim N\left(\gamma_0 + \gamma_1 \mu_x, \gamma_1^2 \sigma_x^2 + \gamma_2^2 \sigma_\varepsilon^2\right)$. If we had individual information about education and family background, we could easily test the validity of the previous model by estimating equation (4) cross-individuals.[16] Unfortunately we only have this information available for few countries and for very few years. On the contrary, we have more information available on their distribution. School enrolment rates can be thought of as intervals of the cumulative distribution function:

$$
\begin{aligned}
P_1 &= \text{primary school enrolment} &&= \int_{n_1}^{\infty} f(S)dS \\
P_2 &= \text{secondary school enrolment} &&= \int_{n_2}^{\infty} f(S)dS \\
P_3 &= \text{tertiary school enrolment} &&= \int_{n_3}^{\infty} f(S)dS
\end{aligned}
\tag{5}
$$

where n_1, n_2 and n_3 are respectively the numbers of years required to complete the primary, secondary or tertiary level of education, and $f(S)$ is the density function of S. In addition, the statistics on income distribution most widely accessible is the Gini concentration index[17]

$$
G_X = \int_0^{\infty} 2[F(X) - Q(X)]g(X)dX, \; Q(X) = \frac{1}{\overline{X}} \int_0^X tg(t)dt \tag{6}
$$

where $g(X)$ is the density function of X and the term in squared brackets is the vertical distance between the Lorenz curve and the perfect equality relationship.

Under the joint assumption of the validity of the model described by equation (3) and the lognormal distribution for X, school enrolment and Gini index are linked by a linear relationship. In fact, when $x \sim N\left(\mu_x, \sigma_x^2\right)$ its density function is given by

$$
N\left(x; \mu_x, \sigma_x^2\right) = \frac{1}{\sigma_x \sqrt{2\pi}} \exp\left[-\frac{\left(x - \mu_x\right)^2}{2\sigma_x^2}\right] \tag{7}
$$

and the associated Gini index is

[16] The estimate of $\hat{\gamma}_1$ would obviously be biased if the unobservable random component is correlated with family background. See Card 1994.

[17] See for example Cowell 1995, p.141 ss.

$$G_X = 2\int_{-\infty}^{\frac{\sigma_x}{\sqrt{2}}} \frac{1}{\sqrt{2\pi}} \exp\left[-\frac{t^2}{2}\right] dt - 1 = 2\int_{-\infty}^{\frac{\sigma_x^2}{\sqrt{2}}+\mu_x} \frac{1}{\sigma_x\sqrt{2\pi}} \exp\left[-\frac{(x-\mu_x)^2}{2\sigma_x^2}\right] dx - 1 \tag{8}$$

In addition, when $s \sim N\left(\gamma_0 + \gamma_1\mu_x, \gamma_1^2\sigma_x^2 + \gamma_2^2\sigma_\varepsilon^2\right)$, its density function is given by

$$N\left(s; \gamma_0 + \gamma_1\mu_x, \gamma_1^2\sigma_x^2 + \gamma_2^2\sigma_\varepsilon^2\right) = \frac{1}{\sqrt{2\pi\left(\gamma_1^2\sigma_x^2 + \gamma_2^2\sigma_\varepsilon^2\right)}} \exp\left[-\frac{(s-\gamma_0-\gamma_1\mu_x)^2}{2\left(\gamma_1^2\sigma_x^2 + \gamma_2^2\sigma_\varepsilon^2\right)}\right] \tag{9}$$

Leaving aside for simplicity the random component or its variance (either $\gamma_2 = 0$ or $\sigma_\varepsilon^2 = 0$) it simplifies to

$$N\left(s; \gamma_0 + \gamma_1\mu_x, \gamma_1^2\sigma_x^2\right) = \frac{1}{\gamma_1\sigma_x\sqrt{2\pi}} \exp\left[-\frac{(x-\mu_x)^2}{2\sigma_x^2}\right] \tag{10}$$

Enrolment rates can now be redefined as[18]

$$P_i = \int_{\log(n_i)}^{\infty} f(s)ds = 1 - \int_{-\infty}^{\log(n_i)} f(s)ds = 1 - \int_{-\infty}^{\frac{\log(n_i)-\gamma_0}{\gamma_1}} \frac{1}{\gamma\alpha_1} f(x)\gamma_1 dx =$$

$$= 1 - \frac{1}{2}\left[2\int_{-\infty}^{\frac{\sigma_x^2}{\sqrt{2}}+\mu_x} f(x)dx + 2\int_{\frac{\sigma_x^2}{\sqrt{2}}+\mu_x}^{\frac{\log(n_i)-\gamma_0}{\gamma_1}} f(x)dx\right] = \tag{11}$$

$$= \left[\frac{1}{2} - \int_{\frac{\sigma_x^2}{\sqrt{2}}+\mu_x}^{\frac{\log(n_i)-\gamma_0}{\gamma_1}} f(x)dx\right] - \frac{1}{2}\left[2\int_{-\infty}^{\frac{\sigma_x^2}{\sqrt{2}}+\mu_x} f(x)dx - 1\right] = \lambda_j - \frac{1}{2}G_X, \qquad j = 1,2,3$$

The intuition underlying this relationship can be grasped by observing figure 1. In the upper quadrant there are two normal density functions, the solid line corresponding to the case of $\mu_x = 0, \sigma_x^2 = 1$, and the dashed line to the case of $\mu_x = 0, \sigma_x^2 = 2$. This translates below into the corresponding cumulative distribution function (northeast quadrant). Assuming a linear combination of the type

[18] Whenever $\frac{\log(n_i)-\gamma_0}{\gamma_1} < \frac{\sigma_x^2}{\sqrt{2}} + \mu_x$ one has to consider the opposite of an integral with inverted extremes of integration.

$s = 0.5 + 0.8 \cdot x$ (southeast quadrant), this maps the cumulative distribution function of $s \sim N(0.5, 0.64)$ or $s \sim N(0.5, 1.28)$ (southwest quadrant). In the last (north-west) quadrant we have reported the Lorenz curve corresponding to the distribution of *X*.[19] Now let us consider an increase in the dispersion of incomes around a given mean (i.e. the passage from the solid to the dashed line). This implies an increase in the population share with an income below any given value, and correspondingly an increase in the population share that is unable to achieve the income threshold that is necessary to access a fixed amount of education. At the same time the Gini concentration index for incomes increases. We find corroboration of the negative association of Gini index for incomes and school participation rates. Figure 2 and 3 consider alternative cases where we have variations in the distribution of s independently of changes in income dispersion (as measured by the Gini concentration index). Figure 2 shows the case of an increase in mean income (from 0-solid line to 1-dashed line) for a given variance ($\sigma_x^2 = 1$). We obtain here an increase in the access to education for any level of income, given a constant Gini index. Finally figure 3 keeps income distribution constant and modifies the relationship between income and education (due to a change in the parameter γ_0 that reflects educational expenditure, technology, returns to schooling and stage of development). The solid line corresponds to the case of $s = 0.5 + 0.8 \cdot x$, whereas the dashed line depicts the case $s = 1 + 0.8 \cdot x$. Once again, we obtain an increase in educational achievements for any given level of income.

[insert figures 1-2-3 about here]

Summing up, in the context of optimal demand of schooling with heterogeneous agents we have shown that educational attainments and family incomes are positively correlated. As long as it is possible to control for the mean income and other variables affecting the educational choice in the aggregate (cost of accessing the school, public resources devoted to education, wage premium for educated workers in the labour market and stage of development), we expect to find a negative relationship between the Gini concentration index on income distribution and enrolment rates at any level of education. In the sequel we find an existing negative relationship either at the secondary level of education or for female component only. These results are incompatible with a relationship between educational achievements and family income based on talent transmission. In fact if the brightest students hail from the richest families, we should observe the same relationship subsisting at

[19] It is known that the Gini concentration index corresponds to the ratio of the areas in the Lorenz graph: $G_X = \frac{A}{A+B}$.

any stage of education and for both male and female component of young cohorts. On the contrary, finding that this relationship exists for specific educational choices (going beyond compulsory education or investing in a daughter's future) does not contradict the idea of existing liquidity constraints in the educational choices.

3. Data description

The data utilised in this analysis come from different sources; data on educational achievements and school quality are from Barro and Lee (1993, 1994, 1996, and 1997).[20] Data on income inequality are from Deininger and Squire (1996); data on physical capital stocks are from Nehru and Dhareshwar (1993); finally, data on female fertility, child mortality and population growth have been extracted from World Bank (1998). In all cases the series have been updated to 1995, when available, using World Bank (1998) and Unesco (1998). Data refer to 108 countries for the period 1960-95 and report information at quinquennial intervals: therefore at best we have 8 observations for each country. However with a theoretical dimension of the data-set equal to 864 observations (108×8), missing information (mainly on income distribution) reduces it by more than one third, transforming it into an unbalanced panel. For the main variables (income inequality indices, enrolment rates, gross national products and population) we rely on 470 observations (with an average of 4.3 observations per country), but in most cases when considering additional information this number has to be reduced even further. Descriptive statistics about these main variables are reported in Table 1 (entire data-set), whereas information on additional control variables available are reported in Table A2 in the Appendix. Regional averages are also reported in the Appendix (tables A1.a-A1.g).

On the whole, these data cover almost half of the 210 countries listed by the World Bank (1998), but account for 86.3% of the world population (as measured in 1990). Given the fact that this data-set is forcibly tailored according to the availability of income distribution data, one may suspect the possible introduction of sample bias. In order to check this possibility, using all the available information on a greater set of 132 countries, we have run a panel probit regression predicting the availability of data on income distribution (see Table A3 in the Appendix). The results are reassuring: there is only evidence of easier availability of data for bigger countries (in terms of population) and for less recent years. In particular, availability of information on income distribution seems unrelated with information on school enrolment at primary and secondary level, whereas it is positively

[20] Barro and Lee 1994 is in turn based on Summers and Heston 1991.

correlated with higher education (since countries with a better educated labour forces have easier access to income data). Therefore I think that this data-set may provide a representative picture at the world level of the determinants of schooling participation.

Table 1 - Descriptive statistics - entire sample - 1960-95

	Mean entire sample	*standard deviations*	*restricted sample*	*standard deviations*	*mean year=60*	*mean year=70*	*mean year=80*	*mean year=90*
Gross enrolment rate in primary education	0.839 (812)	0.251	0.899 (470)	0.189	0.731 (101)	0.790 (103)	0.879 (102)	0.885 (101)
Gross enrolment rate in secondary education	0.424 (801)	0.313	0.482 (470)	0.290	0.226 (98)	0.342 (103)	0.467 (100)	0.547 (96)
Gross enrolment rate in higher education	0.114 (797)	0.136	0.134 (470)	0.135	0.036 (99)	0.070 (101)	0.120 (101)	0.181 (89)
Gini index of income distribution	0.414 (526)	0.105	0.422 (470)	0.101	0.456 (55)	0.428 (75)	0.396 (70)	0.402 (83)
Total population (thnds)	36040 (831)	117146	46629 (470)	128627	24970 (102)	30879 (102)	37399 (102)	44075 (107)
Real gross domestic product per capita - US dollars (PPP adjs. 1985 intern.prices)	3916.4 (824)	4003.0	4524.9 (470)	4061.0	2453.8 (98)	3336.7 (104)	4417.1 (105)	5115.2 (107)

Notes: numbers in brackets report the number of non-missing observations in each sample (or sub-sample).

Looking at the descriptive statistics (Table 1), we find evidence of well-known stylised facts. In the aggregate data inequality in income distribution declined during the 60´s and the 70´s, then showed an upward surge during the 80´s. However when looking at regional areas, we cannot find a uniform pattern, thus providing some support to the argument that inequality does not exhibit a specific trend since 1960.[21] Inequality is highest in Sub-Saharan Africa and Latin America, and lower in industrialised countries and South Asia. Educational achievements rose quickly during the first two decades, but this rise slowed down during the 80´s. By the beginning of the 90´s, many countries had in having all the population enrolled in primary education (OECD countries, Latin America, North Africa and East Asia). However, while OECD countries have almost reached complete saturation also for the second stage of secondary education, all the other countries are still lagging behind, the worst situation being recorded for Sub-Saharan and South-Asian countries. An analogous picture emerges looking at higher education. Graphical inspection of the association between school enrolment and income inequality confirms that most of the countries have achieved full participation in education at the primary level, thus reducing the potential variation in the former variable (Figure 4). On the contrary, at the secondary and tertiary level of education, a negative correlation emerges clearly (Figures 5 and 6). However, at this stage we do not know whether this evidence is the result of spurious correlation (when for example inequality and school participation are both functions of the stage of development) or whether it represents a genuine effect. To ascertain the nature of this effect we have to move to multivariate regressions.

[21] See, for example, Grilli 1994, Jones 1997 or Li, Squire and Zou 1998.

[insert figures 4-5-6 about here]

4. The empirical analysis

In the sequel we investigate the determinants of enrolment rates at different stages of education, and in particular we will concentrate on the effects of income distribution.[22] In line with the model introduced in Section 2, the observed enrolment rate is a reduced form incorporating elements describing household behaviour (demand for schooling) and government provision of this public service (supply of schooling).[23] On the supply side, information about state spending, employed teachers and repetition rate is available; on the demand side, beyond information about income distribution, we will consider demographic factors (birth rates), family composition (fertility rates) and socio-cultural environment (proxied here by the mortality rates). Given that schooling is a stage-by-stage process (you cannot enrol at university unless you have completed secondary school), educational achievement at a certain stage is conditioned by the achievement obtained at the previous stage (what we term "ratchet effect"): given the absence of detailed information on schooling flows, we will proxy this effect with the average achievement of the entire population for that level of education. Finally, we will control for the stage of development by conditioning on the level of real GNP per capita.

Primary education

Full enrolment for primary education has been almost completely achieved by all countries, especially in most recent years. The public push towards attending compulsory education has lowered any cost barrier to accessing education, at least at this stage. We do not find evidence of any negative effect of income distribution (as measured by Gini indices) on gross enrolment for primary education.[24]

[22] Deininger and Squire 1996 provide data of different quality, according to the coverage of the sample, the inclusion/exclusion of non-labour incomes and information about the recipients (individuals or families). Using what they define "high quality" data reduces the available observations to 277 (which do not include data referred to 1995). However the results are not very different when extended to include the "low quality" data, even if given their greater variability the estimates are less efficient. They also stress the different source of information (incomes or expenditures), but controlling with a dummy on this aspect (either unconstrained or interacted with the Gini variable) does not lead to statistically significant results. Estimates on a restricted sample including only "high quality" data are available from the author. The original Deininger and Squire 1996 data-set has been expanded using additional observations referred to 1995 from World Bank 1998.

[23] Information on the private provision of schooling is scattered, and therefore we cannot take into account information on the supply of private schooling. Arnove et al.1997 report an impressive increase of private institutions providing education, especially at the university level, as a consequence of the decline in public expenditure in education: in Latin America the share of students enrolled in private universities rose from 5% in 1970 to approximately 30% in 1990.

[24] The insignificance of the estimated coefficient for the Gini index is robust against model misspecification (using Huber-White estimator) and censoring of the dependent variable (random effect tobit model estimation - see Table A4 in the appendix). Both estimates are available upon request.

However, since the Gini index does not provide a complete ordering of income distributions (because of crossing of corresponding Lorenz curves) we have also experimented with the income share accruing to the poorest segment of the population, the lowest quintile. In this case, the variable is statistically weakly significant. Columns 1 and 2 of Table 2 report the fixed effect OLS regressions, whereas random effect estimations for censored data are reported in the Appendix (Table A4). However a negative correlation still exists for the female component of student population: Column 4 of Table 2 re-estimates Column 1 by restricting to female primary enrolment, and again we find a weakly negative significant impact of income distribution. This could be taken as evidence that expansion of compulsory education has mainly benefited boys, irrespective of availability of financial resources from the family. Since we do not have good reason to believe that talent is unequally distributed according to gender, we consider this result as the first piece of evidence in favour of the borrowing constraints interpretation of the negative correlation between Gini index and enrolment rates. It is noteworthy that the same effect does not carry over to the random effect estimation (Column 4 in Table A4 in the Appendix), nor in cross section (Column 5 in Table A7 in the Appendix): this could imply that there is something that is country-specific in this effect. In other words, financial resources still preclude the access to primary education of girls from poor families in some areas of the world. Why families might be more willing to afford educational expenditure for boys than for girls is strongly intertwined with cultural habits.[25] In effects, when we control for this possibility using random effect estimation on regional sub-samples, we find that this result is attributable to East-Asian countries and, to a lesser extent, to Latin American ones (Column 4 in Table A8 in the Appendix). Some additional effect of income distribution can be found looking at mortality rates. If we take child mortality as a proxy for extreme poverty, we find a significant negative impact on enrolment into primary education.[26]

On the supply side, one finds evidence of a negative impact of population growth (as measured by the crude birth rate), because it necessarily implies a decline of per child resources. It is also true that for

[25] And social structures, at least for the case of castes in India. In this country primary education is not compulsory, and child labour is legal. The huge variation in literacy rates (which is 74% among urban males and 20% among rural females) is supposedly explained by the following factors: "The central proposition of this study is that India's low per capita income and economic situation is less relevant as an explanation than the belief systems of the state bureaucracy ... At the core of these beliefs are the Indian view of the social order, notions concerning the respective roles of upper and lower social strata, the role of education as a means of maintaining differentiations among social classes, and concerns that 'excessive' and 'inappropriate' education for the poor would disrupt existing social arrangements." (Weiner 1991, 5).

[26] Unfortunately children mortality proxies too many effects that interplay with primary education. For example, children mortality is negatively correlated with mother education and with health conditions (sanitation, doctors' availability, etc.). For this reason we do not want to put excessive emphasis on an "income distribution" interpretation. However using household surveys, Filmer and Pritchett 1998 show that the first principal component extracted from information on ownership of durable goods and quality of the housing is a rather good predictor of educational attainment.

many countries, limited resources available may prevent school attendance.[27] This could constitute the explanation of the rather counter-intuitive result of the number of students per teacher exhibiting a significant and positive impact (instead of a negative one, as one would have expected thinking of greater resources and better quality being associated with lower values of this variable). In other words, a greater number of students per teacher would indicate a country's effort to catch up with full attendance of primary education.[28]

On the demand side, family background seems to account for some variation. If we take the fertility rate[29] as proportional to the average number of children in a family, we could expect either negative or positive effects. The former case applies when resources are binding - the greater the number of the children in a family, the lower are the resources per capita, the greater is the opportunity cost of school attendance. On the contrary, the latter case applies when supportive effects could be accounted for; in this case, the larger the number of siblings, the higher the probability that someone else has already had some schooling experience, and therefore the greater is the chance of getting some help at home.[30] The relevance of the cultural environment (the so-called social capital) is also witnessed by the positive effect played by the stock of people with some (but incomplete) primary education. The positive effect could be explained on two grounds. On one side, some of the population (older than 15 years) with uncompleted primary education could re-enrol into primary education, thus raising the gross rate of enrolment. On the other side, it may be correlated with the effort of a country to overcome illiteracy, and therefore it describes the pressure put on children to enrol and complete primary education.[31]

The process of schooling (even at primary level) is obviously related to the stage of development of a country. If we measure this stage with the (real) gross domestic product per capita, we find effectively that primary enrolment is positively associated with its logarithm. But exploiting a suggestion

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[27] In the case of Tanzania, for example, where primary attendance was 0.34 in 1970, 0.93 in 1980 and 0.70 in 1990, class dimension can vary between 30 to 74 in rural areas. See Tibaijuka and Cormack 1998.

[28] That the number of students per teacher does not represent a good proxy for school quality has already pointed out (see for example Hanushek 1986, 1995 and 1996).

[29] The fertility rate indicates the number of potential children that an "average" woman - i.e. following the average behaviour of the country in terms of marriage age, frequency of pregnancies, etc. - could give birth to during her fertility period. We also found a variable describing the "number of person per family" (source: World Bank - correlation coefficient with fertility rate = 0.73), but it has too few observations (211 on the whole sample) and therefore we had to discard it

[30] Similar results were obtained by Schultz 1988 on a sample of 155 countries over the period 1950-80, when he found a positive effect of the relative size of school aged population onto enrolment rates for primary education.

[31] Introducing the illiteracy rate as explanatory variable comes out statistically significant with a negative sign, but the number of observation drops to 195 (corresponding to 69 countries). On the contrary, when using the number of daily newspapers or the number of radio sets for 1000 inhabitants, one obtains negative but statistically insignificant coefficients.

originally advanced by Sen (1976), and subsequently followed by international agencies as a starting point to measure the degree of human development,[32] we correct the level of per capita product Y with the contemporaneous Gini concentration index G, thus obtaining a measure of "inequality-adjusted real income" Y_{adjust}

$$Y_{adjust} = Y \cdot (1 - G) \tag{12}$$

Notice that when using the logarithm of Y_{adjust}, a one-percent increase in Y is (approximately) equivalent to a one point reduction in the Gini index. The variable Y_{adjust} comes out highly significant, with a rather low semi-elasticity of 0.03 (column 3 of Table 2); it implies that in order to obtain an increase in primary enrolment of 1% one would require an increase in per capita income of 33%, maintaining constant the inequality in income distribution. All the other variables keep previous signs and significance.[33]

We were unable to find strong effects of public resources invested in education on enrolment. Using a subset of countries for which educational resources information is available, Table 3 compares the result obtained in column 1 and 4 of Table 2 with a richer specification that includes all available information about quantity and quality of the educational offer at primary level. While income inequality remains insignificant, all the proxies used to capture different aspects of publicly invested resources tend to be insignificant.[34] Additional resources invested in education can take different forms: fewer students per teacher, better paid teachers, a greater ratio of governmental current expenditure on primary education per pupil on per capita GDP (or simply a greater share of education expenditure on GDP), a greater share of educational resources invested in buildings and equipment. Or we could even look at more care devoted to attending children, negatively proxied by drop-out and repetition rates. In accordance with the previous model, we expect that an increase in public resources *ceteris paribus* should facilitate school attendance, and therefore increase school enrolment. In all these cases with the exception of teachers' pay and drop-out rates we do not find strong evidence of positive effects of more resources on primary enrolment. The case of drop-out rate could

[32] See the various issues of the *Human Development Report* (UNDP 1997).

[33] Substantially, Column 3 corresponds (approximately) to imposing a restriction on the coefficients of log Y and G in Column 1, which cannot be rejected by the data. Imposing the restriction $coefficient(\log Y) = -coefficient(G)$ in Column 1 of Table 2 has an F-test(1,337)=0.70 (p-value 0.40).

[34] Part of the insignificance may be attributed to multicollinearity, but using correlation indices among the variables included in table 3, we find that the highest correlation is between drop-out rate and either student per teacher (0.65) or repetition rates (0.62). All the other coefficients are below 0.5.

be due to different regional patterns.[35] The case of teachers' pay is inconclusive: for given resources, having better paid teachers necessarily implies having fewer teachers, fewer or more crowded classes, and consequently less availability of the educational service.[36] This is for example the explanation advanced by Ridker (1994) for the decline in primary enrolment for sub-Saharan Africa in the last decade .[37] Should we take this evidence as supporting the idea of cutting teachers' wages as a measure to increase school participation? Not necessarily; and for at least two reasons. The first one is the limited size of this effect: with the estimated coefficient, in order to increase primary enrolment of 1% it would be necessary (at given GDP per capita) to almost half the existing wage level. Second, at least in the case of Africa, it is argued that given the already low level of pay a reduction in teachers' wages would induce a reduction in effort, in order to supplement their income with additional jobs.[38] The case of drop-out rates is ambiguous, because it is partially endogenous: given an initial level of primary enrolment, an increase in drop-out rates implies by definition a decline in enrolment (with a coefficient restriction equal to –1, which is rejected by the data). As an alternative point of view, we could follow a line of reasoning similar to Hanushek (1995), and we could take the insignificant impact of financial resources on enrolment rates as evidence of inefficient allocation of resources. Since our results are not strong enough to support his conclusion, in our opinion the question of the potential effect of additional resources on primary enrolment has to be left open.

[35] Working on household surveys collected in 35 countries, Filmer and Pritchett (1998) shows that: "Very low primary attainment by the poor is driven by two distinct patterns of enrolment and drop-out. There is a South-Asian and Western/Central African pattern in which many of the poor never enrol in school. In these countries more than 40 per cent of poor children never complete even grade 1 and typically only one in four complete grade 5. In contrast there is a Latin American pattern in which enrolment in grade 1 is (nearly) universal but drop-out is the key problem." (ibidem, p.3). However their conclusion does not contradict present results: "These data cast some doubts on the notion that physical availability of school facilities at the primary or secondary level is the key issue in many countries." (ibidem, p.4).

[36] Which could possibly be of higher quality if the teachers' wage reflects their unobservable ability in teaching.

[37] He notices that the lack of locally trained manpower attracts expatriates, which have higher reservation wages and are often remunerated with grant aids, then crowding out local competencies even further. Also Schultz 1988 finds a negative effect of teacher wages onto primary and secondary enrolment.

[38] Tibaijuka and Cormack 1998 make this argument. However in my data-set teacher wages in Africa are not extremely low, at least in relative terms: in 1990 the average salary for primary school teacher (measured in 1985 US dollar, converted with PPP) was 5442 (17 countries; ratio to per-capita GDP=3.5) for Sub-Saharan Africa, 10324 (8 countries; GDP ratio=2.5) for North Africa and the Middle East, and 7770 (11 countries; GDP ratio=2) for Latin America and the Caribbean.

Table 2 – Estimation of primary education enrolment – fixed effects – 1960-95

	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients
Dependent variable: Gross enrolment rate in primary education	*total*	*total*	*total*	*female*
Gini index of income distribution	0.02 (0.33)	-0.20 (1.34)	---	-0.11 (1.35)
Income share of the lowest quintile in income distribution	---	-0.57 (1.06)	---	---
(Log of) Real gross domestic product per capita	0.04 (2.20)	0.05 (3.08)	---	0.04 (2.05)
(Log of) inequality adjusted real GNP per capita	---	---	0.03 (1.86)	---
Children mortality rate in the 1st year (per 1000 births)	-2.48 (8.05)	-2.13 (7.57)	-2.49 (8.09)	-3.14 (8.98)
Fertility rate (potential children per woman)	0.08 (7.30)	0.06 (6.21)	0.07 (7.24)	0.08 (7.29)
Crude birth rate (per 1000 inhabitants)	-0.01 (5.78)	-0.01 (5.75)	-0.01 (5.76)	-0.01 (5.00)
Share of the corresponding population over 15 with some primary education	0.014 (0.29)	0.011 (0.24)	0.016 (0.32)	0.12 (2.14)
Student per teacher in primary education	0.002 (2.57)	0.003 (3.46)	0.002 (2.50)	0.001 (1.80)
Constant	0.59 (3.31)	0.60 (3.16)	0.71 (4.65)	0.55 (2.70)
# of observations/# of countries	436/92	303/84	436/92	424/92
Corr. btw random component and indv explanatory varibles	0.09	0.03	0.10	0.15
R2 overall	0.54	0.50	0.52	0.62
R2 within	0.43	0.51	0.43	0.46
F test	36.34 (0.00)	28.10 (0.00)	42.11 (0.00)	40.69 (0.00)

T-statistics in brackets.

Table 3 – Estimation of primary education enrolment using different variables for educational resources – fixed effects – 1960-95

	estimated coefficients	estimated coefficients	estimated coefficients	estimated coefficients
Dependent variable: Gross enrolment rate in primary education	*total*	*total*	*female*	*female*
Gini index of income distribution	0.12 (1.21)	0.14 (1.55)	0.09 (1.06)	0.09 (1.07)
(Log of) Real gross domestic product per capita	0.05 (1.93)	0.04 (1.79)	0.03 (1.43)	0.02 (0.66)
Children mortality rate in the 1st year (per 1000 births)	-1.06 (2.05)	-0.86 (1.71)	-2.65 (5.34)	-2.57 (4.90)
Fertility rate (potential children per woman)	0.03 (2.17)	0.03 (2.64)	0.02 (1.80)	0.03 (2.23)
Crude birth rate (per 1000 inhabitants)	-0.005 (2.14)	-0.004 (1.70)	-0.002 (0.84)	-0.002 (0.98)
Share of the corresponding population over 15 with some primary education	0.14 (1.85)	0.05 (0.57)	0.25 (3.60)	0.23 (2.94)
Student per teacher in primary education	---	0.003 (2.05)	---	0.001 (1.02)
Repetition rate - primary education	---	0.001 (0.70)	---	-0.0005 (0.33)
Drop-out rate - primary education	---	-0.27 (3.51)	---	-0.17 (2.11)
Per pupil government expenditure on primary education/ GDP per capita	---	0.001 (0.72)	---	0.002 (1.37)
Government expenditure on education/GDP	---	0.17 (0.29)	---	0.27 (0.45)
(Government expenditure on education/GDP)*Gini index	---	---	---	---
Capital expenditure/total government expenditure on education	---	-0.08 (1.02)	---	0.06 (0.08)
(Capital expenditure/total government expenditure on education)*Gini index	---	---	---	---
Average salary primary school teacher/GDP per capita	---	-0.0001 (2.34)	---	-0.0001 (2.20)
Constant	yes	yes	yes	yes
# of observations/# of countries	169/59	169/59	166/59	166/59
Corr. btw random component and indv explanatory variables	-0.28	-0.25	-0.36	-0.38
R2 overall	0.47	0.45	0.59	0.56
R2 within	0.29	0.41	0.48	0.53
F test	7.30 (0.00)	5.22 (0.00)	15.64 (0.00)	8.16 (0.00)

T-statistics in brackets.

Secondary education

When passing to secondary education, we find a strong correlation between income distribution and school enrolment. The Gini index comes out significantly negative: a 1 per cent decline in the index (more equalitarian distribution) implies a 0.25% rise in secondary enrolment (columns 1 of Table 4). The same effect is obtained when considering inequality-adjusted real income Y_{adjust}, with a somehow lower impact (column 3 of Table 4). Analogous measures obtain for the random effect model (Table A5 in the Appendix). Also in this case we find additional evidence of possible discrimination against girls: a significant increase in inequality (say a $\Delta Gini = +0.05$) reduces secondary school enrolment to 1% for boys and 1.8% for girls. Notice in addition that the coefficient measuring the impact of inequality for girls is bigger than in the case of primary school (-0.35 against -

0.11), and this suggests that financial constraints are more relevant at this stage of education. It is interesting also to note that liquidity constraints seem to affect the whole span of income distribution, since the coefficient of the income share of the lowest quintile is not significantly different from 0.[39]

Table 4 – Estimation of secondary education enrolment – fixed effects – 1960-95

	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients
Dependent variable: Gross enrolment rate in secondary education	*total*	*total*	*total*	*female*
Gini index of income distribution	-0.24 (2.68)	0.01 (0.06)	---	-0.35 (3.73)
Income share of the lowest quintile in income distribution	---	0.69 (0.88)	---	---
(Log of) Real gross domestic product per capita	0.14 (6.37)	0.15 (6.03)	---	0.15 (6.37)
(Log of) inequality adjusted real GNP per capita	---	---	0.13 (7.17)	---
Fertility rate (potential children per woman)	-0.05 (5.33)	-0.06 (5.62)	-0.05 (5.34)	-0.06 (6.03)
Average years of completed primary education in the corresponding population over 15	0.06 (6.15)	0.04 (3.42)	0.06 (6.10)	0.06 (5.20)
Ratio of physical capital stock to GDP (1987 local prices)	0.04 (3.26)	0.05 (3.40)	0.04 (3.56)	0.05 (3.81)
Constant	-0.67 (3.31)	-0.82 (3.05)	-0.67 (3.93)	-0.65 (3.07)
# of observations/# of countries	386/76	264/69	386/76	369/76
Corr. btw random component and indv explanatory variables	-0.65	-0.58	-0.64	-0.73
R2 overall	0.79	0.76	0.79	0.82
R2 within	0.65	0.68	0.65	0.69
F test	115.1 (0.00)	67.27 (0.00)	143.3 (0.00)	127.7 (0.00)

T-statistics in brackets.

On the demand side we find evidence of some effect given by the family composition, as proxied by the fertility rate. While this variable exhibits a positive effect at primary level (and was explained there as evidence of the effort of supportive effect within the family), in this case it presents a clearly negative impact, which can be interpreted as evidence of a family resource effect. If we consider that sending a child to a secondary school (which in most countries exceeds the threshold of compulsory education) is a more requiring task (at least on the financial side), an increase in family size implies a reduction in resources per child (in terms of both income, partially captures by the inequality and output per capita variables, and time devoted to children support by the parents).

On the supply side once more we find weak effects of resources invested in education; the number of pupils per teacher, the ratio of governmental current expenditure on secondary education per pupil on GDP per capita, the repetition rate, the aggregate expenditure on education (as a share on GDP) and its composition, all variables exert a statistically insignificant effect (columns 2 and 5 in Table 5).

[39] It renders the Gini coefficient also insignificant, but it remains significant in random effect estimation using robust estimators: see Table A5 in the Appendix. The Gini coefficient remains also significant when analysing yearly cross-section (Table A7), whereas at regional level its significance seems more attributable to North-African and South-Asian countries (Table A8).

However, when we interact data for public expenditure on education with the Gini index on income distribution, we find that their impact becomes significant: an increase in public resources devoted to current expenditure on education raises secondary enrolment, especially for countries with very unequal income distribution.[40] The Gini index remains negatively significant; in addition, when we take the total derivative of secondary enrolment with respect to Gini index, from the 3rd column we get

$$\frac{\partial \text{ enrolment}}{\partial \text{ Gini index}} = -2.11 + 28.86 \cdot (\text{ed.expenditure}/\text{GDP}) + 2.33 \cdot (\text{capital exp.}/\text{total exp}) \tag{13}$$

which evaluated at sample means is equal to – 0.49. We take this result as a second piece of evidence in support of a liquidity constraint interpretation of the relationship between income distribution and school enrolment. Had this relationship been attributable to talent transmission, we would have expected an opposite result. Since more talented students take more advantage of greater resources invested in education,[41] we should find that an increase in public expenditure widens the dispersion of educational achievements and other things being equal strengthens the relationship between secondary enrolment and Gini index of income distribution. On the contrary, if the relationship is attributable to liquidity constraints, an increase in public expenditure lowers the barriers of access, and weakens the same relationship; this is what we infer from the equation (13). In other words public resources do not have a direct impact, but they are effective by easing family choices of letting their children proceed further in their educational career.

Another aspect related to the public supply of secondary education has to do with the "vertical integration" of this process; if we consider that a student can enrol in a secondary school only if s/he has completed the primary level, evidently an increase in the completion of primary education provides additional inputs to the next stage of production. This "ratchet" effect makes it rather implausible to observe enrolment rates at higher stages greater than those observed at lower stages. Effectively, we find that the average years of completed primary education in the population[42] plays a significant positive effect; raising the sample mean (3.94 years) by an additional year should induce an

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[40] From 3rd column of Table 5, taking the total derivative of secondary enrolment with respect to government expenditure on education over GDP yields positive values for Gini index above 0.37.

[41] See Card 1994.

[42] The variable "average years of primary education" (sample mean referred to the population over 15 is 3.96 years) is obtained by multiplying the variable "share of the population with completed and uncompleted primary education" (sample mean referred to the population over 15 is 0.632) with the variable "years of duration of primary education" (sample mean referred to 1965 is 6.31). Therefore an increase of one year in the average years of primary education can be obtained by increasing the primary attendance in the population by 0.158 (obtained as result of 1/6.31).

increase in secondary enrolment in the order of 4-6 percentage points, depending on the chosen specification. Family choices also seem to respond to the existing situation on the labour market, probably via differential returns for education and/or differential employment probability.[43] Under the assumption of complementarity between human and physical capital in production,[44] we can approximate the skill requirement in the economy with existing capital intensity (ratio of physical capital to output). In such a case, we observe that an increase in demands for skills in the labour market (i.e. an increase in capital/output ratio) induces an increase in secondary school enrolment. However the size of the effect is not very high; a 10% increase in capital/output ratio (from an average of 2.58 to 2.84) would raise secondary enrolment just 0.4%.[45]

Table 5 – Estimation of secondary education enrolment using different variables for educational resources – fixed effects – 1960-95

	estimated coefficients	estimated coefficients	estimated coefficients	estimated coefficients	estimated coefficients	estimated coefficients
Dependent variable: Gross enrolment rate in secondary education	*total*	*total*	*total*	*female*	*female*	*female*
Gini index of income distribution	-0.38 (2.71)	-0.33 (2.18)	-2.11 (4.68)	-0.40 (2.66)	-0.35 (2.20)	-2.44 (5.17)
(Log of) Real gross domestic product per capita	0.20 (5.44)	0.20 (5.00)	0.15 (4.13)	0.21 (5.13)	0.19 (4.44)	0.14 (3.37)
Fertility rate (potential children per woman)	-0.03 (2.27)	-0.03 (1.82)	-0.03 (1.87)	-0.03 (1.92)	-0.03 (1.65)	-0.03 (1.79)
Average years of completed primary education in the corresponding population over 15	0.07 (3.25)	0.07 (2.85)	0.10 (4.04)	0.09 (3.47)	0.09 (3.13)	0.13 (4.63)
Ratio of physical capital stock to GDP (1987 local prices)	0.04 (1.74)	0.04 (1.74)	0.04 (1.78)	0.04 (1.89)	0.04 (1.69)	0.03 (1.58)
Student per teacher in secondary education	---	0.001 (0.40)	0.002 (1.02)	---	0.0001 (0.03)	0.001 (0.73)
Repetition rate - secondary education	---	0.001 (0.68)	0.02 (1.42)	---	0.001 (0.75)	0.003 (1.59)
Per pupil government expenditure on secondary education/ GDP per capita	---	-0.001 (1.19)	-0.001 (1.25)	---	-0.0007 (0.70)	-0.001 (0.77)
Government expenditure on education/GDP	---	-0.08 (0.09)	-10.70 (3.80)	---	0.28 (0.29)	-11.19 (3.80)
(Government expenditure on education/GDP)*Gini index	---	---	28.86 (4.00)	---	---	31.9 (4.22)
Capital expenditure/total government expenditure on education	---	-0.23 (1.64)	-1.11 (2.28)	---	-0.30 (2.02)	-1.79 (3.48)
(Capital expenditure/total government expenditure on education)*Gini index	---	---	2.33 (1.99)	---	---	3.89 (3.13)
Constant	yes	yes	yes	yes	yes	yes
# of observations/# of countries	133/50	133/50	133/50	130/49	130/49	130/49
Corr. btw random component and indv explanatory variables	-0.75	-0.71	-0.71	-0.82	-0.80	-0.80
R2 overall	0.77	0.77	0.78	0.83	0.82	0.82

43 These two channels cannot be directly tested because of the lack of appropriate data. Estimates of returns to schooling for several countries (but limited to very few years) are reported in Psacharopulos 1994. Unemployment rates for educational attainments do not exist on such a long time span and for so many countries.

44 A rather plausible assumption: see Benabou 1996b and 1996c.

45 This evidence is confirmed by including another variable, the "ratio of total worker to population" which Barro and Lee 1994 report as drawn from Summer and Heston 1991, and extends up to 1985. We have been unable to update this variable in a consistent way. However if we re-estimate the model reported in Column 1 of Table 4 over the period 1960-85 including this variable, it comes out significant with coefficient equal to 0.491 (1.96). This implies that an increase in the employment rate of 10% calls for an increase in secondary enrolment of almost 5%. This seems unrelated to the type of secondary education that is available: a variable measuring the share of vocational education in secondary one is statistically insignificant.

R2 within	0.76	0.77	0.82	0.77	0.79	0.84
F test	49.0 (0.00)	25.1 (0.00)	26.7 (0.00)	52.9 (0.00)	27.2 (0.00)	31.1 (0.00)

T-statistics in brackets.

Higher education

Moving finally to higher education, as in the case of primary education, we find weak evidence of direct impact of either income inequality or first quintile shares on higher education enrolment (columns 1 and 2 in Table 6).[46] Given the fact that many authors stress that public finance of tertiary education has a regressive effect because the offspring of the middle-classes are over represented, we have also tested the possible existence of liquidity constraints within this group by using the income share of each quintile (taken either separately or jointly), but we could not detect any statistically significant effect. When we make use of the inequality-adjusted real income Y_{adjust}, the variable is significant but the result is mainly driven by the underlying effect of output per capita.[47] More surprising is the result that income inequality seems to affect male enrolment more than female enrolment. The differences in sample averages between the enrolment rates of the two genders are not very pronounced (16.2% for men against 11.4% for women), and therefore we cannot explain it with a composition effect. The talent transmission explanation cannot account for this difference, unless we pursue a self-selectivity explanation: males and females have different preferences, and the latter withdraw from an educational career more frequently than the former. But we believe that a more realistic explanation lies in the fact that the daughters from financially constrained families have already abandoned school at earlier stages, and therefore the 11% actually enrolled in school belong to rich families. On the contrary, since financial constraints restrain male enrolment only starting from secondary level, the selection according to family resources has operated less strongly among them, and we can still find sons from middle-class families that are financially constrained when asked to afford enrolment at university. In our opinion this is a third piece of evidence supporting the liquidity constraints line of interpretation

Table 6 – Estimation of higher education enrolment – fixed effects – 1960-95

	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients
Dependent variable: Gross enrolment rate in higher education	*total*	*total*	*total*	*female*	*male*
Gini index of income distribution	-0.07 (0.92)	0.14 (0.68)	---	-0.07 (1.05)	-0.13 (2.10)

46 A negative coefficient for the Gini coefficient is obtained in random effect estimation (Table A6 in the Appendix) and for some cross-sections (1970 and 1980 - see column 4 in table A7).

47 Here again, the data (using the specification of Column 1 in Table 6) do not reject the restriction $coefficient(\log Y) = -coefficient(G)$: F-test(1,226)=0.03 (p-value 0.86).

Income share of the lowest quintile in income distribution	---	0.61 (0.83)	---	---	---
(Log of) Real gross domestic product per capita	0.08 (3.91)	0.14 (4.11)	---	0.04 (2.24)	0.08 (4.07)
(Log of) inequality adjusted real GNP per capita	---	---	0.07 (3.97)	---	---
(Log of) Government current expenditure in secondary education per pupil (PPP-adjusted 1985 intn.prices)	0.02 (2.13)	0.02 (1.51)	0.02 (2.52)	0.03 (2.87)	0.01 (0.77)
Average years of completed secondary education in the corresponding population over 15	0.07 (5.88)	0.04 (2.74)	0.07 (5.97)	0.08 (7.22)	0.05 (4.88)
Ratio of physical capital stock to GDP (1987 local prices)	0.01 (1.06)	0.02 (1.01)	0.01 (1.45)	0.01 (0.71)	0.02 (2.57)
Constant	-0.76 (5.08)	-1.39 (4.94)	-0.67 (5.83)	-0.51 (3.76)	-0.60 (4.51)
# of observations/# of countries	303/72	210/65	303/72	254/70	253/69
Corr. btw random component and indv explanatory variables	-0.59	-0.68	-0.55	-0.59	-0.39
R2 overall	0.63	0.57	0.63	0.59	0.60
R2 within	0.57	0.57	0.57	0.60	0.61
F test	60.22 (0.00)	31.47 (0.00)	74.9 (0.00)	54.63 (0.00)	55.51 (0.00)

T-statistics in brackets.

As far as the supply of higher education is concerned, there is evidence of a positive effect of public expenditure per pupil at the previous stage. If we take this variable as a proxy of the quality of education provided at secondary school, this evidence suggests that increasing the resources invested at one stage of education can be ineffective in directly raising student participation at that level, but can be beneficial in favouring the transition to the next stage (for example by raising the self-confidence of the students).[48] This impact is rather low; a 10% increase in public expenditure per student enrolled in secondary school (equal to 103 US dollars measured at 1985 prices) induces an increase of 0.21 percentage points in higher education enrolment. The ratchet effect (namely the interdependence between sequential stages of education) emerges also by the positive effect exerted by the average years of secondary education achieved in the population aged over 15 years; an addition year (from a sample average of 1.4 years) induces an increase of almost 50% in higher education enrolment.[49] When considering alternative measures of educational resources, we find only a significantly positive effect of the total amount of public resources invested in education onto higher education enrolment (Column 2 of Table 7). Other direct measures of invested resources (like the student per teacher) do not have direct information about the resources invested at this stage of education. We would also have expected a negative correlation between the share of students enrolled in vocational secondary schools and enrolment to the university (since students from generalist secondary schools are inputs to higher education), but this does not arise in our data. On

[48] Empirical evidence on the role of self-confidence is limited. In a NLS sample Lillard (1998) finds a significant effect of "... family dummy variables measuring whether or not the son expects 'much' help from his parents to pursue higher education and how much his parents encouraged him to pursue higher education" (p.17). These dummies are significant in predicting both school performance and earnings.

[49] One could think of the possibility that education at later stage could influence enrolment at earlier stages (think of the case of limited access to the university reducing the enrolment to secondary school). While being valid in principle, this objection neglects the fact that it is always possible to create a private supply of the rationed good.

the demand side, the only evidence comes from the demand for skilled workers, as proxied by the capital/output ratio. Even if the coefficient is lower than in the case of secondary education, the elasticities are of comparable magnitude (see the following Table 8). This is possibly indicative that the productive sector requires more technical training (mostly provided by secondary schools) than professional credentials provided by universities. Notice moreover that the effect of this variable is significantly higher for men than for women.

Table 7 – Estimation of higher education enrolment using different variables for educational resources – fixed effects – 1960-95

	estimated coefficients	estimated coefficients	estimated coefficients	estimated coefficients	estimated coefficients
Dependent variable: Gross enrolment rate in higher education	*total*	*total*	*female*	*female*	*male*
Gini index of income distribution	-0.11 (0.63)	-0.06 (0.34)	-0.38 (1.86)	-0.40 (1.92)	-0.40 (1.83)
(Log of) Real gross domestic product per capita	0.14 (3.70)	0.15 (3.55)	0.07 (1.30)	0.11 (1.65)	0.06 (0.96)
Average years of completed secondary education in the corresponding population over 15	0.05 (2.57)	0.05 (2.21)	0.08 (2.78)	0.04 (1.44)	0.02 (0.86)
Ratio of physical capital stock to GDP (1987 local prices)	0.02 (0.83)	0.004 (0.16)	0.01 (0.36)	0.01 (0.38)	0.01 (0.58)
Student per teacher in higher education	---	0.0001 (0.16)	---	0.001 (0.98)	0.005 (4.27)
(Log of) Government current expenditure in secondary education per pupil (PPP-adjusted 1985 intn.prices)	---	-0.01 (0.74)	---	-0.02 (0.95)	0.003 (0.11)
Government expenditure on education/GDP	---	2.25 (2.11)	---	0.96 (0.66)	1.50 (0.95)
Capital expenditure/total government expenditure on education	---	-0.24 (1.86)	---	-0.26 (1.92)	0.01 (0.10)
Share of vocational training in secondary education	---	0.11 (0.94)	---	0.08 (0.62)	0.002 (0.02)
Constant	yes	yes	yes	yes	yes
# of observations/# of countries	91/35	91/35	70/32	70/32	70/32
Corr. btw random component and indv explanatory variables	-0.82	-0.84	-0.80	-0.82	-0.56
R2 overall	0.59	0.61	0.52	0.58	0.62
R2 within	0.74	0.79	0.73	0.79	0.79
F test	36.3 (0.00)	19.7 (0.00)	23.5 (0.00)	12.6 (0.00)	12.0 (0.00)

T-statistics in brackets.

5. Concluding remarks

In this study we have examined some empirical evidence in support of the negative correlation between inequality and growth. Starting from a very general model of optimal demand for education, we have argued that the dependence on family income may derive either from talent transmission or from borrowing constraints with imperfect financial markets. In both cases, if family incomes are log-linearly distributed, we derive two testable predictions in the analysis of aggregate data on school enrolments: a negative (linear) dependence on Gini concentration index on income distribution; and a positive dependence on public resources invested in education and/or on skill premiums in the labour market. These predictions are then tested on a (unbalanced) panel of 108 countries for the period 1960-95.

The main findings of this analysis are summarised in Table 8. Once we control for the degree of development with the (log of) per capita output, income inequality seems mainly relevant in limiting the access to secondary education. However, when we consider gender differences, there is evidence that female participation in education is more strongly conditioned by family income, starting from primary education. On the contrary there is no clear evidence of a relevant impact of invested resources, except but at the tertiary level. Some positive effect is also played by labour demand for skilled workers, which tends to raise enrolment in post-primary education. Other conditioning variables, at primary and secondary level, are fertility rates and mortality rates, which tend to capture other aspects of social development. Finally, the data show that increasing education at one stage raises the odds for following stages.

Table 8 – Comparative elasticities of enrolment at different educational level

	Primary	Secondary	Higher
Gini index of income distribution (1st column in tables 2-4-6)	-0.011	-0.211**	-0.185
(Log of) inequality adjusted real GNP per capita (3rd column in tables 2-4-6)	0.033*	0.281**	0.529**
Average years of completed education at previous stage (1st column in tables 2-4-6)	0.006**	0.520**	0.622**
Ratio of physical capital stock to GDP (1st column in tables 2-4-6)	---	0.215**	0.194
only female			
Gini index of income distribution (4th column in tables 2-4-6)	-0.054	-0.311**	-0.260
Average years of completed education at previous stage (4th column in tables 2-4-6)	0.060*	0.467**	0.907**

* statistically significant at 95% ** statistically significant at 99%

When we come to the interpretation of these results, we have argued that there is clear evidence in favour of a borrowing constraint interpretation against a talent transmission reading. First, we found differential effects of income inequality on male and female enrolment rates. While still compatible with a differences in preferences story, we believe that this is the reflection of family behaviours: with scarce financial resources, families invest traditionally more easily in boys' than in girls' education. Second, we found that public resources affect secondary enrolment when interacted with income inequality. We take this as evidence of public expenditure on education alleviating family liquidity constraints. The opposite reading, where the brightest children are the offspring of the richest families, cannot account for these two facts. An alternative explanation of the same evidence is put forward by Bourguignon and Verdier (1998). They present a model where an oligarchic class decides upon the optimal size of the poor to be educated. Since the franchise is one to one with education, the latter variable feeds back into taxation and redistribution decided upon by majority voting. Thus when inequality is high, the majority voting is likely to produce strong redistribution, and therefore the oligarchy has an incentive to restrict the access to education. However, their explanation is valid as long as democratic participation is positively correlated with educational achievements. Since the former variable is hard to define, this constitutes the focus of future research.

As long as our reading based on borrowing constraints is accepted, income redistribution should matter for educational goals. The size of the effect is not impressive: lowering the Gini index by 5 percentage points, a sizeable change at sample means, produces a total increase in school participation of almost 2 percentage points.[50] However, if one is willing to believe in the conclusions of the present study, when a country wants to raise the educational level of its population, more than spending additional resources on building schools and hiring teachers (which at best have an indirect effect on secondary school enrolments), it should rather prefer to implement redistributive policies (via taxes and/or subsidies). As long as these policies are effective in reducing income inequalities within the population, they are also capable of relaxing the financial constraints faced by the poorest families, and promote school enrolment. In the light of statistical irrelevance of invested resources in promoting enrolment, any policy recommendation on expenditure reallocation (for example, from tertiary to primary, or vice versa) seems pointless, given the limited impact of resources on school enrolment.[51] But a similar argument applies to the idea of expanding a private provider of education. As long as school fees create an additional financial barrier to continuing education, we expect a reduction in total enrolment because it raises financial barriers against constrained families.[52]

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[50] This incorporates the direct effect (first line of table 8) and the indirect effect (first line times third line lagged of one level).

[51] These policy advises are based on the comparison between private and social returns to education. Since the typical ranking of returns is primary > secondary > tertiary, there should be ground to claim an expenditure reallocation in favour of primary level. See Birdsall and James 1993 and Psacharopulos 1994.

[52] For this reason the following conclusion seems not granted: "...preliminary evidence suggests that the second pattern - restricted public sector capacity and a large private sector - is superior with respect to access, providing much higher overall enrolment ratios and thus higher rates of participation by lower-income groups." (Birdsall and James 1993, p.344).

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Appendix

Table A1.a - Descriptive statistics – Sub-Saharan Africa

	mean entire sample	*standard deviations*	*mean year=60*	*mean year=70*	*mean year=80*	*mean year=90*
Gross enrolment rate in primary education	0.610 (227)	0.292	0.425	0.525	0.703	0.692
Gross enrolment rate in secondary education	0.135 (220)	0.135	0.038	0.078	0.149	0.213
Gross enrolment rate in higher education	0.013 (221)	0.019	0.002	0.007	0.013	0.025
Gini index of income distribution	0.485 (97)	0.098	0.517	0.540	0.485	0.456
Total population (thnds)	10221 (240)	15314	6058	7929	10573	13670
Real gross domestic product per capita - US dollars (1985 international prices)	1031.6 (234)	918.3	806	986	1187	1261

Notes: numbers in brackets report the number of non-missing observations in each sample (or sub-sample). It includes 30 countries: Botswana, Burkina Faso, Cameroon, Central African Republic, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Côte d'Ivoire, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Uganda, Zambia, Zimbabwe.

Table A1.b - Descriptive statistics – North Africa and Middle East

	mean entire sample	*standard deviations*	*Mean year=60*	*mean year=70*	*mean year=80*	*Mean year=90*
Gross enrolment rate in primary education	0.804 (69)	0.235	0.611	0.722	0.872	0.921
Gross enrolment rate in secondary education	0.397 (68)	0.260	0.192	0.276	0.474	0.637
Gross enrolment rate in higher education	0.087 (70)	0.092	0.021	0.045	0.111	0.136
Gini index of income distribution	0.413 (34)	0.073	0.472	0.436	0.404	0.376
Total population (thnds)	15210 (72)	15835	9032	11817	15311	20419
Real gross domestic product per capita - US dollars (1985 international prices)	2871.7 (67)	2021.4	1675	2370	3138	3662

Notes: numbers in brackets report the number of non-missing observations in each sample (or sub-sample). It includes 9 countries: Algeria, Egypt, Morocco, Tunisia, Iran, Israel, Jordan, North Yemen, Cyprus.

Table A1.c - Descriptive statistics – East Asia and the Pacific

	mean entire sample	*standard deviations*	*mean year=60*	*mean year=70*	*Mean year=80*	*mean year=90*
Gross enrolment rate in primary education	0.931 (86)	0.147	0.853	0.908	0.960	0.964
Gross enrolment rate in secondary education	0.498 (86)	0.279	0.258	0.420	0.583	0.606
Gross enrolment rate in higher education	0.123 (85)	0.114	0.042	0.077	0.123	0.205
Gini index of income distribution	0.403 (67)	0.071	0.439	0.397	0.389	0.397
Total population (thnds)	38962 (85)	47889	26836	33118	40333	49369
Real gross domestic product per capita - US dollars (1985 international prices)	3860.4 (87)	3513.2	1480	2648	4389	6612

Notes: numbers in brackets report the number of non-missing observations in each sample (or sub-sample). It includes 11 countries: Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, Fiji, Papua New Zealand.

Table A1.d - Descriptive statistics – South Asia

	mean entire sample	*standard deviations*	*mean year=60*	*mean year=70*	*mean year=80*	*mean year=90*
Gross enrolment rate in primary education	0.699 (40)	0.261	0.486	0.584	0.734	0.874
Gross enrolment rate in secondary education	0.277 (40)	0.174	0.144	0.230	0.270	0.390
Gross enrolment rate in higher education	0.036 (40)	0.024	0.010	0.031	0.040	0.046
Gini index of income distribution	0.352 (32)	0.058	0.377	0.335	0.362	0.298
Total population (thnds)	172884 (40)	263567	112602	142258	178410	221599
Real gross domestic product per capita - US dollars (1985 international prices)	1019.8 (40)	382.6	792	914	1123	1446

Notes: numbers in brackets report the number of non-missing observations in each sample (or sub-sample). It includes 5 countries: Bangladesh, India, Nepal, Pakistan, Sri Lanka.

Table A1.e - Descriptive statistics – Latin America and the Caribbean

	mean entire sample	*standard deviations*	*mean year=60*	*mean year=70*	*mean year=80*	*mean year=90*
Gross enrolment rate in primary education	0.951 (180)	0.117	0.872	0.932	0.965	0.970
Gross enrolment rate in secondary education	0.405 (180)	0.203	0.195	0.323	0.475	0.521
Gross enrolment rate in higher education	0.117 (179)	0.092	0.029	0.064	0.138	0.186
Gini index of income distribution	0.490 (121)	0.077	0.489	0.504	0.493	0.493
Total population (thnds)	14142 (184)	26831	8848	11658	14889	18114
Real gross domestic product per capita - US dollars (1985 international prices)	3085.5 (183)	1737.9	2261	2959	3787	3394

Notes: numbers in brackets report the number of non-missing observations in each sample (or sub-sample). It includes 23 countries: Barbados, Costa Rica, Dominica, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Trinidad and Tobago, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Surinam, Uruguay, Venezuela.

Table A1.f - Descriptive statistics – OECD countries

	mean entire sample	*standard deviations*	*mean year=60*	*mean year=70*	*mean year=80*	*mean year=90*
Gross enrolment rate in primary education	0.992 (176)	0.047	0.981	0.974	0.988	0.990
Gross enrolment rate in secondary education	0.773 (174)	0.254	0.485	0.690	0.807	0.905
Gross enrolment rate in higher education	0.253 (175)	0.175	0.089	0.164	0.249	0.387
Gini index of income distribution	0.358 (131)	0.077	0.432	0.365	0.336	0.328
Total population (thnds)	29227 (179)	46967	24833	27756	30142	31717
Real gross domestic product per capita – US dollars (1985 international prices)	9674.5 (179)	3841.6	5842	8355	10544	12666

Notes: numbers in brackets report the number of non-missing observations in each sample (or sub-sample). It includes 23 countries: Australia, Austria, Bahamas, Belgium, Canada, Denmark, Finland, France, (West) Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

Table A1.g - Descriptive statistics – Centrally planned economies

	mean entire sample	*standard deviations*	*mean year=60*	*mean year=70*	*mean year=80*	*mean year=90*
Gross enrolment rate in primary education	0.978 (34)	0.082	1.000	0.965	0.987	0.912
Gross enrolment rate in secondary education	0.646 (33)	0.189	0.365	0.530	0.692	0.680
Gross enrolment rate in higher education	0.168 (27)	0.091	0.078	0.133	0.174	0.142
Gini index of income distribution	0.274 (44)	0.056	0.242	0.245	0.270	0.273
Total population (thnds)	269046 (31)	415109	337947	425523	509219	196341
Real gross domestic product per capita - US dollars (1985 international prices)	3538.1 (34)	1298.5	1953	2629	4099	4058

Notes: numbers in brackets report the number of non-missing observations in each sample (or sub-sample). It includes 7 countries: China, Hungary, Poland, Yugoslavia, Bulgaria, Romania, (former) Soviet Union.

Table A2 – Descriptive statistics – 1960-95

Variable	Obs	Mean	Std.Dev.	Min	Max
Gross enrolment rate in primary education	470	0.900	0.190	0.050	1.350
Gross enrolment rate in secondary education	470	0.482	0.291	0.005	1.065
Gross enrolment rate in higher education	470	0.134	0.135	0.000	0.947
Gini index of income distribution	470	0.422	0.101	0.233	0.795
Income share of the lowest quintile in income distribution	319	0.059	0.020	0.016	0.109
Fertility rate (potential children per woman)	460	4.351	1.944	1.440	8.256
Crude birth rate (per 1000 inhabitants)	462	29.508	12.716	9.000	57.200
Children mortality rate in the 1st year (per 1000 births)	466	0.060	0.049	0.001	0.218
Government current expenditure in primary education per pupil – US dollars (PPP-adjusted 1985 intern.prices)	358	764.1	1042.9	25.0	7003.0
Government current expenditure in secondary education per pupil – US dollars (PPP-adjusted 1985 intern.prices)	338	1027.5	951.2	32.0	4572.0
Student per teacher in primary education	469	31.3	11.8	6.1	90.4
Student per teacher in secondary education	447	19.5	6.7	6.1	44.2
Student per teacher in higher education	193	15.7	10.6	4.3	127.8
Real gross domestic product per capita – US dollars (PPP-adjusted 1985 international prices)	470	4524.9	4061.0	308.0	18399.0
Ratio of physical capital stock to GDP (1987 local prices)	413	2.598	0.965	0.674	7.432
Share of the population over 15 with some primary education	430	43.49	17.85	2.2	90.1
Average years of completed primary education in the population over 15	428	3.941	1.758	0.2	8.1
Average years of completed secondary education in the population over 15	430	1.331	0.987	0.0	5.1

Table A3 – Panel probit regression on the availability of income distribution data – GEE population averaged model regression – robust estimates - 1960-95

Dependent variable: (1: income data available 0: income data not available)	Estimated Coefficients	Semi-robust Standard Errors	p-values
(Log of) real gross domestic product per capita	0.013	0.030	0.672
(Log of) population	0.242	0.077	0.002
Growth rate of population	-0.168	0.138	0.223
Gross enrolment rate in primary education	-0.036	0.064	0.570
Gross enrolment rate in secondary education	0.034	0.044	0.431
Gross enrolment rate in higher education	0.218	0.091	0.017
Dummy for OECD countries	0.600	0.553	0.278
Dummy for North-African and Middle East countries	-1.044	0.487	0.032
Dummy for Sub-Saharan countries	-0.502	0.468	0.283
Dummy for Latin-American countries	0.661	0.655	0.313
Dummy for year=1965	-0.029	0.010	0.007
Dummy for year=1970	-0.055	0.020	0.006
Dummy for year=1975	-0.085	0.030	0.005
Dummy for year=1980	-0.120	0.040	0.003
Dummy for year=1985	-0.157	0.049	0.001
Dummy for year=1990	-0.190	0.058	0.001
Dummy for year=1995	-0.209	0.068	0.002
Constant	-0.880	0.861	0.307
# of observations/# of countries	891/132		
$\chi 2$ test	94.67 (0.00)		

Table A4 – Estimation of primary enrolment – Random-effects tobit regressions – 1960-95

	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients
Dependent variable: Gross enrolment rate in primary education	*total*	*total*	*total*	*female*
Gini index of income distribution	0.15 (0.11)	-0.21 (0.23)	---	-0.05 (0.13)
Income share of the lowest quintile in income distribution	---	-0.58 (0.82)	---	---
(Log of) Real gross domestic product per capita	0.06 (0.02)	0.06 (0.02)	---	0.08 (0.02)
(Log of) inequality adjusted real GNP per capita	---	---	0.04 (0.02)	---
Children mortality rate in the 1st year (per 1000 births)	-2.27 (0.42)	-1.72 (0.36)	-2.32 (0.43)	-2.88 (0.47)
Fertility rate (potential children per woman)	0.06 (0.01)	0.06 (0.02)	0.06 (0.01)	0.07 (0.02)
Crude birth rate (per 1000 inhabitants)	-0.01 (0.002)	-0.01 (0.002)	-0.01 (0.002)	-0.01 (0.002)
Share of the corresponding population over 15 with some primary education	0.20 (0.06)	0.15 (0.06)	0.20 (0.06)	0.27 (0.07)
Student per teacher in primary education	0.002 (0.001)	0.003 (0.001)	0.002 (0.001)	0.002 (0.001)
Average salary primary school teacher/GDP per capita	---	---	---	---
Constant	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes
# of observations/# of countries	436/92	303/84	436/92	433/92
Wald $\chi 2$ test	381.4 (0.00)	305.1 (0.00)	328.6 (0.00)	415.5 (0.00)
Log-likelihood	23.33	34.65	21.11	9.28

Standard errors in brackets.

Table A5 – Estimation of secondary enrolment – Random-effects GLS robust regressions – 1960-95

	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients
Dependent variable: Gross enrolment rate in secondary education	*total*	*total*	*total*	*female*
Gini index of income distribution	-0.27 (0.10)	-0.18 (0.27)	---	-0.34 (0.11)
Income share of the lowest quintile in income distribution	---	0.15 (0.98)	---	---
(Log of) Real gross domestic product per capita	0.12 (0.02)	0.11 (0.02)	---	0.12 (0.03)
(Log of) inequality adjusted real GNP per capita	---	---	0.12 (0.02)	---
Fertility rate (potential children per woman)	-0.04 (0.01)	-0.05 (0.01)	-0.04 (0.01)	-0.05 (0.01)
Average years of completed primary education in the corresponding population over 15	0.05 (0.01)	0.03 (0.01)	0.05 (0.01)	0.04 (0.01)
Ratio of physical capital stock to GDP (1987 local prices)	0.04 (0.01)	0.06 (0.02)	0.04 (0.01)	0.05 (0.01)
Constant	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes
# of observations/# of countries	386/76	264/69	386/76	369/76
χ2 test	876.5 (0.00)	730.6 (0.00)	844.5 (0.00)	882.3 (0.00)

Standard errors in brackets.

Table A6 – Estimation of higher education enrolment
Random-effects GLS robust regressions – 1960-95

	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients
Dependent variable: Gross enrolment rate in higher education	*total*	*total*	*total*	*female*	*male*
Gini index of income distribution	-0.08 (0.06)	0.05 (0.21)	---	-0.08 (0.05)	-0.14 (0.05)
Income share of the lowest quintile in income distribution	---	0.22 (0.65)	---	---	---
(Log of) Real gross domestic product per capita	0.05 (0.02)	0.07 (0.03)	---	0.03 (0.02)	0.05 (0.02)
(Log of) inequality adjusted real GNP per capita	---	---	0.05 (0.02)	---	---
(Log of) government current expenditure in secondary education per pupil (PPP-adjusted 1985 intn.prices)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.004 (0.01)
Average years of completed secondary education in the corresponding population over 15	0.07 (0.01)	0.06 (0.01)	0.07 (0.01)	0.07 (0.01)	0.05 (0.00)
Ratio of physical capital stock to GDP (1987 local prices)	0.01 (0.00)	0.01 (0.01)	0.01 (0.00)	0.01 (0.00)	0.01 (0.00)
Constant	Yes	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes	Yes
# of observations/# of countries	303/72	210/65	303/72	254/70	253/69
χ2 test	270.3 (0.00)	178.6 (0.00)	264.7 (0.00)	194.7 (0.00)	398.2 (0.00)

Standard errors in brackets.

Table A7 – Cross-section OLS and tobit regressions – 1960-95
estimated coefficients on Gini index

	total enrolment				female enrolment			
year:	primary	primary *tobit*	secondary	higher	primary	primary *tobit*	secondary	higher
1960	0.049 (0.17)	-0.021 (0.06)	-0.257 (1.12)	-0.123 (1.26)	0.008 (0.023)	-0.142 (0.28)	-0.217 (0.90)	-0.045 (0.69)
1965	0.232 (1.20)	0.502 (1.88)	0.067 (0.34)	-0.050 (0.56)	0.231 (1.12)	0.385 (1.32)	-0.038 (0.18)	-0.016 (0.19)
1970	0.552 (2.95)	0.546 (2.00)	-0.376 (2.18)	-0.111 (1.21)	0.637 (3.53)	0.676 (2.94)	-0.242 (1.31)	-0.043 (0.52)
1975	0.047 (0.224)	0.238 (0.65)	-0.562 (2.03)	-0.136 (0.83)	0.270 (1.06)	0.574 (1.61)	-0.255 (0.86)	-0.034 (0.21)
1980	0.425 (2.63)	1.032 (3.03)	-0.545 (2.33)	-0.271 (1.71)	0.545 (2.75)	1.00 (2.57)	-0.256 (1.01)	-0.227 (1.30)
1985	0.398 (2.43)	0.715 (1.97)	-0.634 (2.79)	0.115 (0.54)	0.582 (3.06)	1.11 (2.94)	-0.395 (1.93)	0.082 (0.36)
1990	0.214 (1.58)	0.412 (1.70)	-0.468 (2.58)	-0.059 (0.31)	0.368 (2.27)	0.458 (1.78)	-0.219 (1.16)	n.a.
1995	0.496 (1.71)	0.060 (0.18)	-0.452 (1.62)	n.a.	0.644 (1.54)	0.286 (0.59)	-0.014 (0.06)	n.a.

T-statistics in brackets. The specification for primary enrolment corresponds to the first column of Table 2 and includes as regressors: log of real GDP per capita, children mortality, fertility rate, crude birth rate, share of the population over 15 with some primary education, student per teacher. The specification for secondary enrolment corresponds to the first column of Table 4 and includes as regressors: log of real GDP per capita, fertility rate, average year of completed primary education in the population over 15, ratio of capital stock to output. The specification for higher enrolment corresponds to the first column of Table 6 and includes as regressors: log of real GDP per capita, average year of completed secondary education in the population over 15, expenditure per pupil in secondary education over GDP per capita, ratio of capital stock to output.

Table A8 – Regional effects on enrolment – Random-effects GLS regressions – 1960-95
estimated coefficients on Gini index

	total enrolment			female enrolment		
	primary	secondary	higher	primary	secondary	higher
Sub-Saharan Africa	0.464 (0.24)	0.024 (0.19)	-0.007 (0.02)	0.332 (0.24)	0.058 (0.18)	-0.004 (0.00)
North Africa and Middle East	1.235 (0.40)	-2.46 (0.63)	0.565 (0.33)	1.759 (0.46)	-2.178 (0.63)	0.433 (0.15)
East Asia and the Pacific	-0.002 (0.21)	0.048 (0.30)	0.063 (0.19)	-0.522 (0.27)	0.243 (0.34)	-0.019 (0.15)
South Asia	0.113 (0.37)	-0.324 (0.25)	-0.095 (0.10)	0.208 (0.35)	-0.355 (0.30)	0.021 (0.10)
Latin America and the Caribbean	-0.010 (0.09)	-0.029 (0.13)	-0.036 (0.08)	-0.109 (0.09)	-0.045 (0.13)	-0.085 (0.08)
OECD countries	0.104 (0.05)	-0.067 (0.16)	0.070 (0.13)	-0.070 (0.09)	-0.349 (0.17)	0.121 (0.10)
Centrally planned economies	0.769 (0.43)	n.a.	n.a.	0.860 (0.61)	n.a.	n.a.

Standard Errors in brackets. The specification for primary enrolment corresponds to the first column of Table 2 and includes as regressors: log of real GDP per capita, children mortality, fertility rate, crude birth rate, share of the population over 15 with some primary education, student per teacher. The specification for secondary enrolment corresponds to the first column of Table 4 and includes as regressors: log of real GDP per capita, fertility rate, average year of completed primary education in the population over 15, ratio of capital stock to output. The specification for higher enrolment corresponds to the first column of Table 6 and includes as regressors: log of real GDP per capita, average year of completed secondary education in the population over 15, expenditure per pupil in secondary education over GDP per capita, ratio of capital stock to output.

Figure 1 - The effect of an increase in income dispersion

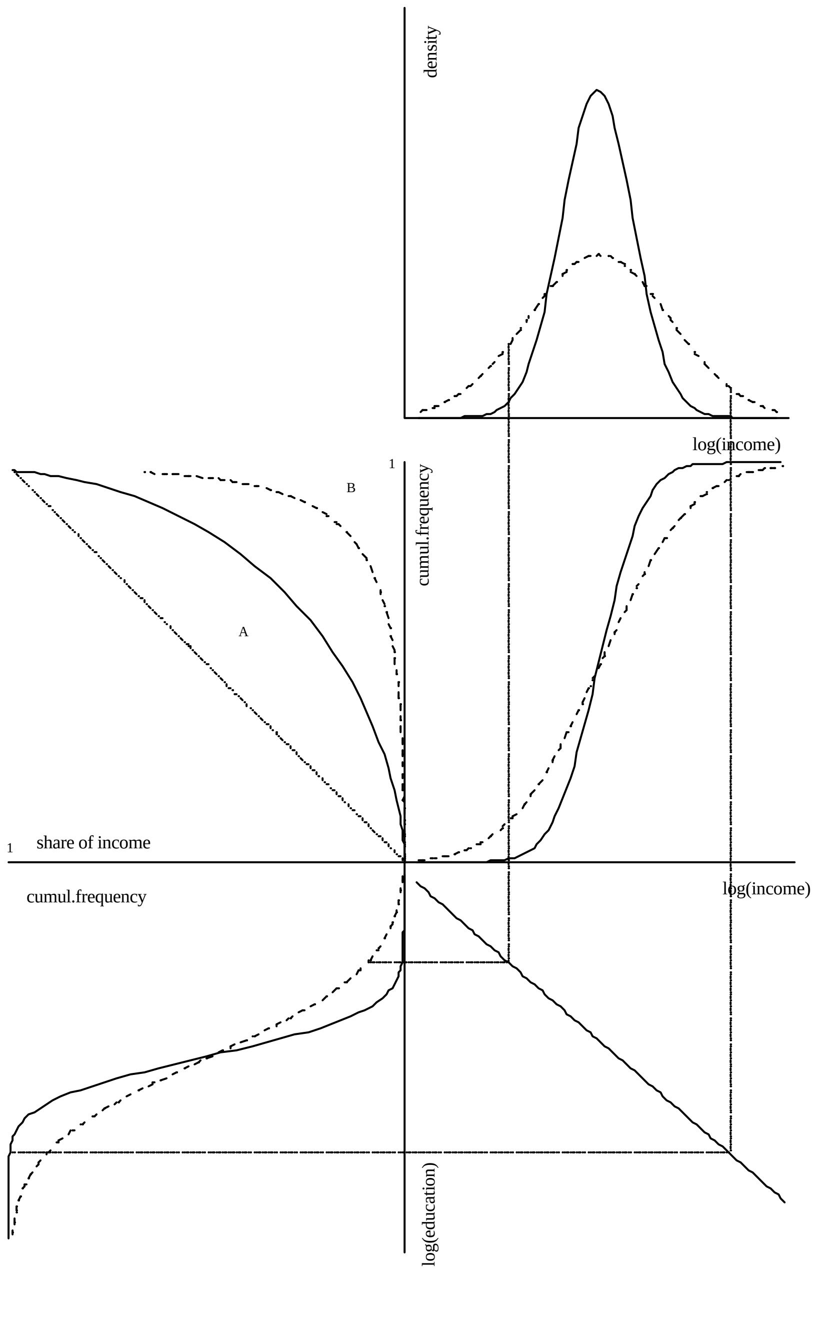


Figure 2 - The effect of an increase in mean income

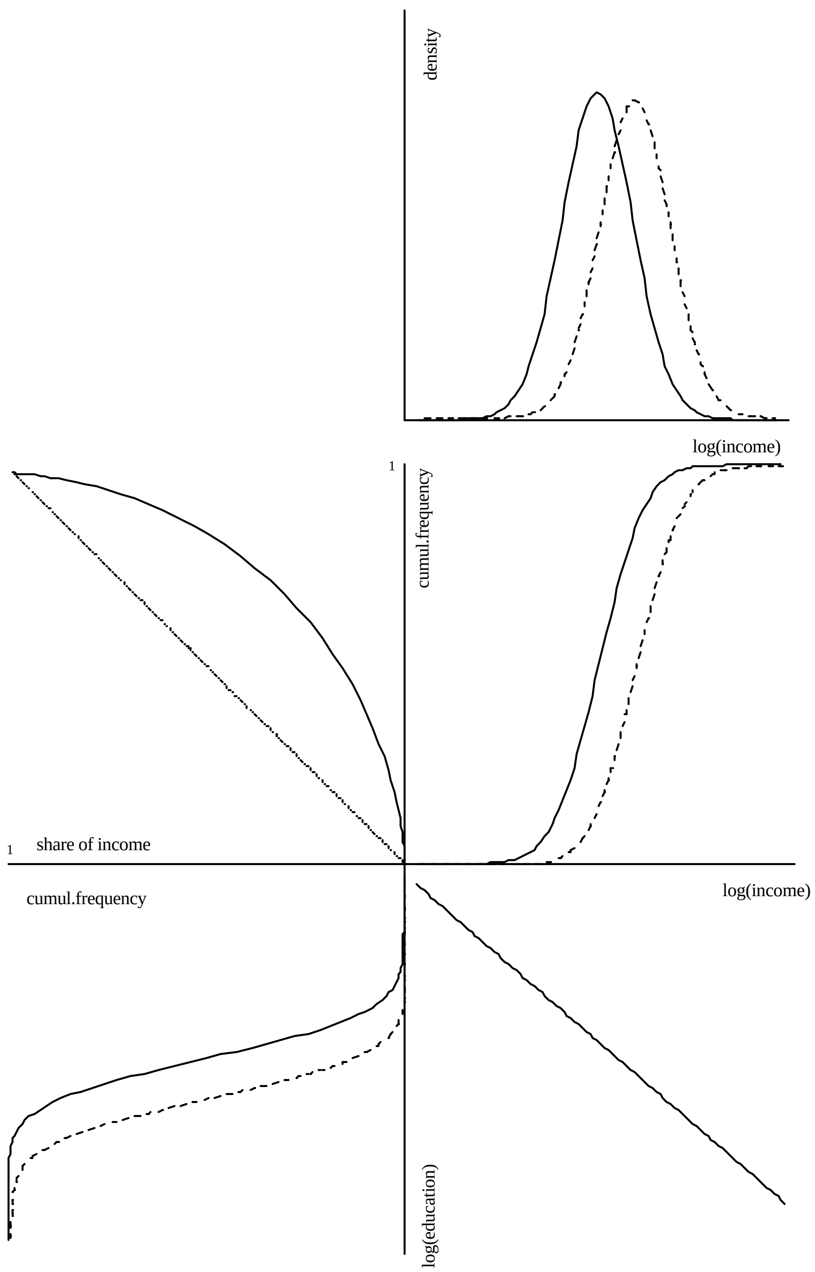
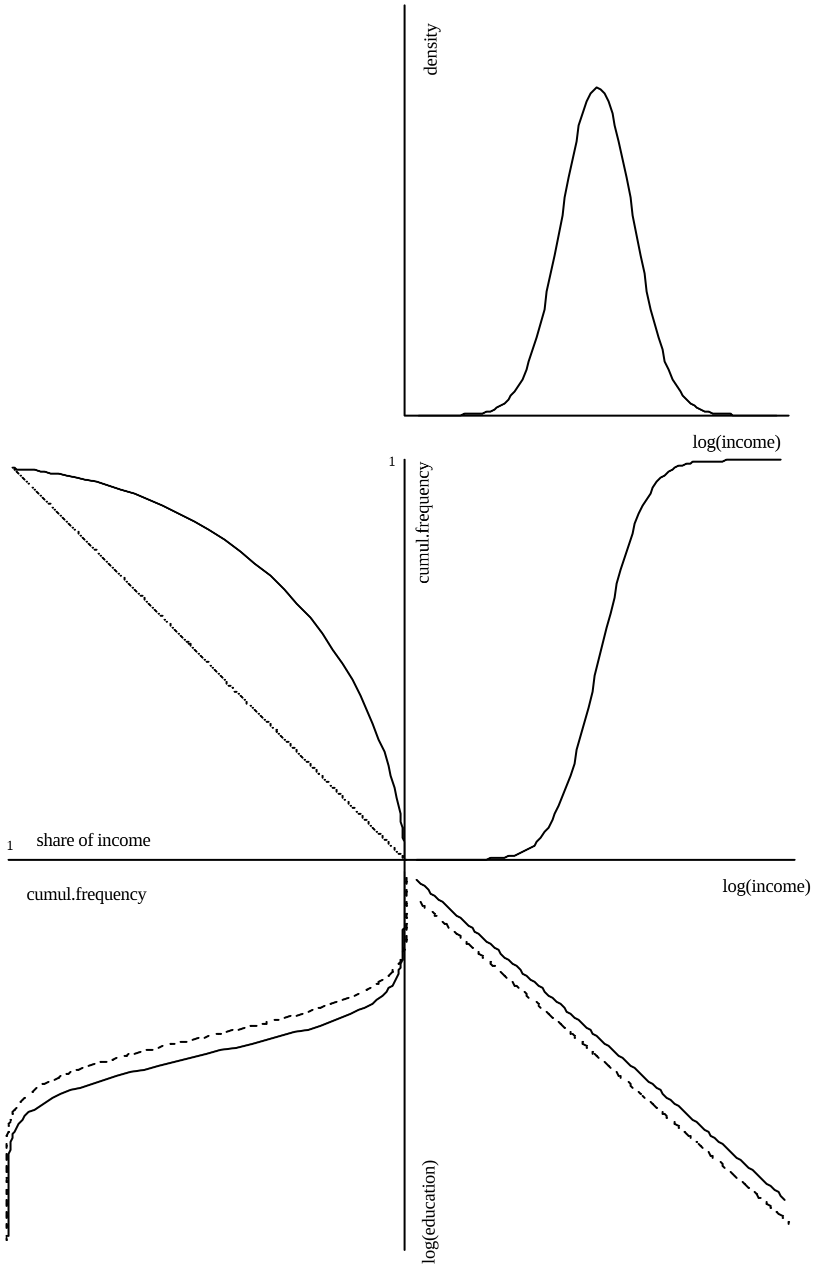


Figure 3 - The effect of an increase in public spending in education and/or in the demand for skills



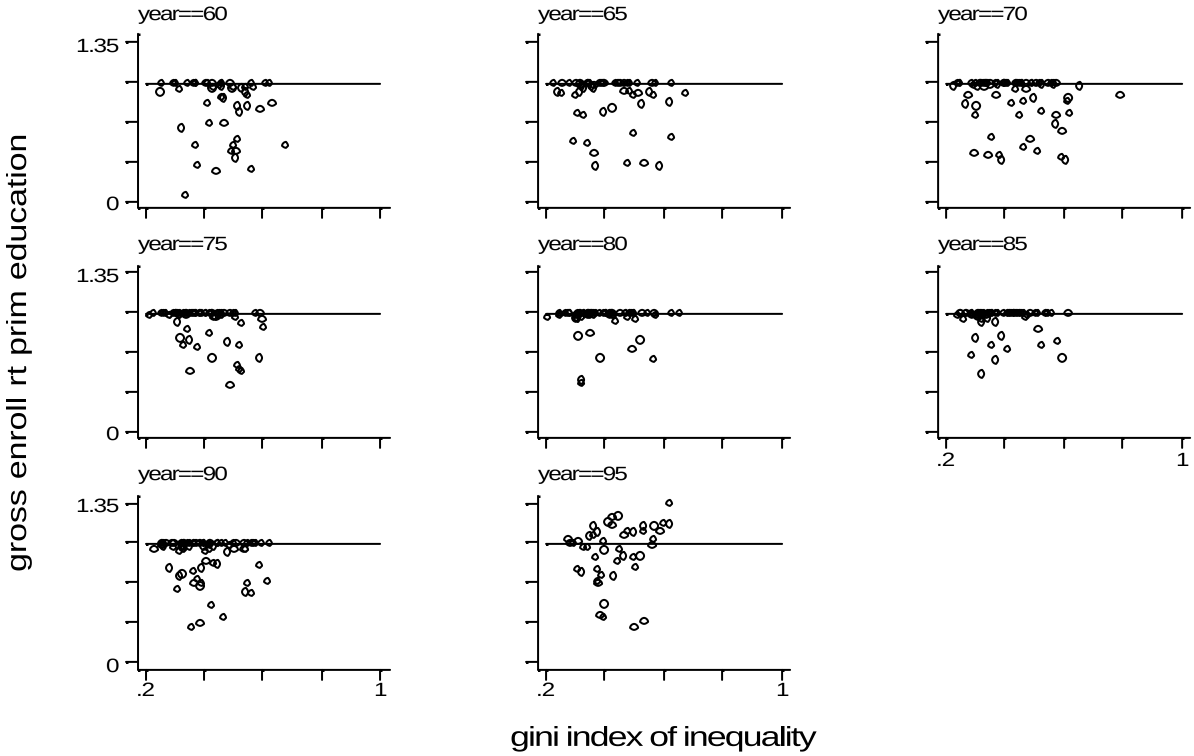


Figure 4 - All countries by year - primary education

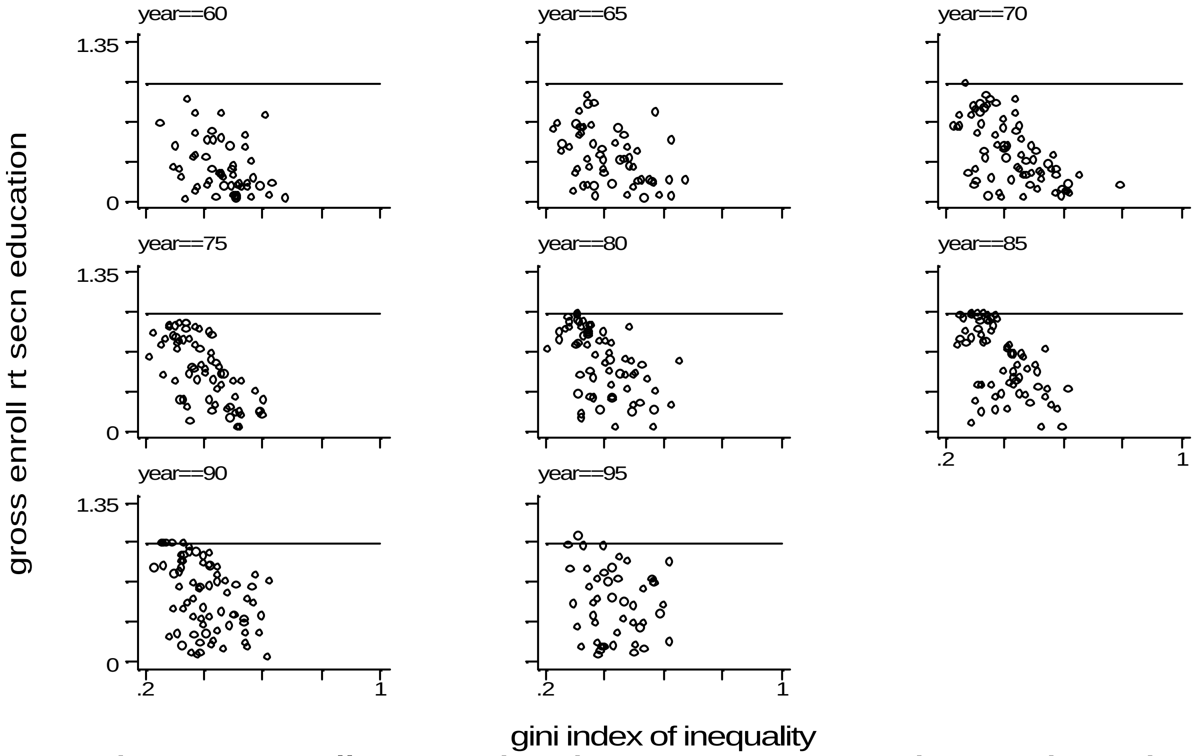


Figure 5 - All countries by year - secondary education

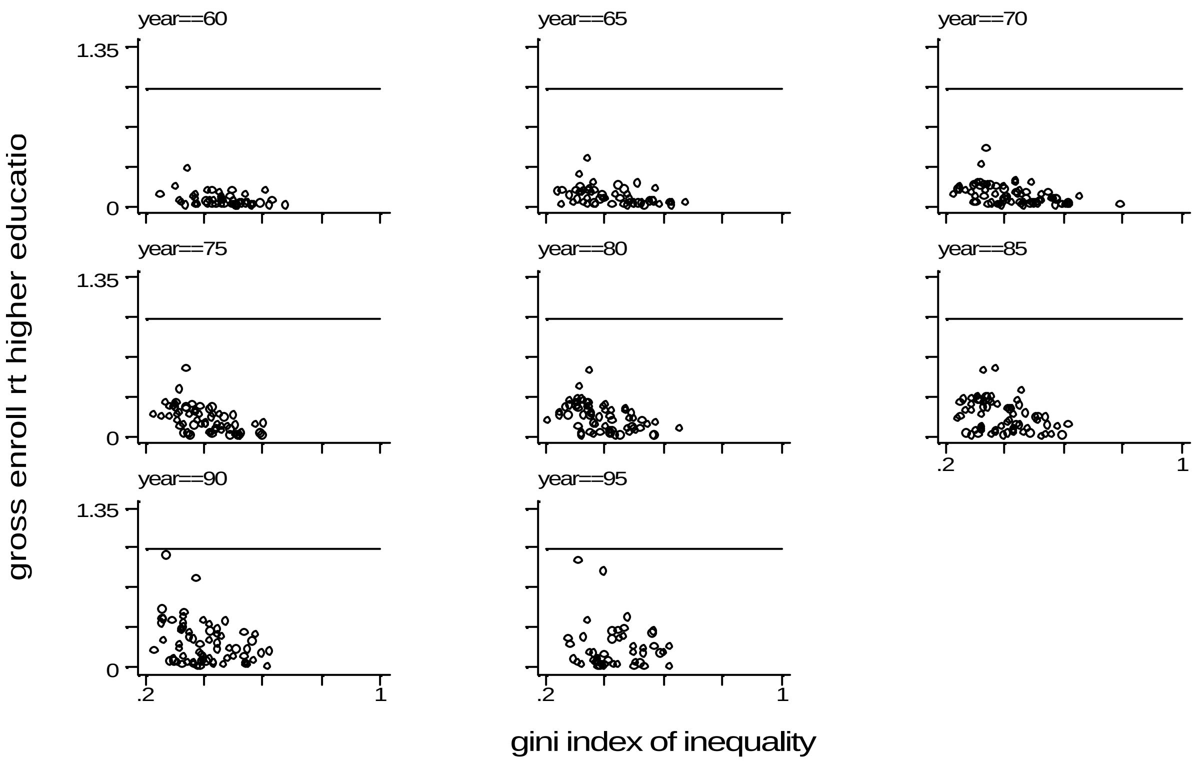


Figure 6 - All countries by year - higher education

Notes for the referees.

Equation (1) can be derived by an optimal investment model with imperfect financial markest, as mentioned in the text. The original version of this paper contained such a derivation, which can be thought as redundant in a journal version. However I reproduce here the main assumptions underlying that model, in order to facilitate the understanding of my line of argument.

Let us consider an overlapping generation model with constant population of *n* individuals. In the first period of her life, each agent allocates her total amount of time ($\overline{T}$) among going to school (S_t), working (L_t) and leisure (T_t). The amount spent in school increases the human capital of the agent, and consequently raises the wage in the second period. Thus

$$\overline{T} = S_t + L_t + T_t \tag{A.1}$$

In the second period she works, consumes (C_{t+1}) and leaves a bequest (X_{t+1}) to her off-spring.[53]

Technology

This economy is populated with *n* small identical firms, each one producing a homogeneous commodity.[54] Their technology is given by

$$Y_t = \left(\sum_i H_t L_t \right)^{\beta} \overline{K}^{1-\beta} \tag{A.2}$$

Total output (Y_t) is net of capital depreciation, the stock of physical capital ($\overline{K}$) is fixed, and the labour input is given by the sum of human capital endowment (H_t) of existing workers (L_t). To avoid further complications required by saving decisions of different classes, I assume that the ownership of fixed capital is external to this economy (for example, by foreign capitalist holding the control of the productive sector in a developing economy). This dispenses us from analysing financial savings decision, and focuses on human capital investment.

The firms face an infinitely elastic demand for the commodity at a given price ($\overline{P}$). Then profit maximisation induces the following labour demand

$$\left(\sum_i H_t L_t \right) = \overline{K} \cdot \left(\frac{b\overline{P}}{W_t} \right)^{\frac{1}{1-b}} \tag{A.3}$$

In each period total labour supply is given by the sum of the human capital supply from the young $\left(\sum H_t^y L_t^y \right)$ and the human capital supply of the old $\left(\sum H_t^o L_t^o \right)$, where $L_i^j, i = 0,1,\ldots,\infty,\ j = y,o$ is the labour supply of an individual born in period *i* and appearing in the market in the first (*y*) or in the second (*o*) period of her life. If each person is born with a unitary capital endowment ($H_t^y = 1, \forall t$), leisure consumption is ruled out in the second period of life and the length of the working time is normalised to one ($L_t^o = 1, \forall t$), labour market equilibrium is given by

[53] Commodity consumption in the first period and leisure in the second period have been neglected for simplicity.

[54] This assumption can be easily relaxed, since each firm is paying the same wage rate per unit of human capital, and skilled and unskilled workers are perfect substitutes.

$$W_t = \beta\overline{P}\left(\frac{\overline{K}}{L_t + H_{t-1}}\right)^{1-\beta} \qquad \text{(A.4)}$$

where, in order to simplify notation, L_t represents the labour supply of a young person and H_{t-1} is the human capital achievement of the (contemporaneous) old person.[55] Notice that H_{t-1} is predetermined, because it is based on decisions undertaken in the previous period; on the contrary, the labour supply decision of the young generation creates a negative externality on the earnings of the old generation. If working during her youth, an agent earns an income equal to

$$W_t L_t = \beta\overline{P}\left(\frac{\overline{K}}{L_t + H_{t-1}}\right)^{1-\beta} L_t \qquad \text{(A.5)}$$

Human capital can be accumulated through spending some time during the youth in school. The human capital producing technology is given

$$H_t = E_t^{\gamma} S_t^{\theta} \qquad \text{(A.6)}$$

where E_t indicates total resources devoted to education and is intended to capture all the different aspects (public expenditure in education, social capital, family background). When old, a person earns an income equal to

$$W_{t+1} H_t = \beta\overline{P}\left(\frac{\overline{K}}{L_{t+1} + H_t}\right)^{1-\beta} E_t^{\gamma} S_t^{\theta} \qquad \text{(A.7)}$$

Therefore education is rewarded in the labour market, and the return is increasing in the state of technology of production (as proxied by $\overline{K}$) and in the amount of resources invested in education (as proxied by E_t).

Preferences

Individuals are altruistic, and their preferences are defined over leisure when young, and consumption and bequest when they are old.

$$U(T_t, C_{t+1}, X_{t+1}) = (1+\rho)\lg(T_t) + \alpha\lg(C_{t+1}) + (1-\alpha)\lg(X_{t+1}) \qquad \text{(A.8)}$$

where C_{t+1} indicate the commodity consumption when old and X_{t+1} is the bequest left over to the next generation; ρ is the intertemporal discount rate.

Optimal choice of education

[55] In each period there are 2*n* persons contemporaneously alive, half of which are young. Competition among *n* firms allocates 2 workers to each firm; competition among workers allocates one old person and one young person to each firm. Alternative allocations (for example 2 or more old persons within the same firm) would offer different wages (because of diminishing marginal productivity), and the worker would be attracted away by firms offering higher wages.

Education has a per unity cost of access equal to B_t (think of enrolment fees, textbooks, etc.), and therefore the cost of accessing education $(S_t B_t)$ is proportional to the preferred amount of education. When financial markets are absent,[56] the budget constraints in the two periods are independent.

$$S_t B_t = W_t L_t + X_t \tag{A.9}$$

$$C_{t+1} + X_{t+1} = W_{t+1} H_t \tag{A.10}$$

where X_t is the inherited wealth from the parents. The optimal choice of education is given by

$$S_t = \frac{X_t + W_t \overline{T}}{B_t + W_t + (1+\rho)\dfrac{W_t + B_t / \eta_{WL}}{\theta(\beta - \eta_{WL})}} = f\Big(\underset{+}{X_t}, \underset{-}{B_t}, \underset{\pm}{W_t}, \underset{\pm}{\eta_{WL}}\Big), \eta_{WL} = \frac{\partial W}{\partial L} \cdot \frac{L}{W} \tag{A.11}$$

Notice that when financial markets are absent, the optimal amount of education depends linearly on inherited wealth, whereas the cost of accessing education has a negative impact. The prevailing wage rate in the labour market has both an income and a substitution effect. The income effect (through the numerator) is positive because it raises the value of the agent's endowment. The substitution effect (through the denominator) is negative because attending school has the opportunity cost of foregone income. For the very same reasons the wage elasticity has an ambiguous effect.[57]

The alternative case to be considered is the existence of imperfect financial markets. The imperfection is modelled as a dependence of the interest rate on individual wealth. If we consider the possibility of debt default, the incentive to repudiate is proportional to the borrowed amount. If all the borrowers have the same probability of default (i.e. they belong to the same class of risk), the lender can ration the credit by setting an interest rate increasing with the requested loan. In the context of the present model, every agent would like to acquire the same amount of education, but

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[56] Financial markets for financing investment in education are very thin or in most cases absent. The imperfection of financial markets in this case can be explained by the impossibility to collaterise future effort on the job. See Pikett 1997.

[57] This is evident if we consider the first order conditions corresponding to the maximisation of utility (A.8) under the constraint given by equations (A.1)-(A.5)-(A.7)-(A.9)-(A.10). Solving initially for C_{t+1} and X_{t+1} and replacing these optimal choices we are left with the following problem

$$\max_{L_t, S_t} (1+r)\lg\left(\overline{T} - L_t - S_t\right) + \lg\left(W_{t+1}(S_t)\right) + \theta\lg(S_t) + \text{constant} + \mu\left[S_t B_t - W_t(L_t)L_t - X_t\right]$$

Equating the two first order conditions leads to

$$S_t = \frac{1}{\mu} \cdot \frac{\eta_{WS} + \theta}{W_t \eta_{WL} + B_t} = \frac{1}{\mu} \cdot \frac{\theta(\beta - \eta_{WL})}{W_t \eta_{WL} + B_t}$$

where

$$\eta_{WL} = \frac{\partial W_t}{\partial L_t} \cdot \frac{L_t}{W_t} = -(1-\beta)\frac{L_t}{L_t + H_{t-1}} \cong -(1-\beta)\delta,$$

$$\eta_{WS} = \frac{\partial W_{t+1}}{\partial S_t} \cdot \frac{S_t}{W_{t+1}} = -(1-\beta)\theta\frac{H_t}{L_{t+1} + H_t} \cong -(1-\beta)\theta(1-\delta) = -(1-\beta+\eta_{WL})\theta$$

$$\mu = \text{Lagrange multiplier } = \frac{dU}{dX_t}$$

For a constant μ (i.e. when the income effect is excluded), we get $\frac{\partial S_t}{\partial W_t} < 0$ and $\frac{\partial S_t}{\partial \eta_{WLt}} < 0$.

someone can finance it with family wealth, whereas someone else has to go on the financial market. The poorer an agent, the higher the required loan, the higher the interest rate charged by the lender. In a reduced form, the interest rate is inversely related to family wealth.[58]

$$R = R(X_t), R' < 0 \tag{A.12}$$

The intertemporal budget constraint now writes as

$$S_t B_t + \frac{C_{t+1} + X_{t+1}}{1 + R(X_t)} - W_t(S_t)L_t - X_t - \frac{W_{t+1}H_t}{1 + R(X_t)} = 0 \tag{A.13}$$

and the optimal choice of education is

$$S_t = \left\{ \frac{[1 - (1 - \beta + \eta_{WL})\theta] W_{t+1}(S_t) E_t^{\gamma}}{(W_t \eta_{WL} + B_t)(1 + R(X_t))} \right\}^{\frac{1}{1-\theta}} = f\left(\underset{+}{X_t}, \underset{-}{B_t}, \underset{-}{W_t}, \underset{-}{\eta_{WL}}, \underset{+}{E_t} \right) \tag{A.14}$$

With the existence of financial markets the ambiguity of substitution and income effects disappears, and one is able to sign each partial derivative. Family wealth still favours the acquisition of education via a reduction in the relevant interest rate. An increase in the cost of education lowers its demand, but there can be a countervailing effect coming from total resources employed in education. Eventually, the current wage in the labour market works as an opportunity cost, thus reducing the demand for education.

The present results heavily depend on the assumption of identical individuals that is implicit in equation (A.6), where individual ability is neglected. Had we assumed individuals who are heterogeneous in ability (with ability being an input in human capital production) and intergenerational persistence of ability (for genetic and/or cultural reasons), we could observe the same positive relationship between family wealth and educational achievements implied by equations (A.11) or (A.14) even in presence of perfect capital markets.[59] The debate between supporters of a "natural" explanation and defender of the "imperfect market" explanation of inequality has not yet reached (and we suspect it will *never* achieve) a definite conclusion, lacking of natural experiments to discriminate among the twos. Since individual data-set containing proxy variables for ability do not exist for a sufficient number of countries, we cannot proceed further in considering this question, and therefore we will limit our analysis to the assumption of identical individual.

Testable implications

Whether financial markets for education financing exist and/or work closely to the ideal of market perfection is an empirical issue to be judged case by case. Nevertheless, equation (A.11) and (A.14) provide as with testable predictions on the determinants of educational achievements:

* *family income* (or wealth) exerts a positive effect, which declines when financial markets imperfections decline.
* the *cost of education* creates a barrier to accessing education, which can be lowered with an increase of *public resources invested in education*.

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[58] An alternative explanation, leading to the same reduced form, is that a lender takes family wealth as collateral, and charges lower rates to people offering more valuable collaterals. Examples of the interest rate being dependent of family wealth can be found in Galor and Zeira 1993 or Banerjee and Newman 1993. Empirical evidence on the relevance of borrowing constraints in human capital investment can be found in Lillard 1998; different opinions are reported in Mulligan 1997.

[59] See for example Mulligan 1997.

* *wage differential in favour of educated workers*: a lower differential (i.e. a higher W_t for any given W_{t+1}) raises the opportunity cost of schooling and reduces education.

Moving towards empirical testing of these predictions, we can log-linearise equation (A.14) obtaining

$$\begin{aligned}\lg(S_t) = s_t &= \text{constant} + \frac{1}{1-\theta}\lg(1+R(X_t)) - \frac{1}{1-\theta}\lg(W_t\eta_{WL}+B_t) + \frac{\gamma}{1-\theta}\lg(E_t) + \frac{1}{1-\theta}\lg(W_{t+1}(S_t)) = \\ &= \text{constant} + \frac{1}{1-\theta}\lg(1+R(X_t)) - \frac{1}{1-\theta}\lg(W_t\eta_{WL}+B_t) + \frac{\gamma}{1-\theta}\lg(E_t) + \frac{1-\beta}{1-\theta}\lg(\overline{K}) - \frac{1-\beta}{1-\theta}\lg\left(L_{t+1}+E_t^{\gamma}S_t^{\theta}\right)\end{aligned} \tag{A.15}$$

and using first order approximation

$$\lg(S_t) = \alpha_0 + \alpha_1\lg(X_t) + \alpha_2\lg(W_t) + \alpha_3\lg(B_t) + \alpha_4\lg(E_t) + \alpha_5\lg(\overline{K}) \tag{A.16}$$

or using small letters to indicate logarithms

$$s_t = \alpha_0 + \alpha_1 x_t + \alpha_2 w_t + \alpha_3 b_t + \alpha_4 e_t + \alpha_5 \overline{k} \tag{A.17}$$

which is identical to equation (1) in the text, once we neglect ability.