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Daniele Checchi
November 2000, Milan

ABSTRACT

In this paper we propose to measure the inequality of educational achievements by constructing a Gini index on educational attainments. We then use the proposed measure to analyse the relationship between inequality in incomes and educational achievements (in terms of both the average attainments and the dispersion of attainments). Even if theoretical considerations suggest a non-linear relationship between these two measures of inequality, actual data indicate that there is a strong negative linkage between average years of education and measured income inequality. Multivariate regressions also demonstrate that, if we take into account the negative correlation between average educational achievement and the dispersion of educational achievement, the relationship between income inequality and average years of schooling appears U-shaped, with a lower turning point at 6.5 years. Income inequality is also negatively related to per capita income and positively related to the capital/output ratio and government expenditure on education. Looking at the relative contribution of education to income inequality, we find that it explains between 3 per cent and 16 per cent of the variance, though the fraction is higher and shows a rising trend in developed countries.

I THE ISSUE

In the literature on the relationship between income inequality and output growth, several authors claim that greater income inequality reduces growth.[1] The empirical evidence indicates that one standard deviation decrease in income inequality raises the annual growth rate of product per capita by 0.5-0.8 percentage points. However, there is no consensus about the underlying causal mechanism. On one side, a political economy mechanism calls for a role for redistributive policies: greater income inequality generates increased social pressure and social instability, and this creates an adverse environment for investment in physical capital. On the other side, greater income inequality and greater poverty inhibit access to schooling and investment in human capital, thus reducing the potential for growth. Both explanations are at odds with a deeper scrutiny. The political mechanism hinges on the disincentive effect created by fiscal redistribution, which is not confirmed by the data.[2] The liquidity constraint explanation requires that the access to education be prevented by lack of financial resources, which is hardly the case in countries where public education is nearly cost-free at the compulsory level.[3]

On the whole, this literature seems unable to provide conclusive results for the very same reasons that the contribution of Kuznets (1955) has never achieved the status of a stylized fact in economics: it is impossible to identify a common pattern of development among countries throughout the world because social structures evolve differently (according to historical heritage, religion, ethnic composition, and cultural traditions).[4] While we largely share the opinion on the impossibility to identify a unique model for a 'social structure of accumulation', we still believe that there is something to be learnt from generalizing single country experiences. In this respect, the causal relationships governing aggregate educational choices have yet to be understood. The theoretical literature makes many simplifying assumptions, the main one of which is that income inequality and educational choices are perfectly correlated and that the resulting earning distribution replicates educational choices. This allows the identification of an intergenerational equilibrium in income and education distributions. Since the two variables are perfectly

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[1] Good surveys of this literature can be found in Benabou (1996a), Bourguignon (1996), Aghion, Caroli and Gracia-Peñalosa (1999), and Barro (1999).

[2] See Perotti (1996).

[3] Some empirical evidence in support of these propositions is offered in Bourguignon (1994), Checchi (1999) and Filmer and Pritchett (1998).

[4] This is the explanation put forward by Brandolini and Rossi (1998) to account for different relationships between inequality and growth in subgroups of countries.

correlated, the distribution of incomes and the distribution of human capital are shaped by the same factors. In many models, the same barriers (the absence of financial markets for education financing, the cultural poverty of the environment, the inefficiency of the public administration in tax levying) prevent investment in human capital by a fraction of the population, who subsequently earns less income.[5] Whenever there is some intergenerational persistence (via monetary inheritance or the effects of family cultural background), the very same portion of the population remains trapped at low levels of education and low levels of income for more than one generation. Thus, within the logic of formal models, illiterate people and the poor are synonymous. But in reality things are far more complicated. Educational choices are also correlated with the public provision of schools, the prohibition on children labour and the generally available opportunities in the labour market.[6] Analogously, income distribution can be more closely related to employment composition, labour legislation, trade union coverage, and fiscal policies than to educational achievements among the population.[7]

However, the distribution of incomes and the distribution of educational attainments are obviously related. On one hand, income inequality may prevent access to education when education is too costly for the family: the more skewed the income distribution, the higher the population share excluded from schooling and the higher the inequality in educational achievements. In this respect, we have a self-perpetuating poverty trap that can only be avoided by easing access to education.[8] On the other hand, improved access to education raises the earning opportunity of the lowest strata and, other things being constant, reduces earnings inequality. As long as total income is proportional

[5] For example, Galor and Zeira (1993), Banerjee and Newman (1993) and Piketty (1997) consider financial market imperfection, while Benabou (1996a) takes into account the role of social capital, and Perotti (1993) points to the stage of development and the level of available resources.

[6] For example, in rural economies the output gains of child labour are the main obstacle to schooling among children. See the Zambian case described by Skyt Nielsen (1999), the Bangladesh case analysed by Ravallion and Wodon (1999) and the Indian case discussed by Weiner (1991).

[7] See Gottschalk and Smeeding (1997) and Bardone, Gittleman and Keese (1998) for the determinants of earnings distribution in OECD economies. Globalization and the effect on wage inequality are discussed in Borjas and Ramey (1995), Sachs and Shatz (1996) and Feenstra and Hanson (1996).

[8] Checchi (1999) shows that income inequality effectively reduces school enrolment, mainly at secondary level. Similar results are in Flug, Spilimbergo and Wachtenheim (1998). From a formal point of view, this corresponds to the case where *current* income inequality affects the *rate of change* of inequality in educational achievement.

to labour income, we can expect a positive correlation between the distribution of educational achievements and the distribution of incomes in the population. But the 'other things being constant' assumption is rather crucial here, since we have to take into account the general equilibrium consequences of these changes. Consider for example the case of skill-biased technological change. Many authors agree that this is one of the potential reasons for the boost in the college 'premium', at least in the United States. With a time lag, this has produced an increase in college enrolments despite the rise in tuitions. Until the supply of new college graduates depresses the premium, we will observe growing income inequality, accompanied by a reduction in inequality in educational achievement.[9]

Therefore, we cannot predict *a priori* the sign of the relationship between educational achievements and income inequality. For this reason, in this paper we intend to investigate the empirical determinants of aggregate income inequality and, more specifically, the relative contribution of education to measured income inequality. In our opinion, this is crucial for two considerations. First, from a theoretical point of view, it is important to understand the plausibility of studying intergenerational equilibria under stationary distributions of income and human capital in the population. Second, and far more important, from a policy point of view we want to understand whether urging countries (or people) to increase their educational achievements is going to exacerbate, moderate, or have little influence on the subsequent earnings distribution.

The paper is organized as follows. The next section reviews the literature on income inequality determinants. The third section provides empirical evidence. The fourth section concludes. Appendix I indicates data sources and discusses data reliability.

II THE EXISTING LITERATURE

There is a growing literature on the current trends in income inequality at world level.[10] Rising income inequality occurred initially in Anglo-Saxon

[9] Freeman (1986) has shown the existence of a similar phenomenon during the 1960s for engineers in the US and has provided a 'cobweb' model for the dynamics of this phenomenon. For more recent evidence, see Murphy, Riddel and Romer (1998).

[10] See Atkinson (1999), Cornia (1999) and the references therein.

countries, but now is affecting most industrialized nations.[11] Among the potential causes of this phenomenon, the reduction of the redistributive role of the state, the decline in union presence in the workplace, the increased competition at international level, technological progress and all possible combinations of these are often indicated. (These explanations are sometimes referred to as 'the transatlantic consensus'). However, the experiences at national level are very diversified, and it is quite hazardous to draw general conclusions. Apart from the Kuznets (1955) hypothesis on the existence of a non-linear relationship between output per capita and income inequality, we do not find much progress in the statistical explanation of the observed inequality. In particular, little work has been undertaken so far seeking to test alternative explanations of the evidence on income distribution and even less concerning the relationship between educational attainment and income inequality. This is surprising, given the fact that compulsory education is publicly and freely provided in almost all countries of the world.

The existing literature on the effects of educational attainments on income inequality mainly focuses on the two first moments of income distribution, namely, the average educational attainment and the dispersion of schooling in the population. For the first, Barro (1999) suggests that the relationship between income inequality and output growth is negative for poor countries and positive for rich countries, the threshold being a gross domestic product per capita lower than $2,070 at 1985 prices.[12] He runs conditional convergence regressions on the income inequality (from the Deininger and Squire, 1996, dataset) measured five years earlier in order to exclude the case of reverse causation. Then he moves this regressor to the left-hand side and studies the determinants of income inequality. He puts forward some evidence on the existence of an inverted-U-shaped relationship between output per capita and income inequality (with a turning point around $1,636). He controls for educational achievement by introducing average educational attainments at three levels (primary, secondary and tertiary).[13] But his results are difficult to interpret in this respect, because of the contemporaneous presence of different information on the distribution of educational achievements (namely, the

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[11] Milanovic (1999) has computed an increase of 3 Gini points in world income inequality from 1988 and 1993, mainly attributable to between-country inequality.

[12] Perotti produced some evidence pointing in the same direction as discussant of Benabou (1996b).

[13] 'The panel also includes the average years of school attainment for people older than 15, classified over three educational levels: primary, secondary and higher. The results are that primary schooling is negatively and significantly related to inequality, secondary school is negatively (but not significantly) related to inequality, and higher education is positively and significantly related to inequality' (Barro, 1999: 26).

contribution of average human capital and its distribution across population subgroups).[14]

A similar strategy is followed by O'Neil (1995), who decomposes output growth over 1967-85 into a 'quantity' component (as measured by enrolment rates) and a 'price' component (as measured by relative stocks of human capital). His analysis suggests that, while there is convergence among countries in the level of educational achievement, the price effect works in the opposite direction.[15] In the same line of research, Deininger and Squire (1998) show that initial inequality in assets (land) is relevant in predicting both income growth and changes in income inequality.[16] Since land inequality also reduces average years of education in their regressions, they explain this evidence by referring to the liquidity constraints on access to education. As a consequence, income inequality and educational attainments are positively correlated because of the presence of a third conditioning variable (wealth inequality). However, while asset (or income) inequality may reduce the creation of new human capital (the 'flow' represented by new school-leavers), we see no good reason to suppose it might depreciate existing human capital (the 'stock' represented by the average educational attainment of the population).[17] In a related paper, Li, Squire and Zou (1998) interpret the evidence that the effect of (initial-period) average secondary school years on income inequality is significant as a proxy for a political effect: the more political freedom there is, the more informed is society, the more difficult it will be for the rich to appropriate extra resources. Gradstein and Milanovic (2000) provide additional evidence on the potential existence of links between political inclusion and income equality. However, it is not clear which is the direction of causation: whether extended franchise supports more redistributive

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[14] To be more precise: an additional average year in either primary school, or in college should raise average educational achievement, but, in fact, if the percentage of the population attending primary school increases, variance in education is reduced, whereas if the percentage of the population attending college increases, educational variance also increases.

[15] 'The results in Table 2 also show that, for both developed countries and Europe, the rise in the return to education experienced over the last two decades has caused incomes to diverge substantially, as those countries that are better endowed with skilled labor reap the benefit of the rising premium' (O'Neil, 1995: 1,295).

[16] 'Low initial inequality is thus doubly beneficial. It is associated with higher aggregate growth, the benefits of which accrue disproportionately to the poor' (Deininger and Squire, 1998: 261).

[17] In addition, their analysis involves only 52 observations, and liquidity constraints are represented mainly not by land distribution, but by the level of current income.

policies, or whether less unequal societies strengthen democracy.[18] Finally, Breen and García-Peñalosa (1999) find that greater income inequality is positively associated with higher income volatility, as measured by standard deviation in output growth rates, and they show that this finding is robust even if one controls for previous variables.[19]

All these papers recognize the existence of a distributional aspect in the relationship between income inequality and educational inequality, but they rely mainly on average attainments. In contrast, the issue of education distribution is central in the paper by Lopez, Thomas and Wang (1998).[20] They demonstrate that human capital, as measured by average educational attainment, is statistically non-significant in output-growth regressions unless one does not control for the distribution human capital ('who gets what') or for openness to international trade ('what to do with education'). They explain their evidence (on 12 countries over 1970-94) through reference to the absence of tradability in human capital that makes price equalization impossible and can produce shortages in human capital during physical capital accumulation. Along the same lines is the argument by Higgins and Williamson (1999), who predict the Gini index of income inequality using output per worker (linear and quadratic, in accordance with the hypothesis of Kuznets) and cohort-size effects (large mature working-age cohorts are associated with lower aggregate inequality because of relative excess supply). However, as they explicitly recognize, this approach neglects the endogeneity of educational choices. Let us suppose that a society is undergoing a transitional phase, in which the average educational requirement is rising, such that the younger cohorts are more well educated than the older ones. Other things being constant, the smaller the size of the more well educated cohort, the lower the recorded inequality in incomes. It is therefore rather possible that, through reliance on age-composition variables, the authors were actually capturing educational changes.[21]

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[18] Justman and Gradstein (1999) present similar ideas through a formal model that predicts the existence of an inverted-U-shaped relationship between income inequality and franchise. When the median voter income exceeds the average income, regressive redistribution policies are adopted, and inequality rises; as long as the median voter income remains below the average income, progressive redistributive policies tend to be adopted.

[19] They suggest that this could be due to the fact that firms offer an implicit contract to risk-averse workers. When the environment becomes more uncertain, the cost of this implicit insurance rises, and wages are consequently reduced, thus increasing income inequality.

[20] Galor and Tsiddon (1997) offer another theoretical paper focusing on educational inequality as a source of technological progress (and output growth).

[21] It is true that they control for secondary enrolment rates, but, as we have already argued above, this variable measures the flow and not the distribution of the stock of human capital.

At any rate, the two measures for educational achievement (average educational attainment and some measure of the dispersion of attainment) are intertwined. Both Ram (1990) and Londoño (1996) claim the existence of an inverted-U-shaped relationship between educational achievement and educational inequality, and they locate the turning point at 6.8 average years of education.[22] However, they do not provide a sound theoretical argument to explain this occurrence, nor do they show whether this relationship might hold for alternative measures of dispersion or concentration.

What do we learn from this mainly empirical literature? Income inequality is clearly related to the stage of development in accordance with some sort of Kuznets relationship. It may also reflect the skill level of the population, as proxied by average educational attainment. The evidence on the role played by the distribution of schooling is weaker, and it is still unclear how mean attainment and dispersion jointly contribute to shape income distribution. In addition, in all previous work, we find no measure related to labour market institutions (such as the presence of unions, unemployment benefits, or the minimum wage).[23] In the sequel, we will analyse the determinants of income inequality, making use of average educational achievement and dispersion in the population, as well as some measure of the quality/quantity of the resources invested in education.

III EMPIRICAL ANALYSIS

Starting from enrolment rates and making appropriate assumptions about mortality rates, Barro and Lee (1996) provide estimates of the human capital stock of a country. Using mild assumptions on the demographics (similar to the permanent inventory method used to estimate the stock of physical capital), starting from enrolment rates and possessing the distribution of educational

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[22] 'In a society where there is no education for everyone, the level of education is zero and the variance of education among the population is naturally zero. In a society where the entire population reaches the maximum level of education, the level of education is at maximum, but the variance, again, is zero. … In the interim period, the variance of education tends to rise with the increase in the level of education until it reaches a turning point, after which it decreases' (Londoño, 1996: 13). However, this reasoning is not rigorous on statistical grounds since a generalized increase of education in the population produces an increase in average achievement without necessarily raising educational inequality.

[23] Nor do we find controls for inequality in explaining employment/unemployment rates. See Glyn and Salverda (2000) for an analysis of OECD countries in this respect.

achievement at some reference time-point, one can obtain estimates of the average years of education among the population for each level of education. Let us illustrate this with an example. Consider a population in which each age cohort grows at a constant rate n and in which the probability of death is constant across ages and equal to δ. If we define k as the life expectancy in the population[24] and $Pop_{t,j}$ as the population aged j at time t, the entire population is given by $Pop_t = Pop_{t,k} + Pop_{t,k-1} + ... + Pop_{t,0} =$

$$= Pop_{t-k,0}(1-\delta)^k + Pop_{t-k,0}(1-\delta)^{k-1}(1+n) + ... + Pop_{t-k,0}(1+n)^k = Pop_{t-k,0}\sum_{i=0}^{k}(1-\delta)^{k-i}(1+n)^i$$

Suppose that schooling consists of one year and dropout rates are zero (such that enrolment rates coincide with graduation rates). Under this assumption, if we indicate by π_t the percentage of the population born at t that achieves education, we obtain the number of people with education as:

$$Pop_t^{educated} = \pi_{t-k}Pop_{t,k} + \pi_{t-k+1}Pop_{t,k-1} + ... + \pi_t Pop_{t,0} = Pop_{t-k,0}\sum_{i=0}^{k}\pi_{t-i}(1-\delta)^{k-i}(1+n)^i$$

Therefore, under the previous assumptions, the current population share with education is given by:

$$HC_t = \frac{Pop_t^{educated}}{Pop_t} = \frac{\pi_{t-k}Pop_{t,k} + \pi_{t-k+1}Pop_{t,k-1} + ... + \pi_t Pop_{t,0}}{Pop_{t,k} + Pop_{t,k-1} + ... + Pop_{t,0}} = \frac{\sum_{i=0}^{k}\pi_{t-k+i}(1-\delta)^{k-i}(1+n)^i}{\sum_{i=0}^{k}(1-\delta)^{k-i}(1+n)^i} =$$

(1)

$$= \frac{\sum_{i=0}^{k}\pi_{t-k+i}\left(\frac{1-\delta}{1+n}\right)^{k-i}}{\sum_{i=0}^{k}\left(\frac{1-\delta}{1+n}\right)^{k-i}} = \sum_{i=0}^{k}\pi_{t-k+i}\frac{\omega^{k-i}}{\sum_{j=1}^{k}\omega^{k-j}} = \sum_{i=0}^{k}\pi_{t-k+i}\omega^{k-i}\left[\frac{1-\omega}{1-\omega^{k+1}}\right],\ \ \omega = \left(\frac{1-\delta}{1+n}\right) < 1$$

which is a weighed average of past enrolment rates (with declining weights, as in an Almon's polynomial). In the particular case of constant enrolment rates (that is, $\pi_i = \pi,\ \forall i$), equation (1) collapses to $HC = \pi$.[25] Repeated applications of equation (1) yield:

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[24] This can be determined as $k : (1-\delta)^k \approx 0$.

[25] With educational cycles lasting more than one year and positive dropout rates, things are more complicated, but the logic of the argument holds unchanged. Indicating by λ_t the age-cohort share enrolling in a school level lasting n years (say, primary school starting at the

$$(2) \qquad HC_t = \left(\omega HC_{t-1} + \pi_t\right)\left[\frac{1-\omega}{1-\omega^{k+1}}\right] = \left(\omega HC_{t-1} + \pi_t\right)\Omega, \qquad \Omega < 1$$

If we now indicate the population share with some primary education as HC_{pt} and the enrolment rate for primary education as P_{pt}, both measured at time t, it is easy to understand why the former variable can be thought of as the integral of the latter (using the decline rate $\mu = 1-\omega$ as a discount factor). In symbols:

$$(3) \qquad HC_{pt} = \Omega\left\{\left[HC_{p0}\cdot(1-\mu)+P_{p1}\right]\cdot(1-\mu)+P_{p2}\right\}\cdot(1-\mu)+.....=\Omega\left[HC_{p0}\cdot(1-\mu)^t+\sum_{i=1}^{t}P_{pi}\cdot(1-\mu)^{t-i}\right]$$

where HC_{p0} is the (estimated) population share with primary education at a given year of reference (usually a census year), and μ represents the (constant) decline rate of an age cohort in the population. The use of a continuous time representation yields:

$$(4) \qquad HC_{pt} = \Omega\left[HC_{p0}\cdot(1-\mu)^t + \int_0^t P_p(s)\cdot\exp(-\mu\cdot s)ds\right]$$

Should the growth rate of the population or the mortality rate not remain constant over the years, the above derivations do not correspond exactly to the theoretical value implied by equation (4). By multiplying HC_p by the number of years required to complete primary education, we obtain the average number of years of primary education for the population. When we possess this piece of information for each level of education, we have an approximation of the distribution of the human capital stock in a country. The calculation is only an approximation because in many cases an attained educational level, say, a secondary degree, may actually be acquired after a longer-than-average period of study (because of repetition); in addition, we could encounter cases of people who have attended school without attaining any certificate (because they drop out). Even if the information on dropout rates is available, we may not know when individuals leave a course of study;

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age of m and lasting n years) and subject to a (constant) dropout rate y, then the enrolment rate would be:

$$\pi_t = \frac{\lambda_{t-n}(1-\delta)^{m+n}(1+n)^{k-m-n}(1-\gamma)^n + \lambda_{t-n+1}(1-\delta)^{m+n-1}(1+n)^{k-m-n+1}(1-\gamma)^{n-1} + ... + \lambda_t(1-\delta)^m(1+n)^{k-m}}{(1-\delta)^{m+n}(1+n)^{k-m-n}(1-\gamma)^n + (1-\delta)^{m+n-1}(1+n)^{k-m-n+1}(1-\gamma)^{n-1} + ... + (1-\delta)^m(1+n)^{k-m}}$$

which is a weighted average of the enrolments at the first year, taking into account the decline due to dropouts.

therefore, we cannot integrate this information in the computation of the average stock of human capital.[26] Once we have the rough distribution of educational achievement in the population, it is possible for us to calculate several measures of inequality, among which the Gini concentration index of the distribution of attained education is one of the easiest to compute. If only subgroup averages are known, the general definition of the index is modified accordingly:

$$(5) \qquad G = \frac{1}{2n^2 \cdot \mu} \sum_{i=1}^{N} \sum_{j=1}^{N} \left| n_i - n_j \right| = \frac{1}{2\mu} \sum_{k=1}^{M} \sum_{h=1}^{M} \left| \overline{n}_k - \overline{n}_h \right| \cdot HC_k \cdot HC_h$$

where N is the population size, n_i is the number of years of schooling of individual i, μ is the average years of schooling in the population, M is the number of subgroups and $\overline{n}_h$ is the (average) educational attainment in subgroup h. In the case of educational attainments, Barro and Lee (1996) provide us with the available information on three educational levels.[27] This allows us to divide the population into four subgroups: higher education (a share HC_h has attained n_h years of education), secondary education (a share HC_s with n_s years), primary education (a share HC_p with n_p years), and a residual group without education ($HC_n = 1 – HC_h – HC_s – HC_p$, for which zero education is assumed).[28] By construction, the average population attainment is given by:

$$(6) \qquad \mu = \overline{HC} = HC_p \cdot n_p + HC_s \cdot n_s + HC_h \cdot n_h ,$$

and the Gini index of educational attainments is computed as follows:

26 Dropout rates are effectively available in the Barro and Lee (1996)[Qu?: correct reference year?] dataset at the primary level. This variable ranges from an average (over the period 1960-95) of 3.35% in OECD countries to 39.8% in sub-Saharan Africa, 39.7% in South Asia and 36.6% in Latin America.

27 This is another obvious approximation, since we are standardizing educational systems into a tripartite classification, corresponding to UNESCO 'ISCED' (international standard classification system of education levels) standards. However, if a country (like Germany) has double-track secondary education (high school and vocational training), each with a different duration, the duration will nevertheless be computed as a though it were a single figure.

28 Barro and Lee (1996) make a distinction between 'attained' and 'completed' educational levels. Given the high correlation between the two series, we have preferred to adopt the former variable because there are fewer missing observations for it.

(7) $$G_{ed} = \frac{HC_h \cdot n_h \cdot (HC_s + HC_p + HC_n) + HC_s \cdot n_s \cdot (-HC_h + HC_p + HC_n) + HC_p \cdot n_p \cdot (-HC_h - HC_s + HC_n)}{\overline{HC}} = $$
$$= HC_n + \frac{HC_h HC_s (n_h - n_s) + HC_h HC_p (n_h - n_p) + HC_s HC_p (n_s - n_p)}{\overline{HC}}$$

Starting from the original Barro and Lee (1996) dataset, we have extended the observations up to 1995. We therefore have information about educational achievements in the population for 149 countries at five-year intervals over the period 1960-95. Overall, these data cover three-fourths of the 210 countries listed by the World Bank (1998), but account for 86.3 per cent of the world population (in 1990). However, missing values have reduced the potential number of observations from 1,192 to 848 cases, corresponding to 117 countries (with an average of 7.2 observations per country). Descriptive statistics on these variables appear in Table 1 at world aggregate level, in Table 2 with a temporal disaggregation and in Table 3 with temporal and regional disaggregations; additional information on the data sources is contained in Appendix 1.

TABLE 1
DESCRIPTIVE STATISTICS

Variable	Variable name	Mean	Median	Standard deviation	Observations
		(weight = population)			
Population without education	HC_n	40.4%	43.1%	0.278	883
Population with primary education	HC_p	33.8%	32.3%	0.172	902
Population with secondary education	HC_s	19.8%	17.2%	0.143	916
Population with higher education	HC_h	5.6%	2.5%	0.077	919
Average duration, primary education	n_p	5.35	5.10	1.153	869
Average duration, secondary education	$n_s - n_p$	4.59	4.58	0.824	929
Average duration, higher education	$n_h - n_s$	3.49	3.33	0.791	898
Average years of education	μ	4.66	3.89	2.757	848
Gini: educational attainment inequality	Ginied	49.32	51.74	23.261	848
Gini: income inequality	Gini	38.01	36.85	8.239	546

Source: computations based on data presented in Appendix 1.

TABLE 2
MEAN VALUES (WEIGHT=POPULATION) ACROSS YEARS

Variable	1960	1965	1970	1975	1980	1985	1990	1995
Population without ed. %	46.3	46.7	44.1	44.6	43.1	38.6	33.5	35.5
Population with primary ed. %	38.1	37.1	37.4	34.8	31.2	32.6	33.2	32.3
Population with secondary ed. %	12.5	12.7	14.0	16.2	20.4	22.5	25.3	22.9
Population with higher ed. %	2.5	2.8	3.5	4.4	5.4	6.3	8.1	9.0
Average duration, primary ed.	4.91	5.02	5.11	5.05	5.22	5.34	5.40	6.37
Average duration, secondary ed.	4.45	4.53	4.65	4.61	4.47	4.52	4.59	4.85
Average duration, higher ed.	3.21	3.75	3.45	3.55	3.45	3.40	3.41	3.70
Average years of ed.	4.31	3.67	3.93	3.92	4.30	4.81	5.39	5.86
Gini: ed.'al attainment inequality	44.89	53.63	52.43	53.71	52.07	48.38	44.31	47.03
Gini: income inequality	42.05	36.65	37.14	36.47	37.65	37.67	38.43	39.35

Source: computations based on data presented in Appendix 1.

In the most recent year of observation (1995), we find that one-third of the world population is illiterate; one-third has primary education, and the remaining one-third have secondary schooling or more. During the time span under consideration in this paper, the average number of years of education rose from 4.3 to 5.8 at the world level, although this rise was accompanied by growing gaps in the same variable computed at regional level. The population share composed of illiterate people or people with primary education exhibited a declining trend, with some reversal at the end of the period, and there was a similar trend in the index of inequality of educational achievement. But the global picture varied by region: while educational inequality declined in North Africa, South Asia and the formerly planned economies, it decreased during the first three decades, but rose thereafter in other regions (especially in sub-Saharan Africa). Inequality in terms of years of schooling remained almost constant at low levels in the OECD countries, despite the increase in the average educational attainment. It is therefore difficult to trace out a single trend at world level, especially because there seems to be a difference among countries in the rates of change, as well as in the levels of the variables.

Since we are interested in the relationship between educational achievement and income distribution, we now add the dynamics of income inequality to the picture. Here, we rely on the dataset of Deininger and Squire (1996) and on the larger 'world income inequality dataset' (WIID) collected by WIDER, both of which contain a substantial amount of information on inequality measures collected from secondary sources. Among these measures, the Gini index on income inequality is the most readily available.[29] In the present case, we have

[29] See Appendix 1 for a discussion of the changes made in the original (Deininger and Squire and WIID) datasets, including the 1995 update of the observations.

TABLE 3
MEAN VALUES (WEIGHT = POPULATION) ACROSS YEARS:
REGIONAL VARIATIONS

Variable	1960	1965	1970	1975	1980	1985	1990	1995
	OECD countries							
Average years of education	6.75	6.98	7.46	7.65	8.59	8.66	9.00	8.81
Gini: ed.'nal attainment inequality	20.68	21.41	21.26	22.64	20.75	20.72	20.98	24.21
Gini: income inequality	39.55	37.27	38.01	36.87	35.87	36.20	36.35	37.36
	North Africa and the Middle East							
Average years of education	1.03	1.12	1.36	1.57	2.14	2.77	3.48	4.90
Gini: ed.'al attainment inequality	85.95	86.03	83.38	83.21	77.70	71.00	64.82	52.71
Gini: income inequality	49.05	46.87	49.59	49.29	41.37	47.40	38.72	35.30
	Sub-Saharan Africa							
Average years of education	1.01	1.65	1.61	1.66	1.96	2.14	2.32	2.74
Gini: ed.'al attainment inequality	82.47	74.39	74.83	72.79	67.08	64.33	63.08	75.35
Gini: income inequality	51.86	50.76	56.22	44.31	42.47	46.24	52.75	44.98
	South Asia							
Average years of education	0.91	1.37	1.74	2.08	2.45	2.81	3.20	4.23
Gini: ed.'al attainment inequality	86.23	79.67	77.99	76.14	76.71	72.78	69.08	61.49
Gini: income inequality	38.90	37.40	36.74	38.37	38.22	38.64	35.52	30.02
	East Asia and the Pacific							
Average years of education	3.72	3.96	4.34	4.71	5.35	5.82	6.31	6.43
Gini: ed.'al attainment inequality	50.64	49.02	41.24	39.11	35.33	31.86	31.44	39.27
Gini: income inequality	40.19	37.51	36.41	39.65	39.18	39.88	40.02	38.38
	Latin America and the Caribbean							
Average years of education	3.06	2.99	3.37	3.47	3.97	4.13	4.74	6.17
Gini: ed.'al attainment inequality	49.70	50.75	47.68	45.05	44.27	44.23	39.08	43.22
Gini: income inequality	52.22	49.93	53.99	53.77	52.31	54.66	54.63	56.05
	Formerly Centrally Planned Economies							
Average years of education	3.92	4.83	5.28	3.61	3.68	4.96	6.09	8.17
Gini: ed.'al attainment inequality	33.37	35.72	32.20	56.04	52.86	44.69	35.15	23.12
Gini: income inequality	–	30.52	27.83	26.72	32.06	30.50	33.37	41.53

Source: computations based on data presented in Appendix 1.

information on 546 observations, corresponding to 113 countries (with an average of 4.8 observations per country). If we restrict our selection to the subset in which there is information about both income and education inequality, we have 477 observations for 97 countries (with an average of 4.9 observations per country; Appendix 1 contains a list of the countries). Table 2 reports the population-weighted average for this measure computed on all available information in the dataset.[30] We notice that, despite a declining trend

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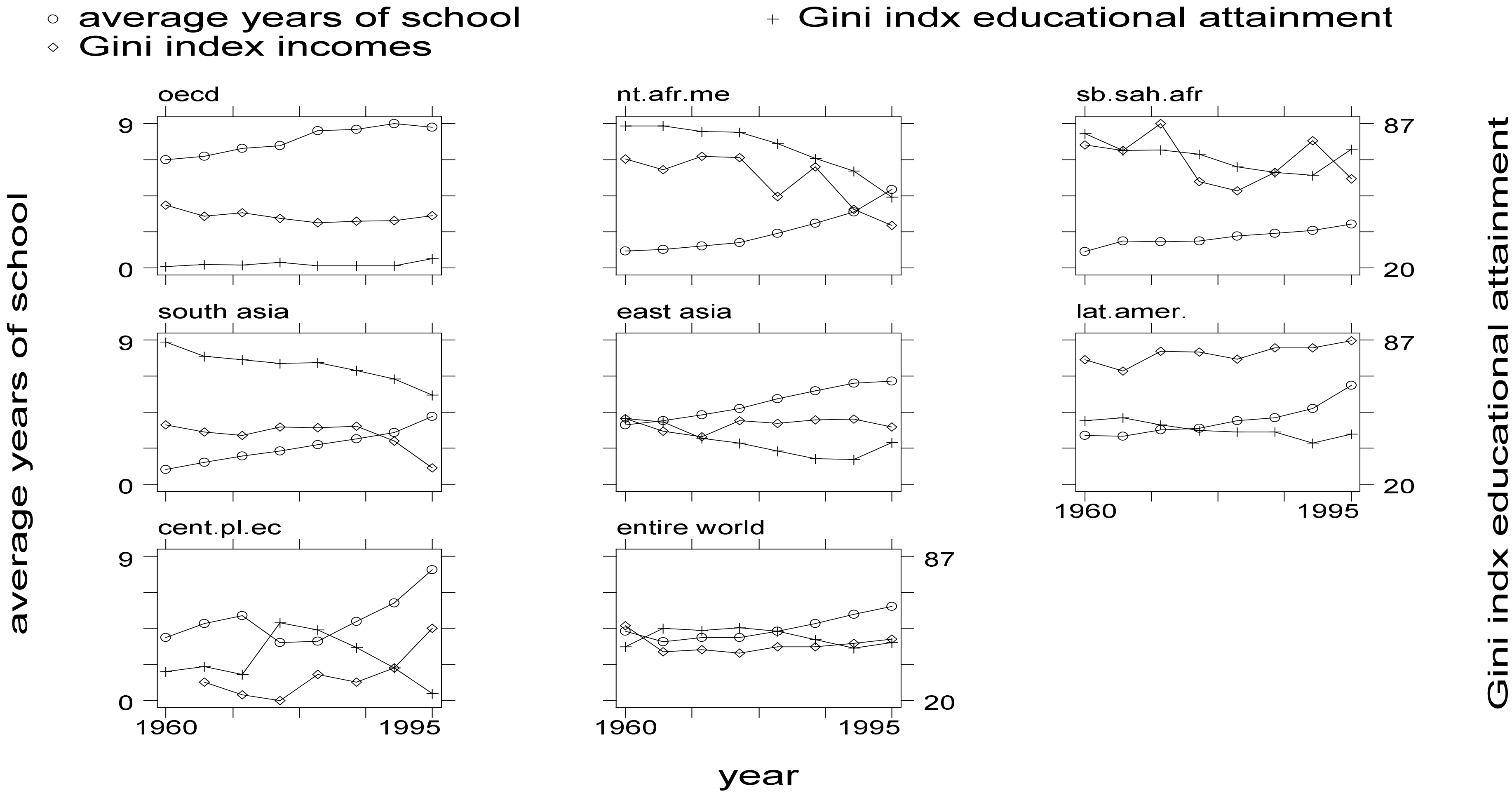
[30] Given that the Gini index is not decomposable by population subgroup, the trend in the population-weighted average has to be viewed with caution. See Milanovic (1999) for a more accurate picture based on population surveys (albeit with observations only over two years, 1988 and 1993).

FIGURE 1

EDUCATIONAL ACHIEVEMENT AND INCOME INEQUALITY



Source: data presented in Appendix 1.

in educational inequality (reversed only during the 1990s), income inequality at world level started rising after 1975. Figure 1 (which graphs the data reported in Table 3), seems to indicate that this is mainly attributable to the OECD, the Latin American countries and the formerly centrally planned economies.

So that we can make more precise statements, let us now consider what we may expect from theoretical models. If we adopt a standard version of the theory of human capital investment, initially proposed by Becker (1964) and subsequently taken up by Mincer (1974) to estimate the returns to education, the (log)incomes and years of education are linearly related. In fact, when a Mincer-Becker theory of earnings applies, individual earnings would be determined as:

(8) $\log(y_i) = \alpha + \beta \cdot n_i +$ individual characteristics (gender, age, experience, etc.) $+ \varepsilon_i$

where y_i is the earning capacity of individual, i, n_i is the educational attainment of individual, i (measured in years of schooling), β is the (percentage) rate of return to education, α is the earning of an individual without formal education; ε_i is an error term assumed to be i.i.d. (identically independently distributed). If we assume that the *individual characteristics* are idiosyncratic in the population and orthogonal with acquired education, population subgroups differ only in terms of average educational achievement (namely, the within-group variance is constant).[31] We therefore expect there to be a relationship between the distribution of educational achievements and the distribution of actual incomes. However, the things are not so simple. Inserting equation (8) into equation (7) and ignoring the (average) individual characteristics, we obtain the Gini index of log-income inequality as:

(9)
$$G_{\text{log-income}} = \frac{HC_h \cdot \beta \cdot n_h \cdot (HC_s + HC_p + HC_n) + HC_s \cdot \beta \cdot n_s \cdot (-HC_h + HC_p + HC_n) +}{\alpha + \beta \cdot \overline{HC}}$$
$$\frac{+ HC_p \cdot \beta \cdot n_p \cdot (-HC_h - HC_s + HC_n)}{\alpha + \beta \cdot \overline{HC}}$$

or more synthetically:

[31] Actually, Mincer (1996) shows that between-group variance in earnings distribution in the US remained nearly constant during 1970-90, whereas the within-group variance expanded after the 1980s.

$$(10) \quad G_{\log-\text{income}} = \frac{\overline{HC}}{\frac{\alpha}{\beta} + \overline{HC}} \cdot G_{ed}\left(\overline{HC}\right) = f\left(\underset{\pm}{\overline{HC}}\right)$$

Equation (10) suggests that, at a given average in educational achievements, the inequality in education and the inequality in (log)earnings are linearly related. If incomes are proportional to earnings, this also applies to inequality in (log)incomes. However, since the inequality in education is negatively related to average education, the actual relationship is non-linear.[32] The situation is rendered more complicated by the fact that we do not possess individual data allowing the calculation of inequality measures for (log)incomes. Rather, we are forced to rely on aggregate measures based on actual incomes. Once more, the relationship between the inequality measures obtained from the actual values of the variables and the corresponding measures computed based on the logarithms is not easily ascertained.[33] However, it can be formally demonstrated that—under mild assumptions about the distribution of education in the population and the general assumption that the rate of return to education is constant—the relationship between the Gini index of actual incomes and the average years of education initially rises and

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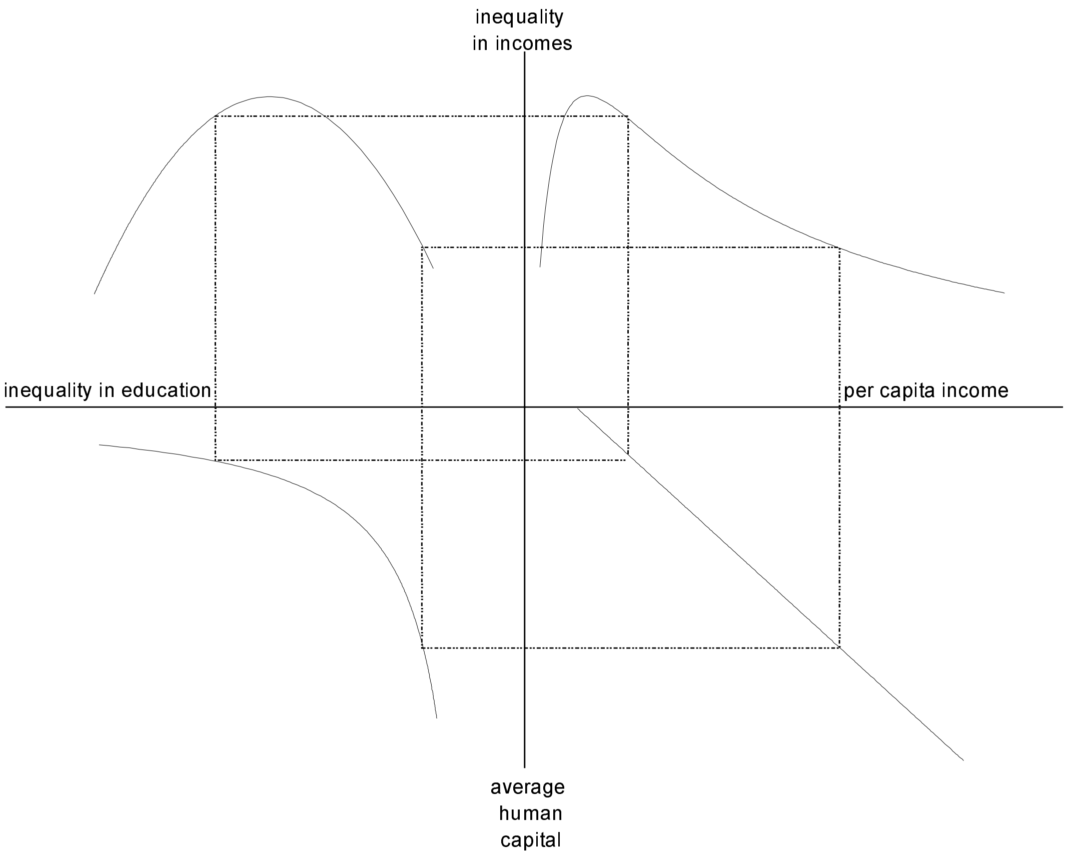
[32] In a previous version of this paper, we made use of simulations (relying on the observed values for educational achievement) to analyse the relationship between education and income inequality under the assumption that returns to education are constant. We found that the relationship is positive and stronger in countries with low-to-middle inequality in education (lower than 45%), whereas the same relationship is negative in countries with very high inequality in education. This is because the Gini concentration index is scale invariant (that is, it does not vary when we change the unit of measure), but not translation invariant. Therefore, given the presence of a constant ($\alpha \neq 0$), a generalized rise in educational achievement (at the given inequality in educational attainments) induces a change in income inequality.

[33] If we impose more structure to the problem by assuming a specific functional form for the frequency distribution, we are able in some cases to determine the relationship between the two. For example, if the incomes (y) are distributed according to a Pareto distribution $y \sim P(\alpha,\theta)$, $\theta > 1$, where α represents the minimum income observed in the distribution, the density function is given by $f(y) = \theta\alpha^{\theta}y^{-(\theta+1)}$, and the associated Gini index is given by $Gini_y = \frac{1}{2\theta - 1}$ (see Zenga, 1984). When we consider a logarithmic transformation, $x = \log(y)$, the frequency distribution associated with the logarithmic transformation is given by $f(x) = \theta\alpha^{\theta}e^{-\theta x}$. It can be shown that the associated dispersion measure is given by $Gini_{\log(y)} = \frac{\alpha^{\theta}}{2}\left(2\alpha^{\theta} - 1\right)$. The two measures are therefore positively correlated in a non-linear way. We are indebted to Fulvia Mecatti for the derivation of this result.

then declines.[34] When the assumptions hold, income inequality, education inequality and average educational inequality are strictly related, as shown in Figure 2, where we have also added a fourth variable, the output per capita, in order to control for an exogenous driving force.

FIGURE 2
THEORETICAL RELATIONSHIPS



Source: author.

Starting from the lower right-hand quadrant, we assume that an increase in per capita income is associated with an increase in the average educational attainment. By construction, this yields a consequent decline in educational inequality (lower left quadrant). If the relationship between average educational attainment and income inequality is non-linear, this necessarily implies a non-linear relationship between income inequality and education inequality (upper left quadrant). By the same token, we also obtain an inverted-U-shaped relationship between income inequality and per capita income, in the Kuznets tradition (upper right quadrant). The graph tells us a story about the transition from an uneducated population to an actual level of schooling. When

[34] See Checchi (2000).

only the elite attends schools, the average level of human capital development among the population is low, whereas the inequality in educational achievements and in incomes is high. A lowering of the access barriers to education leads to an initial increase and then to a decline in both inequality measures, and this is accompanied by a rise in average educational attainments.

A first inspection of our dataset indicates that this story may have some plausibility. Figure 3 gathers together all the available observations, whereby income inequality is measured by regression residuals on regional dummies and year-related dummies in order to compensate for trends in the variables and regional disparities. In addition to a mildly non-linear relationship between inequality in actual incomes and inequality in education (see the upper left quadrant), a similar relationship emerges between the former variable and (the log of) GDP per capita, in line with the Kuznets tradition (upper right quadrant). Without concerning ourselves too much about the direction of the causal relationship, we also find evidence of a strict positive correlation between output per capita and educational achievement (lower right quadrant). Finally, almost by construction, we find an inversely proportional relationship between inequality in education and average educational achievement (lower left quadrant).[35]

However, the dispersion of single observations suggests that many other forces are at work. We should not forget that the validity of the story of Figure 2 is conditional on the assumption that individual incomes are determined according to Becker's theory of human capital investment and that returns to education are constant and are, moreover, identical throughout the population. In reality, we know that earnings distribution is shaped by many other factors, including technology, unemployment rates, minimum wages, age composition, the existence of labour unions, and so on.[36] Were it certain that these factors

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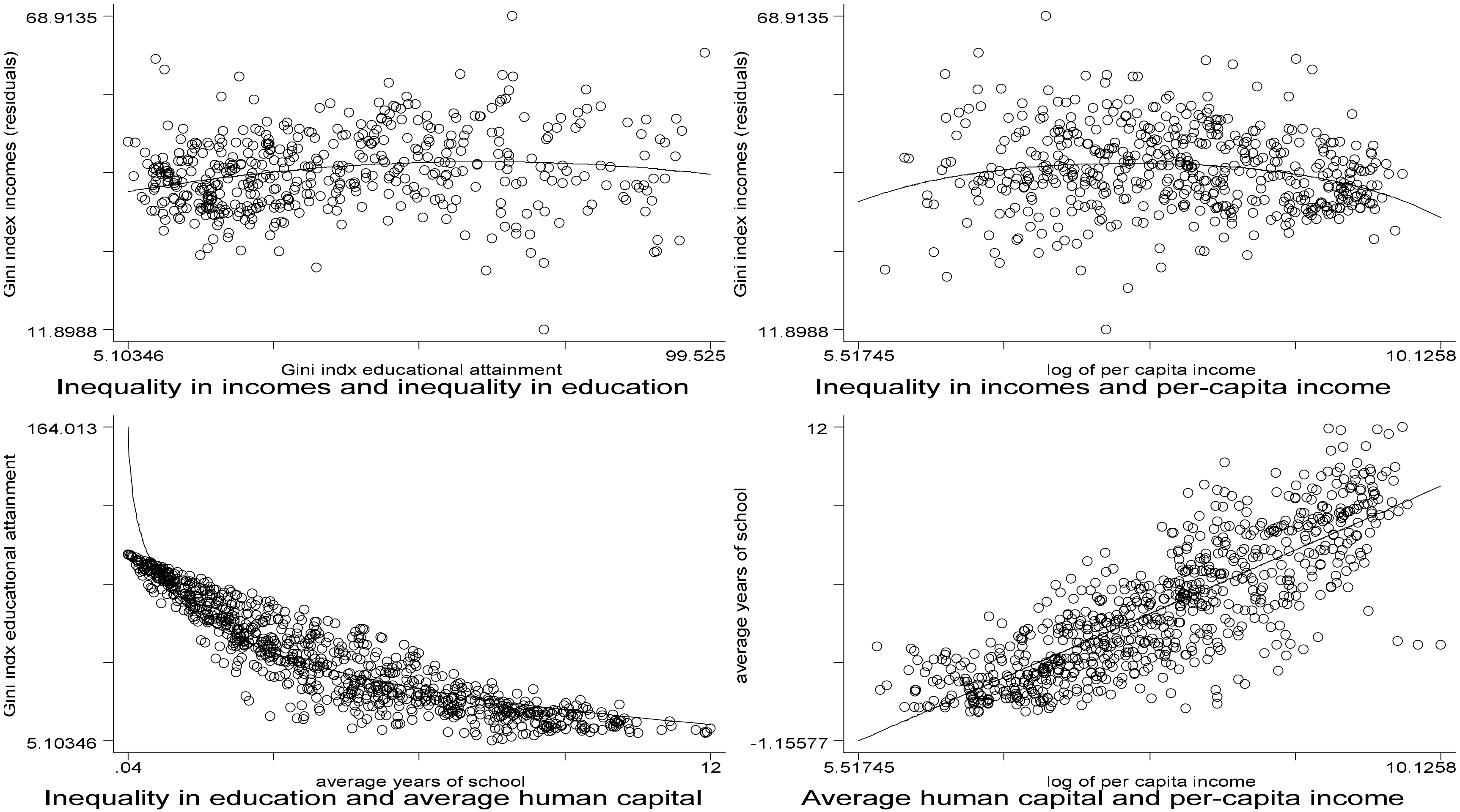
35 However, the way we measure educational inequality is crucial. Had we chosen the standard deviation of educational achievement like Ram (1990), Londoño (1996) and IDB (1998), the relationship between average educational attainment and educational inequality would have appeared non-linear:

$$St.Dev._{ed} = \underset{(24.4)}{1.72} + \underset{(19.6)}{0.644} \cdot \overline{HC} - \underset{(17.8)}{0.056} \cdot \overline{HC}^2, \qquad R^2 = 0.32, \qquad n = 848$$

In such a case, the turning point would occur at 5.75 years (rather than the 6.8 years measured by Ram, 1990).

36 See Neal and Rosen (1998) for a general presentation of determinants of earnings distribution. Higgins and Williamson (1999) find evidence of an effect of age composition (as measured by the share of individuals aged 40-59 in the labour force) in determining income inequality. With reference to OECD countries, Bardone, Gittleman and Keese (1998) show that labour market institutions changed during the sample period: trade union density and coverage declined (especially within the Anglo-Saxon world), while minimum

FIGURE 3
BASIC RELATIONSHIPS



Source: computations based on data presented in Appendix 1.

remained constant during our sample period, we could consider them country-specific fixed effects. The problem is that there is no guarantee that they remained constant, especially if we take into account the transformation in public policies induced by the 'transatlantic consensus' (Atkinson, 1999).

As a consequence, instead of pretending to predict the shape and the evolution of income distribution worldwide, we follow in the sequel the less ambitious aim of discovering whether the average educational achievement and the distribution of educational attainment have played any role in determining income inequality. We have already mentioned the fact that other authors (Londoño, 1996; Deininger and Squire; 1998; Barro, 1999) have shown that average educational achievement is one of the determinants of actual income inequality. To this result, we now add an examination of the effect on income inequality of the distribution of educational achievement in the population.

In order to take into account the simultaneous effects of all the variables, we resort to multivariate regressions. We take our dataset as an unbalanced panel with a potential dimension of 752 observations (94 countries times 8 observations per country), which we reduce to 454 observations because of missing data on one or the other variable. Table 4 shows estimates of actual income inequality using fixed effects, whereas Table A1 in Appendix 2 relies on random effect estimators. In both tables we start with two alternative specifications of the relationship between income inequality and output per capita, without taking into account educational factors (first and second columns). Both specifications reject the hypothesis of a non-linear relationship between income inequality and per capita output. The two measures are negatively correlated, with a rather low elasticity (-0.049 at sample means). This implies that, in order for the Gini index of income inequality to be reduced by 1 point, income per capita has to rise by $2,311 (at 1985 international prices). If we replace per capita income by educational variables (third and fourth columns), we notice an increase in explanatory power only if we consider average educational achievement. This is not surprising given the high correlation of the latter measure with per capita income. Both average educational achievement and educational inequality are significant, but the relationship between the two measures of inequality is opposed to the theoretical expectation (being U shaped and not inverted-U shaped). We consider GDP per capita and educational variables together in the fifth column. Here, we find that output per capita has a low negative impact, as does average human capital, though with a higher effect: an average increase of one year of education in the population lowers the Gini index of income inequality by more than 1 point. The sixth column offers an alternative (hyperbolic) specification of the functional relationship relating income inequality and average human capital: given the non-linear relationship existing between the Gini index of educational inequality, the variable $1/h_c$ seems able to capture all the explanatory power contained in the educational distribution variable.[37]

TABLE 4
ESTIMATES OF INCOME INEQUALITY: FIXED EFFECTS, 94 COUNTRIES, 1960-95 (T-STATISTICS IN PARENTHESES)

Countries	94	94	94	94	94	94
Observations	454	454	454	454	454	454
Dependent variable	Gini	Gini	Gini	Gini	Gini	Gini
Intercepts	46.953	47.401	49.283	59.164	57.491	48.163
	(29.91)	(31.75)	(15.76)	(12.17)	(11.67)	(15.26)
GDP	-0.000	-0.001			-0.000	-0.001
	(-0.77)	(-2.39)			(-1.86)	(-2.64)
GDP^2	-0.000					
	(-0.16)					
1/GDP		-423.050				
		(-0.23)				
Ginied			-0.182	-0.310	-0.279	-0.069
			(-1.45)	(-2.31)	(-2.08)	(-0.53)
$Ginied^2$			0.002	0.002	0.002	0.000
			(1.48)	(1.95)	(2.03)	(0.32)
h_c				-1.470	-1.134	
				(-2.64)	(-1.94)	
$1/h_c$						2.364
						(2.84)
Years	Yes	Yes	Yes	Yes	Yes	Yes
R^2(within)	0.066	0.066	0.056	0.075	0.084	0.095

Source: regressions based on data presented in Appendix 1.

However, the explanatory contribution of the distribution of educational achievement is rather unstable. If we include repeated cross-sectional estimates (as in Table 5), we find that the average educational achievement and the Gini index of educational inequality (in level and squared level) are statistically significant in five of eight cases, but now the non-linear relationship is of the inverted-U-shaped type (which is in line with human capital investment theory). One potential reason for this instability is that omitted variables might contribute to a reversion in the trend in income inequality.

[37] However, this result is not robust. When we introduce a proxy for technological progress (the capital/output ratio) in the regressions (see Table A2 in Appendix 2), the inequality in educational attainment retains its sign and significance even with the hyperbolic functional form. Notice that the number of observations is reduced under this specification because we do not have information about national capital stocks for 18 of the countries.

TABLE 5
ESTIMATES OF INCOME INEQUALITY: YEARLY CROSS-SECTIONS, ROBUST ESTIMATES (T-STATISTICS IN PARENTHESES)

	1960	1965	1970	1975	1980	1985	1990	1995
Countries	40	47	60	53	55	57	65	24
Dependent variable	Gini	Gini	Gini	Gini	Gini	Gini	Gini	Gini
Intercepts	46.943	40.760	32.317	52.368	37.297	37.560	49.381	19.402
	(4.49)	(3.73)	(2.91)	(6.26)	(3.24)	(3.53)	(2.94)	(0.64)
k/y	2.294	3.595	4.943	2.358	3.926	2.507	0.795	-1.497
	(2.28)	(2.56)	(4.94)	(4.22)	(3.48)	(2.30)	(0.83)	(-0.61)
GDP	0.000	0.000	0.001	0.000	-0.001	-0.001	-0.001	-0.001
	(0.05)	(0.28)	(1.22)	(-0.56)	(-1.98)	(-2.08)	(-1.82)	(-1.97)
Ginied	0.118	0.194	0.574	-0.012	0.291	0.294	0.375	1.150
	(0.56)	(0.60)	(1.92)	(-0.05)	(1.08)	(1.15)	(0.94)	(2.34)
Ginied^2	-0.002	-0.002	-0.006	-0.001	-0.004	-0.003	-0.006	-0.013
	(-0.94)	(-0.76)	(-2.26)	(-0.50)	(-1.72)	(-1.39)	(-1.49)	(-2.44)
h_c	-1.457	-1.980	-2.967	-2.493	-1.052	-0.719	-1.532	2.275
	(-0.98)	(-1.47)	(-3.02)	(-3.09)	(-1.20)	(-0.80)	(-1.28)	(0.67)
R^2	0.263	0.23	0.568	0.498	0.538	0.45	0.38	0.446

Source: regressions based on data presented in Appendix 1.

In Figure 4 we have graphed the coefficients of yearly dummies obtained in the regressions reported in the fifth columns of Tables 4 and A1. These coefficients (normalized by the coefficient of the initial year) measure a shift in the intercepts of the regressions, thus capturing part of the variance that is left unexplained by the estimated model and that is year specific. For the first half of the sample (until 1975), we witness a growing pressure for the compression of income distribution (on the order of 1 point in the Gini index every five years), whereas this effect disappears during the 1980s. In the 1990s the phenomenon works in the opposite direction, favouring widening income disparity. Regional dummies (used in the estimates of random effects reported in Table A1) indicate that the greatest inequality was registered in Latin America and sub-Saharan Africa, where inequality indexes were 6 percentage points higher than they were in the OECD countries (which represent the reference case; see the fifth column in Table A1).[38] Conversely, the distribution was more egalitarian in the currently (or previously) centrally planned economies, where the Gini index was 12 percentage points lower than it was in the OECD, and in South Asia, North Africa and the Middle East.

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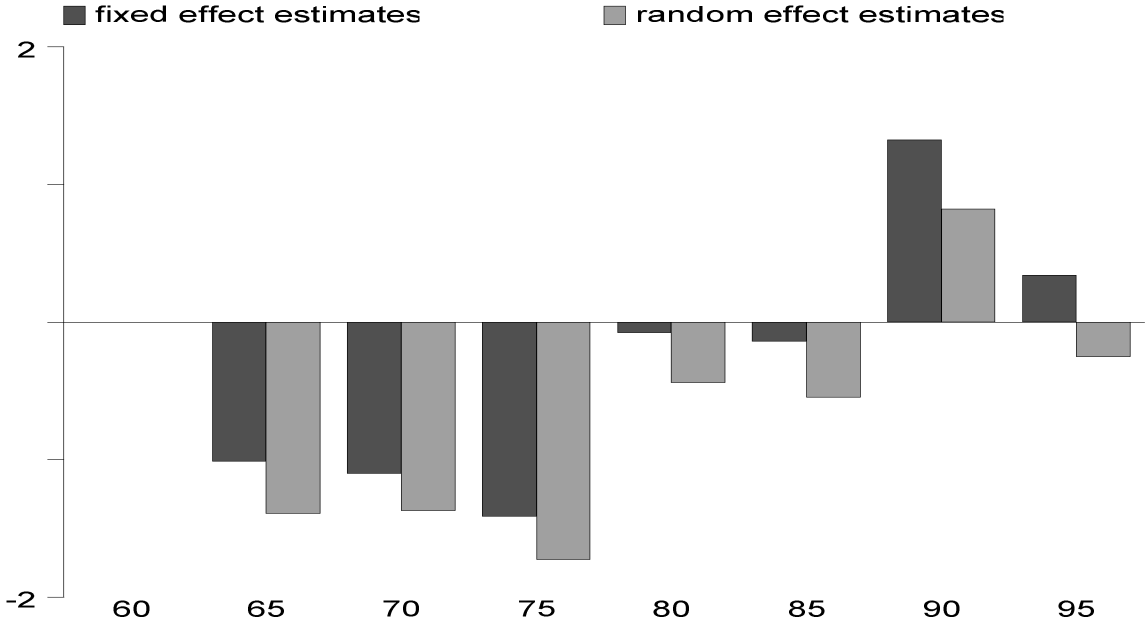
[38] Londoño (1996) compares the theoretical achievement in education associated with the stage of development (as measured by the level of GDP per capita) and estimates that populations in the Latin American countries lack about two average years of education. Mexico and Brazil account for most of this shortage in educational achievement. Similar conclusions are obtained in IDB (1998).

FIGURE 4
COEFFICIENTS OF TEMPORAL DUMMIES



Source: computations based on data presented in Appendix 1.

Since by definition yearly/regional dummies capture unexplained components, we do not have reliable explanations for these effects that do not refer to per capita income or educational achievement. Nevertheless, we have experimented with two additional variables that may capture some of the differences among countries or years. The first one is the physical capital/output ratio. On theoretical grounds, if physical and human capital are substitutes in the aggregate production function, an increase in the former raises the productivity of the latter. Therefore, *cæteris paribus*, we will obtain higher returns to education whenever physical capital accumulation becomes more intensive. Thus, we can expect greater income inequality whenever and wherever there is intensive investment in physical capital.[39] This variable is introduced in Table 5 and also in Table A2 in Appendix 2 (which reproduces information in Table 4, though the number of observations is reduced because of missing information). This variable is not very significant in the fixed effect estimates, but has a positive and significant sign in the repeated cross-sectional estimates (up to 1985). Other things being constant, countries characterized by higher accumulation in physical capital also exhibit higher income inequality: passing from an average *k/y* ratio of 2 in South Asia to 3 in the OECD

[39] This claim is objectionable when we think of information and telecommunications technologies, for which the capital/output ratio is actually lower than it is for manufacturing, notwithstanding the fact that the earnings differentials are higher.

countries raises the Gini index of income inequality by 2 (up to 5) points. However, it is insignificant in more recent years.

The second variable we take into account is the amount of public resources invested in education. If the technology for human capital formation includes invested resources, we can expect increased human capital per unit of time spent in school whenever education expenditure is raised. The resources invested in education should include both public and private expenditure for the management of educational institutions. In the absence of reliable information about private expenditure, we can use the ratio of government educational expenditure to gross domestic product. An undesirable feature of introducing new controls is the increase in the number of inapplicable observations. In the first column of Table A3 in Appendix 2, we have reproduced the fifth column of Table 4 to facilitate comparison. Using the same specification, we restrict the number of cases to applicable observations for the capital/output ratio (second column), and then we introduce the capital/output ratio (third column). We observe that an increase in capital accumulation raises income inequality (though with an elasticity which is quite low); all the other variables preserve their signs and significance. We now proceed to consider the ratio of (current+capital) government expenditure on education to gross domestic product (variable *edgvsh*).[40] The fourth column reduces the sample to country/year observations corresponding to non-missing values for the *edgvsh* variable, whereas the fifth column introduces the *edgvsh* variable; the *k/y* variable is dropped in the sixth column, which makes full use of the available sample. Even in this case, we observe that countries characterized by higher public expenditure on education exhibit higher income inequality. It is obvious that countries with higher educational achievements spend more on education. However, given the fact that we are controlling for average educational achievement (variable h_c) and the distribution of educational achievement (variable $Gini_{ed}$), the additional effect could be taken as evidence that the 'quality' of human capital incorporated in the same number of years of schooling is higher, thus generating more dispersion in earnings. In this specification, however, the capital/output ratio loses significance.[41]

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40 This variable is taken from UNESCO (1998). It is missing for 1960 and 1965, and there is a sample mean of 4.25% (standard deviation: 1.86).

41 A third aspect that we would have liked to consider is the possibility of different returns for different educational levels, which is invoked by Gottschalk and Smeeding (1997) as one potential explanation for rising earnings inequality in the US. We know from the literature (Psacharopoulos, 1994) that returns to education differ from country to country and tend to decline with a rising level of development. But we do not have time-series proxies for this differential effect, and we are forced to leave this effect out.

Summing up, we have found that per capita income and average years of education in the population negatively affect income inequality. Some additional explanatory contribution is provided by the distribution of educational attainments in the population, and this variable exhibits a non-linear relationship with income inequality. Higher investment in physical capital (as proxied by capital/output ratio) or in human capital formation (as proxied by the ratio of educational expenditure to gross output) contributes to higher income inequality. These results are robust to alternative specifications, and we therefore go back to our initial (and preferred) specification, which is provided in the fifth column of Table 4 and reproduced here for simplicity (yearly dummies not shown):

$$(11) \quad Gini_{\text{income}} = \underset{(11.6)}{57.49} - \underset{(1.86)}{0.004} \cdot gdp - \underset{(2.08)}{0.279} \cdot Gini_{educ} + \underset{(2.03)}{0.002} \cdot Gini_{educ}^{2} - \underset{(1.94)}{1.13} \cdot \overline{HC}$$

If we take into account that, on the same sample, fixed effect regression yields (again, yearly dummies are not shown here):

$$(12) \quad Gini_{\text{educ}} = \underset{(43.3)}{71.37} - \underset{(22.84)}{6.77} \cdot \overline{HC}$$

and we replace equation (12) into equation (11), we get:

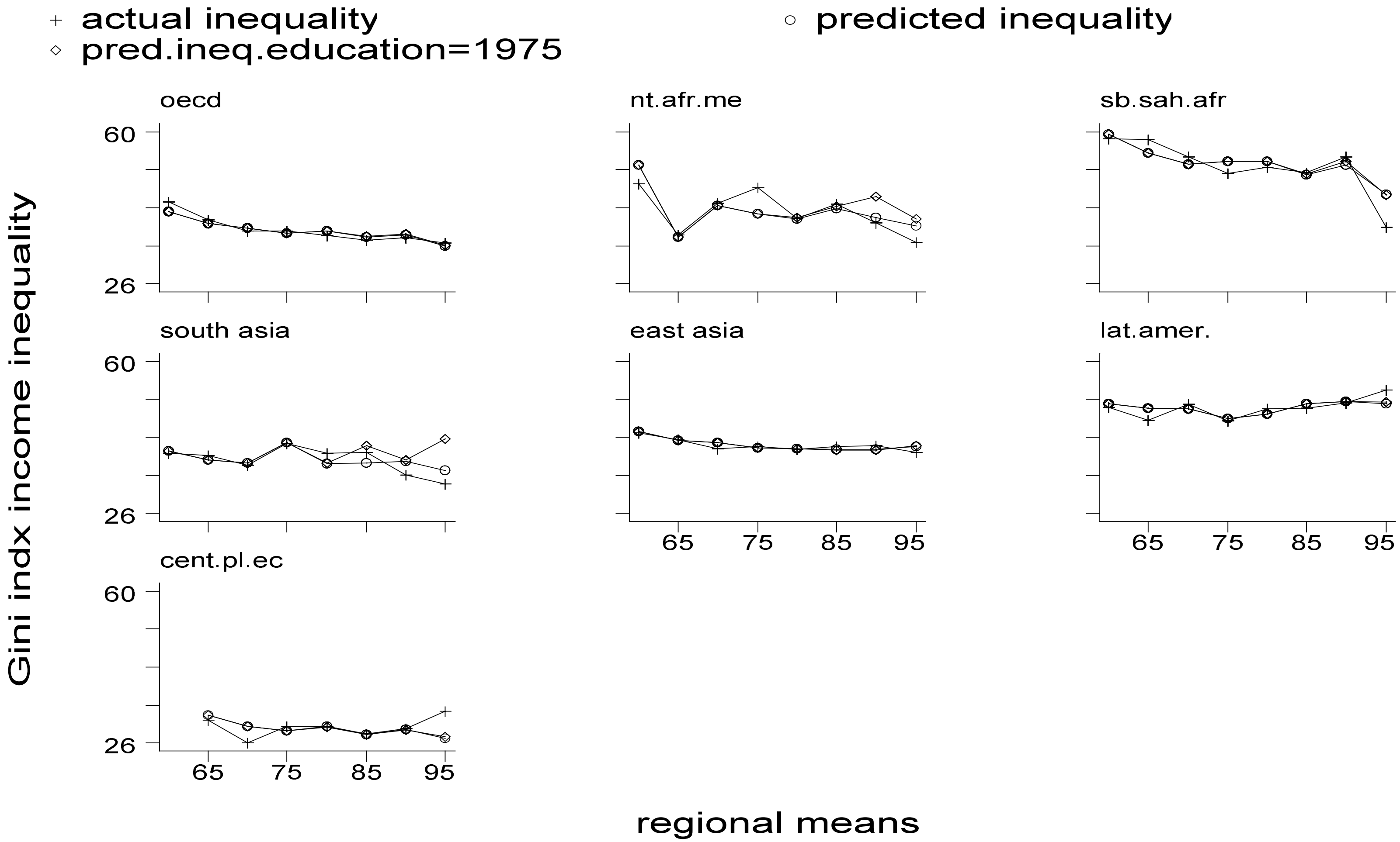
$$(13) \quad Gini_{\text{income}} = 37.72 - 0.004 \cdot gdp - 1.18 \cdot \overline{HC} + 0.091 \cdot \overline{HC^{2}}$$

Equation (13) tells us that, for a given level of per capita income, income inequality has a U-shaped relationship with the average years of education in the population, with a turning point around 6.48 years. For all countries below this threshold, the two variables are negatively correlated, while the two become positively correlated above this threshold. Using the regional averages reported in Table 3, we can say that additional education promotes inequality in the OECD countries (and very recently also in the formerly planned economies), whereas it is beneficial with respect to inequality in the other regions of the world.

We now examine whether these results help us account more accurately for the temporal evolution of income inequality. In Figure 5 we make use of equation (11) to predict the potential evolution that we would have observed if the educational achievement (in terms of both average years and distribution) would have remained at the 1975 levels. We notice that income inequality would have been higher in only two regions, North Africa and South Asia, thus suggesting that the increase in educational achievement and the reduction in educational inequality have effectively helped to reduce income inequality in

FIGURE 5

INCOME INEQUALITY DUE TO EDUCATION



Source: computations based on data presented in Appendix 1.

these two regions. For all the other regions we do not record significant differences between a prediction based on observed educational values and a prediction based on 1975 values for the same variables.

The other measure we can provide for the contribution of educational variables in explaining income inequality is obtained by calculating the increase in the explained variance. In Table 6 we show the variation in the (multiple) correlation coefficient R^2 that we obtain when we insert the educational variables. Thus, the table compares the models reported in the second and fifth columns of Table 4 at regional and yearly levels. At the world level, the table suggests that the contribution of educational achievement in the explanation of the total variance in income inequality ranges between 3 per cent and 16 per cent (the last year looking rather exceptional). Keeping in mind the picture obtained in Figure 4, it seems that the contribution of education is higher during years when income inequality is either declining (1970-5), or increasing (1985-95, especially in the case of the OECD countries). Regional variations have to be viewed with caution because of the limited degrees of freedom; nevertheless, we notice a rising trend in the relative contribution of education to growing income inequality.

TABLE 6
ADDITIONAL VARIANCE EXPLAINED BY EDUCATIONAL VARIABLES: RANDOM EFFECT ESTIMATES

	1960	1965	1970	1975	1980	1985	1990	1995
% of sample	4.2	4.4	16.3	11.0	7.0	3.4	6.3	31.2
Observations	40	47	60	53	55	57	65	24
OECD, %	12.2	12.4	33.4	5.8	24.7	29.3	34.6	45.4
Observations	13	16	19	21	21	18	18	7
Sub-Saharan Africa, %			15.4			79.1	28.2	
Observations			9			7	10	
East Asia, %		56.6	8.0	2.5	15.1	15.0	20.3	
Observations		8	8	8	7	8	8	
Latin America, %	23.6	62.0	35.5	54.1	25.2	33.7	18.8	51.1
Observations	13	12	17	12	13	15	19	9

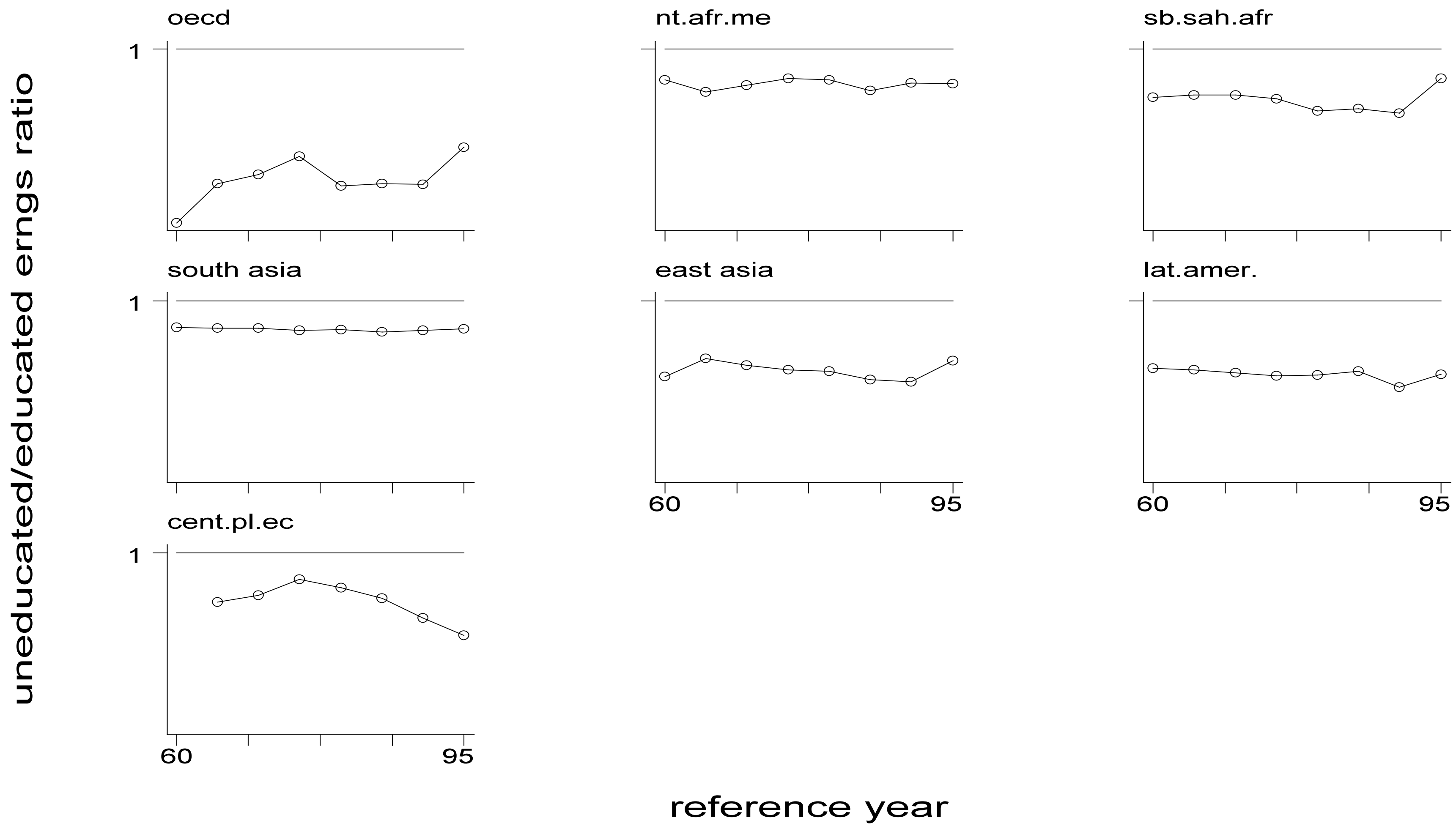
Note: The figures are calculated as $[R^2_{\text{including educational variables}} - R^2_{\text{excluding educational variables}}]$.

Source: regressions based on data presented in Appendix 1.

A final perspective on the relevance of educational achievement in predicting income inequality can be obtained by manipulating equation (10), which can be rearranged as:

$$(14) \quad \frac{\alpha}{\alpha + \beta \overline{\overline{HC}}} = 1 - \frac{G_{\text{log-income}}}{G_{ed}}$$

FIGURE 6
REGIONAL/YEARLY AVERAGES (WEIGHTS = POPULATION)



Source: computations based on data presented in Appendix 1.

Equation (14) tells us that 1 minus the ratio between the inequality in (log)incomes and the inequality in education can provide a rough estimate of the ratio between the income of an uneducated person and the income of a person with average education. The problem is that we do not have information on individual earnings (or incomes), and we therefore cannot compute the Gini index of logarithms of these variables, as required in equation (10). However, using simulations based on the observed distribution of educational achievement in the sample, we have computed the Gini index on both incomes and log-incomes. The two measures are proportionally related, with the goodness of the fit declining with the rate of return, β, assumed in the simulation.[42] Using this result, we have computed an (estimated) Gini index of log-income that allows us to obtain the measure proposed in equation (14). This is depicted in Figure 6. From the dynamics of this indicator at regional level, we notice that the educational premium is higher in the OECD countries (mainly because they have a higher average educational achievement), followed by Asia and Latin America. In all cases but one, this premium has been declining in recent years. In contrast, the return to education seems to be rising in the formerly planned economies.

IV CONCLUSIONS

Our plan in this paper has been to measure the inequality in educational achievement by constructing a Gini index of educational attainment. We have then used the proposed measure to analyse the relationship between inequality in incomes and inequality in educational achievement (in terms of both the average attainments and the concentration of educational achievement). Though theoretical considerations based on the theory of human capital investment suggest that we should expect a non-linear relationship between these two measures of inequality, we have seen that the actual data indicate that average years of education have a stronger negative impact on measured

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[42] For example, the estimated equation, assuming $\alpha = 100$ and $\beta = 0.1$, is:

$$Gini_{\text{log-income}} = -\underset{(2.96)}{0.005} + \underset{(123.8)}{0.009} \cdot Gini_{\text{income}}, \quad R^2(within) = 0.95, \quad obs = 848$$

Based on an average among several simulations obtained by varying α, or β, or both, we have computed a measure of the Gini index of log(income). However, since the right-hand variable includes total incomes (and not merely earnings, as the pure theory of human capital would require), the estimated measure of log-incomes is only an approximation of what we would have liked to measure to evaluate the ratio uneducated/educated.

income inequality. Multivariate regressions also demonstrate that, if we take into account the negative correlation between average educational achievement and the dispersion of educational achievement, the relationship between income inequality and average years of schooling is U-shaped, with a lower turning point at 6.5 years. Obviously, income inequality is also negatively related to per capita income; other things being constant, countries characterized by higher accumulation or greater government expenditure on education experience higher income inequality. In relative terms, we find that education contributes a portion of the variance enclosed between 3 per cent and 16 per cent in explaining income inequality, though the fraction is higher and shows a rising trend in developed countries.

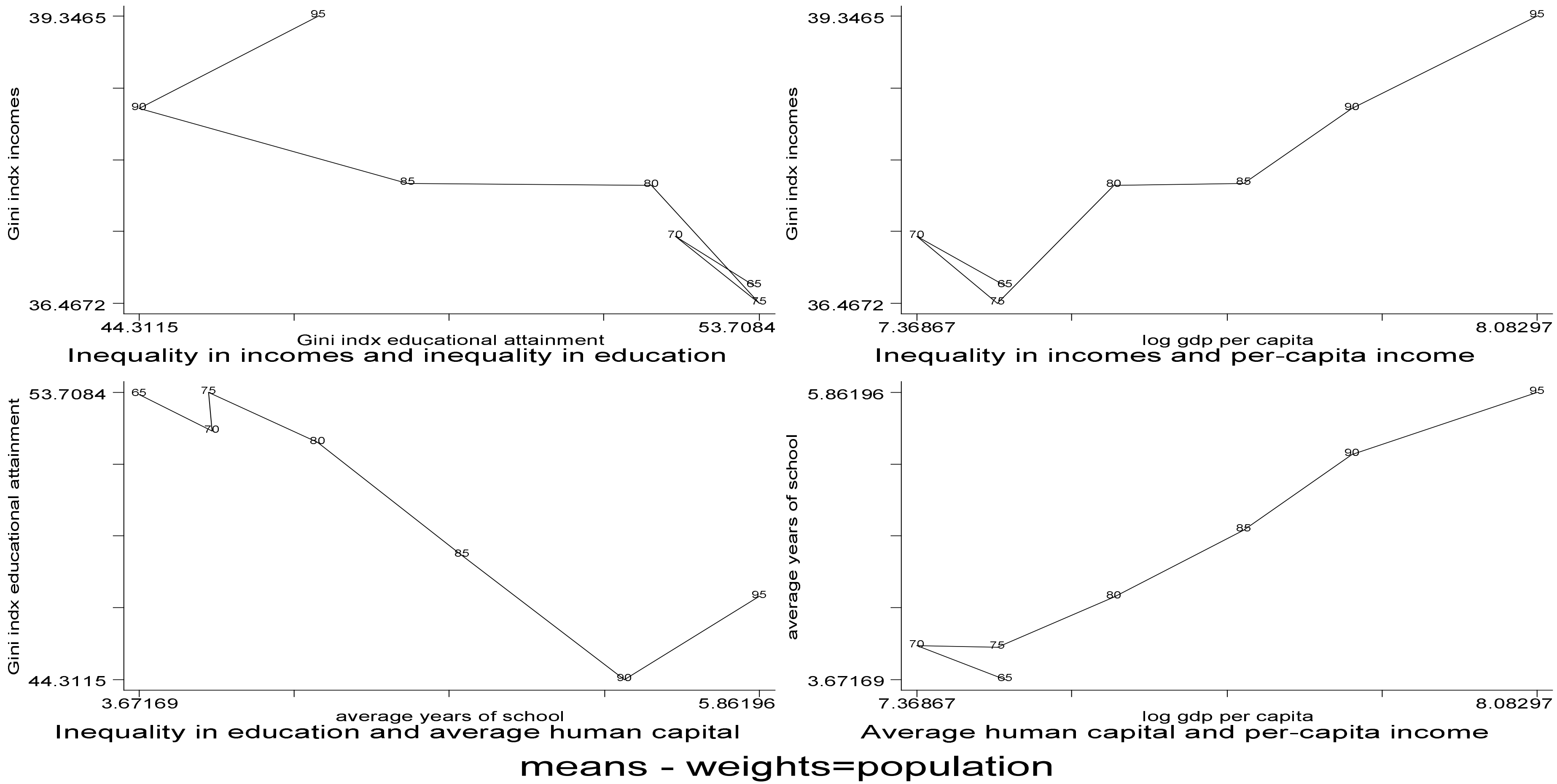
Figure 7 replicates Figure 3 with the addition of the weighted mean values for each time-unit of observation.[43] Looking at the lower left panel, we see that the world has experienced what can called an 'educational cycle' during the post-war period. By investing public resources in education and lowering access barriers to education, various governments were able to increase the average schooling by 2.2 years and to reduce the Gini index of educational inequality by about 9 percentage points (mainly during 1965-90). This effort was eased by a (median) growth in gross domestic product per capita of 60.9 per cent over this period (lower right panel).

Despite these changes, mean income inequality has risen rather steadily at world level, showing an increase of 2.7 points in the Gini index of income inequality (upper right panel). However, while income inequality and educational inequality seem to have been loosely related during the initial subperiod (indicatively until 1980), in more recent years further expansion in schooling among the world population has been accompanied by a widening in the dispersion in income distribution. The observations referring to 1995 reflect a possible further change in the process: while average educational achievement continues to rise (with an additional jump of a half year), inequality in educational achievement, instead of declining, rises by almost 3 points. Both variations are accompanied by a further increase in income inequality of 1 point. The causes of this change are not immediately clear, but we can get an intuition by going to regional level, as in Figure 8, which reports the relationship between income inequality and educational inequality.

[43] Notice that we have suppressed the initial observation (1960) to facilitate the reading of the graph. (The values are, however, reported in Table 2.)

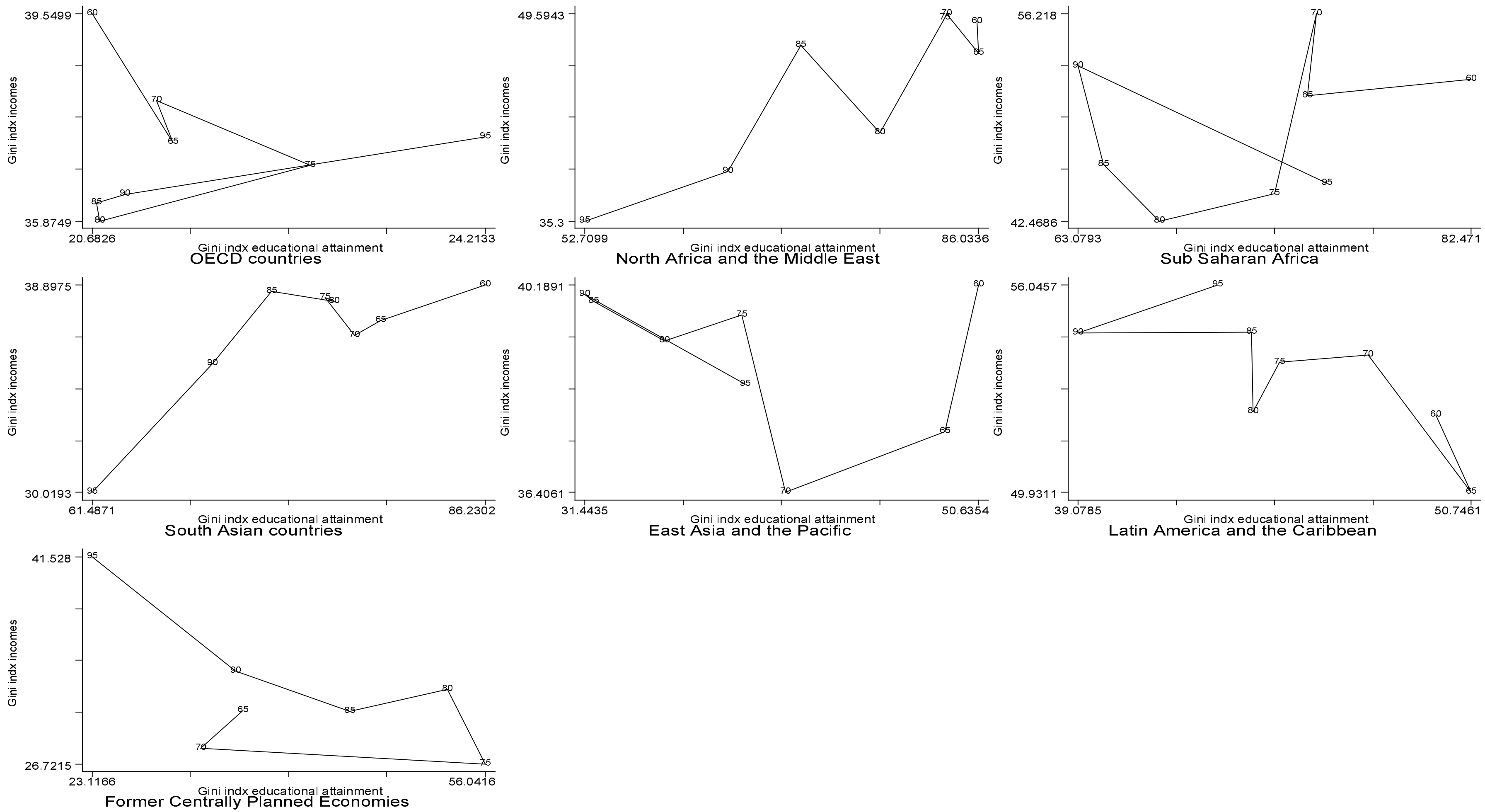
FIGURE 7

WORLD INEQUALITY IN INCOMES AND EDUCATION



Source: computations based on data presented in Appendix 1.

FIGURE 8
THE DYNAMICS OF INEQUALITY IN INCOMES AND EDUCATION



means - weights=population

Source: computations based on data presented in Appendix 1.

In this case we notice that at least three separate patterns can be identified in the 'educational cycle' at world level. North Africa and South Asia exhibit the first pattern. Most of the countries in these regions started from a quite low initial base of educational attainment (around one year of average schooling in North Africa and South Asia in the 1960s), but were quite effective in improving the situation, more than quadrupling this average. These are not the only regions in which we find that education has the effect of reducing inequality (see Figure 5).

A second pattern is represented by East Asia and sub-Saharan Africa, which initially followed the first pattern, though at a slower speed (the average years of schooling increased from 3.7 to 6.4 and from 1.0 to 2.7, respectively, during 1960-95). The 'leap forward' in educational attainment in these countries seems to have been insufficient to modify basic social structures (in contrast to the successful countries in the first group). Inequality in education initially declined, but after the 1970s there was a trend reversal, and this was accompanied by an increase in income inequality.

Finally, the third group is formed by the Latin American countries and the (formerly or currently) centrally planned economies. Both sets of countries were characterized by high initial levels of education (3.1 and 3.9 years on average, respectively, in 1960); nonetheless, they were able to raise the average significantly (to 6.2 and 8.2 years, respectively, by 1995). Educational inequality declined, but income inequality rose substantially, as indicated by the Gini index: 6 additional points in Latin America and more than 10 points in the planned economies.

The OECD countries represent a story on their own. The only group with average educational attainments above the threshold of 6.5 years, these countries experienced a widening in educational differentials during the entire sample period that was accompanied, after 1975, by rising income inequality.

A general lesson emerges from this evidence: increased access to education reduces income inequality only if two conditions are met. First, the initial level of educational attainment must be sufficiently low; second, the average educational attainment must be raised sufficiently rapidly. A potential explanation of these results is offered by the interaction between the supply and the demand of human capital, that is, the educational choices of the population and job creation by firms.[44] When the average educational level in

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[44] On the relationship between the availability of skills and job creation, see Agemoglu (1995, 1996).

the population is low, there are very few highly educated people who are likely to obtain high salaries. At the same time, there are no incentives for the creation of new jobs for skilled workers since firms are constrained by factor demand. However, when more and more educated people begin entering the labour market, the speed of technological innovation increases, followed by the creation of more skilled jobs. More people earn higher wages, and as a consequence income inequality starts declining. When the bulk of the labour force has at least a primary level of education, leaps in technology (such as in information technology and telecommunications) are possible because the more sophisticated tasks can now be accomplished by skilled workers. The rise in the productivity of these workers is reflected in their remuneration, thus inducing a trend reversal in income inequality.[45] In this way, we replicate the non-linear relationship between average educational attainment and income inequality, which is also conditioned by the level of technical development.

45 One may object that causality can work in the opposite direction: lower income inequality facilitates access to education and therefore contributes to a reduction in the inequality in education. However, this may be true only in the steady state. Thus, Checchi (1999) has shown that income inequality reduces enrolment rates, mainly at the secondary level. But enrolment rates reflect the rate of change of the existing human capital stock and therefore affect the *rate of change* in educational inequality. Yet, enrolment rates cannot affect the rate of change and the level of the same variable at the same time. In our framework, current income inequality affects *future* educational inequality, which, according to human capital theory, will shape *future* income inequality. Therefore, reverse causation may apply only along the intertemporal dimension.

APPENDIX 1
DATA SOURCES

We have taken seriously the recommendation of Atkinson and Brandolini (1999). Data on income inequality are from Deininger and Squire (1996)[46] and the WIID (World Income Inequality Dataset), downloadable at <*http://www.wider.unu.edu/wiid/wiid.htm*>.[47] Overall, we have 546 observations on 113 countries (with an average of 4.8 observations per country).[48] While there are no significant differences in Gini indexes when the recipient unit is the (equivalized) household or the individual, we find an average difference of 6.47 percentage points when the same measure is based on gross incomes instead of net incomes.[49] We could have introduced a dummy variable controlling for the income definition (as in Deininger and Squire, 1998), but in this case we would have dispensed with all observations in which this information was absent. For this reason, we have preferred to augment the measures based on the net incomes by the average difference.[50]

Data on physical capital stocks are from Nehru and Dhareshwar (1993). Data on per capita income and educational achievements are from Barro and Lee

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46 Downloaded on 22 October 1998. Among these, 349 observations are labelled 'high quality' (average = 38.79), and 153 observations are labelled 'low quality' (average = 45.87).

47 In addition, 12 observations (average = 35.05) on OECD countries are from Brandolini (1998), and 25 (average = 43.54) are from World Bank (1998). Finally, 7 observations (average = 37.65) are from Honkkila (1998).

48 The number of observations is reduced to 471 (corresponding to 97 countries, with an average of 4.9 observations per country) if we restrict the cases to those with non-missing data on educational variables.

49 By regressing the Gini index of income distribution on a dummy variable INCOME (which is equal to 1 when the recipient unit is the equivalized household and 0 when it is the individual), we get:

$$Gini = \underset{(58.9)}{41.78} - \underset{(1.03)}{1.01} \cdot INCOME, \qquad R^2 = 0.00, \qquad n = 471$$

In contrast, by creating a dummy variable TYPE (equal to 1 when the inequality measure is based on gross incomes and 0 when it is based on net incomes), we get:

$$Gini = \underset{(35.9)}{35.94} + \underset{(6.46)}{6.46} \cdot TYPE, \qquad R^2 = 0.10, \qquad n = 369.$$

50 A similar correction has been applied to Gini measures based on rural samples (5 observations) that were on average higher than the national coverage samples by 8.94 points.

(1993, 1994, 1996, 1997).[51] In particular, the data on the estimated length of schooling, $n_i, i = p, s, h$, have been obtained by dividing the average years of schooling for a given level of education by the population share which has completed this level of education using the definitions of Barro and Lee (1996):[52]

$$n_p = \frac{\text{pyr25}}{\text{pri25} + \text{sec25} + \text{high25}}, \quad n_s = \frac{\text{syr25}}{\text{sec25} + \text{high25}}, \quad n_h = \frac{\text{hyr25}}{\text{high25}}$$

Where possible, the series have been updated to 1995 using World Bank (1998) and UNESCO (1998). Data on average years of schooling for 1995 have been estimated based on the corresponding enrolment rates for the previous three decades.

The list of 97 countries for which we have non-missing observations on inequality in incomes and inequality in educational achievements is as follows (the number of available observations is given in brackets):

Sub-Saharan Africa
Botswana (3), Cameroon (1), Central African Republic (1), Gambia (1), Ghana (3), Guinea-Bissau (1), Kenya (7), Lesotho (1), Liberia (1), Malawi (4), Mauritius (3), Niger (1), Rwanda (1), Senegal (3), Sierra Leone (3), South Africa (6), Sudan (2), Tanzania (6), Uganda (3), Zambia (4), Zimbabwe (2).
North Africa and Middle East
Algeria (2), Egypt (3), Tunisia (7), Iran (3), Israel (5), Jordan (3), North Yemen (1), Cyprus (1).
East Asia and the Pacific
Hong Kong (7), Indonesia (7), Japan (7), Korea (7), Malaysia (7), Philippines (7), Singapore (6), Taiwan (7), Thailand (7), Fiji (3).
South Asia
Bangladesh (7), India (7), Nepal (3), Pakistan (7), Sri Lanka (7).

[51] Barro and Lee (1994) is in turn based on Summers and Heston (1991).

[52] This procedure yields unreasonable values for n_p for a few observations. In these cases, these values have been replaced with the corresponding values computed based on either the population over 15 years of age, or the legal duration of primary education (as measured in 1965: variable *durp* in the original Barro-Lee dataset).

Latin America and the Caribbean Barbados (4), Reunion (1), Costa Rica (8), Dominica (4), El Salvador (6), Guatemala (4), Honduras (4), Jamaica (7), Mexico (8), Nicaragua (1), Panama (6), Trinidad and Tobago (5), Argentina (6), Bolivia (3), Brazil (7), Chile (7), Colombia (8), Ecuador (4), Guyana (2), Paraguay (3), Peru (6), Uruguay (7), Venezuela (7).
OECD Australia (8), Austria (4), Belgium (6), Canada (8), Denmark (6), Finland (8), France (8), (West) Germany (8), Greece (6), Ireland (5), Italy (6), Netherlands (7), New Zealand (7), Norway (7), Portugal (3), Spain (6), Sweden (7), Switzerland (2), Turkey (6), United Kingdom (8), United States (8).
(Formerly) Centrally Planned Economies China (4), Cuba (3), Czechoslovakia (7), Hungary (7), Yugoslavia (6), Bulgaria (7), Romania (1), (former) Soviet Union (5).

APPENDIX 2
ADDITIONAL TABLES

TABLE A1
ESTIMATES OF INCOME INEQUALITY: RANDOM EFFECTS, 94 COUNTRIES, 1960-95 (T-STATISTICS IN PARENTHESES)

Countries	94	94	94	94	94	94
Observations	454	454	454	454	454	454
Dependent variable	Gini	Gini	Gini	Gini	Gini	Gini
Intercepts	46.389	45.999	38.889	53.066	53.149	43.112
	(18.96)	(21.75)	(18.11)	(12.16)	(12.21)	(15.83)
GDP	-0.001	-0.001			0.000	-0.001
	(-1.84)	(-3.65)			(-2.13)	(-3.57)
GDP^2	0.000					
	(0.43)					
1/GDP		-425.957				
		(-0.30)				
Ginied			0.102	-0.108	-0.096	0.135
			(1.07)	(-0.99)	(-0.88)	(1.35)
$Ginied^2$			-0.001	0.000	0.001	-0.001
			(-0.56)	(0.46)	(0.57)	(-1.39)
h_c				-1.557	-1.136	
				(-3.71)	(-2.46)	
$1/h_c$						2.464
						(3.19)
North Africa	-2.161	-1.850	0.160	-1.118	-3.162	-2.840
Middle East	(-0.73)	(-0.64)	(0.05)	(-0.38)	(-1.03)	(-0.92)
Sub-Saharan Africa	7.381	8.222	11.021	7.864	5.541	6.154
Africa	(2.69)	(2.94)	(4.53)	(3.08)	(1.99)	(2.23)
South Asia	-5.373	-4.606	-1.991	-4.236	-6.749	-7.090
	(-1.52)	(-1.32)	(-0.60)	(-1.28)	(-1.91)	(-2.01)
East Asia	-0.588	-0.287	1.953	1.130	-0.580	-1.298
Pacific	(-0.23)	(-0.11)	(0.83)	(0.48)	(-0.23)	(-0.52)
Latin America	7.135	7.411	10.291	8.069	6.338	6.340
	(3.19)	(3.41)	(5.26)	(3.98)	(2.89)	(2.91)
Centrally planned economies	-13.562	-13.367	-9.255	-9.537	-12.206	-13.339
	(-4.52)	(-4.50)	(-3.46)	(-3.61)	(-4.16)	(-4.62)
Years	Yes	Yes	Yes	Yes	Yes	Yes
R^2(overall)	0.52	0.52	0.50	0.52	0.53	0.54

Note: excluded case: OECD, 1960.

Source: regressions based on data presented in Appendix 1.

TABLE A2
ESTIMATES OF INCOME INEQUALITY: FIXED EFFECTS USING K/Y, 1960-95
(T-STATISTICS IN PARENTHESES)

Countries	76	76	76	76	76	76
Observations	401	401	401	401	401	401
Dependent variable	Gini	Gini	Gini	Gini	Gini	Gini
Intercepts	47.109	48.409	51.909	67.357	65.054	54.084
	(22.21)	(23.21)	(13.75)	(12.76)	(12.20)	(13.25)
k/y	0.860	0.931	0.317	0.714	0.791	0.546
	(1.18)	(1.30)	(0.44)	(1.00)	(1.12)	(0.76)
GDP	-0.001	-0.001			-0.001	-0.001
	(-1.56)	(-2.93)			(-2.36)	(-3.11)
GDP^2	0.000					
	(0.46)					
1/GDP		-3515.234				
		(-1.82)				
Ginied			-0.332	-0.556	-0.515	-0.404
			(-2.39)	(-3.81)	(-3.53)	(-2.62)
$Ginied^2$			0.003	0.004	0.005	0.005
			(2.37)	(3.29)	(3.44)	(2.84)
h_c				-2.470	-2.059	
				(-4.09)	(-3.29)	
$1/h_c$						-3.641
						(-1.07)
Years	Yes	Yes	Yes	Yes	Yes	Yes
R^2(within)	0.089	0.098	0.079	0.125	0.141	0.114

Source: regressions based on data presented in Appendix 1.

TABLE A3

ESTIMATES OF INCOME INEQUALITY: FIXED EFFECTS USING EDUCATIONAL EXPENDITURE, 1960-95 (T-STATISTICS IN PARENTHESES)

Countries	94	76	76	69	69	75
Observations	454	401	401	241	241	256
Dependent variable	Gini	Gini	Gini	Gini	Gini	Gini
Intercepts	57.491	66.599	65.054	65.538	66.066	68.070
	(11.67)	(12.93)	(12.20)	(6.69)	(6.82)	(7.20)
GDP	0.000	-0.001	-0.001	-0.001	-0.001	-0.001
	(-1.86)	(-2.31)	(-2.36)	(-3.25)	(-3.47)	(-2.95)
Ginied	-0.279	-0.529	-0.515	-0.614	-0.718	-0.648
	(-2.08)	(-3.64)	(-3.53)	(-3.07)	(-3.53)	(-3.10)
Ginied^2	0.002	0.005	0.005	0.008	0.009	0.007
	(2.03)	(3.59)	(3.44)	(4.21)	(4.67)	(3.95)
h_c	-1.134	-1.977	-2.059	-1.419	-1.523	-1.921
	(-1.94)	(-3.18)	(-3.29)	(-1.70)	(-1.85)	(-2.43)
k/y			0.791	0.570	0.030	
			(1.12)	(0.60)	(0.03)	
Edgvsh					0.979	0.902
					(2.22)	(2.04)
Years	Yes	Yes	Yes	Yes	Yes	Yes
R^2(within)	0.084	0.137	0.141	0.194	0.218	0.169

Source: regressions based on data presented in Appendix 1.

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