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DOES EDUCATIONAL ACHIEVEMENT HELP TO EXPLAIN INCOME INEQUALITY ?

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Abstract

In this paper we propose to measure 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 its concentration). Even if theoretical considerations suggest a non-linear relationship between these two measures of inequality, actual data indicate that average years of education have a stronger negative impact on measured income inequality. Multivariate regressions also prove that, once we take into account the negative correlation between average educational achievement and its dispersion, the relationship between income inequality and average years of schooling is 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 capital/output ratio and government expenditure in education. Looking at relative contribution of education to income inequality, we find that it contributes to explain a portion of variance enclosed between 3% and 16%, but this fraction is higher in developed countries and shows a rising trend.

Contents:

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1. 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 percent points. However consensus lacks about the underlying causal mechanism. On one side, a political economy mechanism calls for the role of redistributive policies: greater income inequality brings in increased social pressure and/or social instability, and this creates an adverse environment for investment in physical capital. On the other side, greater income inequality and higher poverty prevent access to schooling and investment in human capital, thus reducing the potential for growth. Both explanations are at odds with 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 really prevented by lack of financial resources, which is hardly the case in countries where public education is almost free at the compulsory level.[3]

On the whole, this literature seems unable to provide conclusive results for the very same reasons why Kuznets (1955) contribution has never achieved the status of a stylised fact in economics: it is impossible to identify a common pattern of development across world countries, 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 generalising single country experiences. On this respect, the causal relationships governing aggregate educational choices have still 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 ensuing earning distribution replicates educational choices. This allows the definition of an intergenerational equilibrium in income and education distributions. Since the two variables are perfectly correlated, the distribution of incomes and the distribution of human capital are shaped by the same factors. In many models the same barrier (absence of financial markets for education financing, cultural poverty of the environment, inefficiency of the public administration in tax levying) prevent the investment in human capital for a fraction of the population, that later on earns less income.[5] Whenever there is some intergenerational persistence (via monetary inheritance and/or the effects of family cultural background), the very same portion of the population remains trapped at low levels of education and income for more than one generation. Thus in the logic of formal models, illiterates and poor are synonymous. But in reality things are far more complicated. Educational choices are also correlated to the public provision of schools, to the prohibition of children labour, and to the general opportunities available in the labour market.[6] Analogously, income

[1] Good surveys of this literature can be found in Benabou 1996b, Bourguignon 1996, Aghion and oths. 1998 and Barro 1999.

[2] See Perotti 1996.

[3] Some empirical evidence in support of these propositions is 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 countries subgroups.

[5] For example Galor and Zeira 1993, Banerjee and Newman 1993 and Picketty 1997 consider financial markets imperfection, Benabou 1996 takes into account the role of social capital, 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 children schooling (See the Zambian case described by Skyt Nielsen 1999, the Bangladesh case analysed by Ravallion and Wodon 1999 or the Indian one discussed by Weiner 1991).

distribution can be related to employment composition, labour legislation, trade union coverage and fiscal policies, more than to educational achievements in the population.[7]

However the distribution of incomes and the distribution of educational attainments are obviously correlated. On one side, income inequality may prevent the access to education when education, is costly to the family: the more skewed the income distribution, the higher the population share excluded from schooling, and the higher is inequality in educational achievements. In this perspective we have a self-perpetuating poverty trap, that can only be escaped whenever the access to education is eased.[8] On the other side, improved access to education raises the earning opportunity of the lowest strata, and other things being constant reduces earning inequality. As long as total income is proportional to labour income, we 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, because 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 on the fact that this is one of the potential reasons for the rise of college premium, at least in the United States. With a time lag, this has produced an increase in college enrolments despite of the rise of college tuition. Until the supply of new college graduates will depress such a premium, we will observe rising income inequality and at the same time a reduction in educational achievement inequality.[9]

Therefore we cannot predict a priori the sign of the relationship between educational achievements and income inequality. For this reason, in the present 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 aspect is crucial under two respects: first, from a theoretical point of view, it is important to understand the plausibility of studying intergenerational equilibria with stationary distributions of incomes and human capitals 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 be non influential on the resulting earning distribution.

The paper is organised as follows: the next section reviews existing results in the literature on income inequality determinants. The third section provides the empirical evidence, and a forth one concludes. The Appendix indicates data sources and discuss data reliability.

2. 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 countries, but now is affecting most of industrialised

[7] See Gottschalk and Smeeding 1997 and Bardone and oths. 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] In Checchi 1999 we have proved that income inequality effectively reduces school enrolment, mainly at secondary level. Similar results in Flug and oths. 1998. From a formal point of view, this corresponds to the case where *current* income inequality affects the *rate of change* of educational achievements inequality.

[9] Freeman 1986 has shown the existence of a similar phenomenon during the 60 s for engineers in the US, and has provided a cob-web model for its dynamics. For more recent evidence see Murphy and oths. 1998.

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

nations.[11] Among the potential causes of this phenomenon it is often indicated the reduction of the redistributive role of the state, the decline in union presence in workplaces, the increased competition at international level, the technological progress and all possible combinations of these facts (some of these explanations usually referred as Transatlantic consensus). However the national experiences 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 observed inequality. In particular, little work has been produced so far in order to test alternative explanations of 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.

Existing literature on the effects of educational attainments onto income inequality mainly focuses on two first moments of income distribution, namely the average educational attainment and the schooling dispersion in the population. On the first aspect, in a recent papers, 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 2070 US$ at 1985 prices.[12] He runs conditional convergence regressions introducing income inequality (from Deininger and Squire (1996) data set) measured 5 years earlier, in order to dispense for reverse causation. Then he moves this regressor to the left-hand side and studies the determinants of income inequality. Here 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 1636 US$). He controls for educational achievements by introducing the 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 contribution of average human capital and its distribution across sub-groups of the population).[14]

A similar strategy is also followed by O Neil (1995), who decomposes output growth over the 1967-85 period 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 across countries in the level of educational achievements, 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 income inequality changes.[16] Since land inequality also reduces average years of education in their regressions, they explain this evidence as a result of liquidity constraints in accessing education. As a consequence, income inequality and

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

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

[13] The panel also includes the average years of school attainment for adults aged 15 and over the three 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).

[14] To be more precise: an additional year in primary school or in college should both raise average educational achievement, but the former reduces educational variance in the population, while the latter should raise it.

[15] The result 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, 1295).

[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).

educational attainments are positively correlated for the presence of a third conditioning variable (wealth inequality). However asset (or income) inequality can at best reduce the creation of new human capital (the flow represented by new school leavers), but we do not see good reasons for depreciating existing human capital (the stock represented by average educational attainment in the population).[17] In a related paper, Li, Squire and Zou (1998) interpret the evidence of a significant effect of (initial period) average secondary school years onto income inequality as a proxy of the political system: the larger is the political freedom, the more informed is the society, the more difficult will be for the rich portion of the society to appropriate more resources. Also Gradstein and Milanovic (2000) provides 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 provides support for additional redistributive policies, or whether less unequal societies strengthen democracies.[18] Finally Breen and García-Peñalosa (1999) finds 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 controlling for previous variables.[19]

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

At any rate, the two measures for educational achievements (average educational attainment and some measure of its dispersion) are intertwined. Both Ram (1990) and Londoño (1996) claim the existence of an inverted U-shaped relationship between educational achievement and educational inequality, and

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

[18] Justman and Gradstein 1999 present similar ideas with a formal model predicting the existence of an inverted U-shaped relationship between income inequality and franchise. When the median voter income exceed average income, regressive redistribution policies are adopted, and inequality rises; as long as the median voter income go below the average income, progressive redistributive policies start 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 their implicit insurance rises, and wages are consequently reduced, thus increasing income inequality.

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

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

they locate the turning point at 6.8 average years of education.[22] However they do not provide a sound theoretical argument for this occurrence, nor whether this relationship may hold for alternative measures of dispersion or concentration.

What do we learn from this almost empirical literature ? That income inequality is clearly related to the stage of development, in accordance to some sort of Kuznets relationship; it may also reflect the level of skills in the population, as proxied by average educational attainments. Finally, there is somehow weaker evidence of some role played by the distribution of schooling. But it is still unclear how mean and dispersion jointly contribute to shape income distribution. In addition, in all previous works we do not find any measure related to labour market institution (like presence of unions, unemployment benefits, and minimum wages).[23] In the sequel we will analyse the determinants of income inequality, making use of both average educational achievement and dispersion in the population and conditioning on some measure of the quality/quantity of resources invested in education.

3. Empirical analysis

Starting from the enrolment rates and using appropriate assumptions on mortality rates, Barro and Lee (1996) provides estimates of the human capital stock of a country. Using some mild assumptions on the demographics (similar to the permanent inventory method used to estimate the stock of physical capital), it is possible to obtain the estimates of average years of education in the population, for each level of education, starting from enrolment rates and possessing the distribution of educational achievement at some reference point. Let us illustrate this aspect with an example. Consider a population where each age cohort grows at a constant rate n and where the probability of death is constant across ages and equal to δ. If we define k as the life expectancy,[24] and denote with $Pop_{t,j}$ 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 drop-out rates are zero (such that enrolment rates coincide with graduation rates). Under this assumption, if we indicate with π_t the percentage of population born in *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 previous assumptions the current population share with education is given by

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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: a generalised increase of education in the population produces an increase of average achievement without necessarily raising educational inequality.

[23] Nor we control for inequality in employment/unemployment rates. See Glyn and Salverda 2000 for an analysis of OECD countries in this respect.

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

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

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

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 (i.e. $\pi_i = \pi, \ \forall i$), equation (1) collapses to $HC = \pi$.[25] Repeated application of equation (1) yields

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

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

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

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 a age cohort in the population. Using a continuous time representation yields

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

Should the growth rate of the population and/or the mortality rate not remain constant across year, previous derivations are just approximations of real values. By multiplying HC_p by the number of years required to complete primary education, we obtain the average number of years of primary education in the population. When we possess this piece of information for each level of education, we approximately know the distribution of the human capital stock in a country. The approximation

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[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 with λ_t the age cohort share enrolling a school level lasting n years (say primary school starting at the age of m and lasting n years), with a (constant) dropout rate of γ, 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 in turn is a weighed average of enrolment at first year, taking into account the decline due to dropout.

arises because an attained educational level, say a secondary degree, can be achieved in a longer period (because of repetition) or can never be achieved (due to dropout rates). Even when the information on dropout rates is available, we do not know when people leave a course of study, and therefore we cannot integrate this information in the computation of average human capital stock.[26] Once we have the rough distribution of educational achievement in the population, it is possible to compute several measures of inequality, among which the Gini concentration index for the distribution of attained education is one of the easiest to compute. When only subgroup averages are known, the general definition of the index modifies accordingly

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

where N is the population size, n_i is the number of years of schooling attended by individual i, μ is the population average years of schooling, 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 available information on three educational levels,[27] which allows us to partition the population in 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 ($HC_n = 1 - HC_h - HC_s - HC_p$, with zero education by assumption).[28] By construction, the average population attainment is given by

$$\mu = \overline{HC} = HC_p \cdot n_p + HC_s \cdot n_s + HC_h \cdot n_h \tag{6}$$

and the Gini index on educational attainments is computed as follows

$$\begin{aligned} G_{\text{ed}} &= \frac{HC_h \cdot n_h \cdot \left(HC_s + HC_p + HC_n\right) + HC_s \cdot n_s \cdot \left(- HC_h + HC_p + HC_n\right) + HC_p \cdot n_p \cdot \left(- HC_h - HC_s + HC_n\right)}{\overline{HC}} = \\ &= HC_n + \frac{HC_h HC_s \left(n_h - n_s\right) + HC_h HC_p \left(n_h - n_p\right) + HC_s HC_p \left(n_s - n_p\right)}{\overline{HC}} \end{aligned} \tag{7}$$

Starting from the original Barro and Lee (1996) data set, we have extended the observations up to 1995. Therefore we have information about educational achievements for the period 1960-1995, on a quinquennial base for 149 countries. On the whole, these data cover 3/4 of the 210 countries listed by the World Bank (1998), but account for 86.3% of the world population (as measured in 1990). However, from a potential dimension of 1192 observations, missing values reduces it 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 temporal disaggregation

[26] Dropout rates are effectively available in Barro and Lee data set 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, because we are standardising the educational systems into a tripartite classification, corresponding to UNESCO ISIC standards. However, if a country (like Germany) has a double track secondary education (high school and vocational training), with different duration, it will nevertheless be computed as a unique duration.

[28] Barro and Lee 1996 provide a distinction between attained and completed educational levels. Given the high correlation among the two series, we have preferred to adopt the former variable because it had less missing observations.

and in table 3 with temporal and regional disaggregation; additional information about data sources is in Appendix 1.

In the most recent year of observation (1995) we find that the world population is composed by one third of illiterate, one third of people with primary education and the remaining divided between college and secondary school educated. In the time span considered in the present paper, the average years of education passed from 4.3 to 5.8 at the world level, but this was accompanied by a wider dispersion of the same variable computed at regional level. The share of illiterate and primary educated in the population exhibits a declining trend with some reversal at the end of the period, as witnessed by a similar trend in the index of inequality of educational achievement. But the global picture varies according to world regions: while educational inequality declines in North Africa, South Asia and formerly planned economies, it declines during the first three decades but raises afterwards in the other regions (especially in sub-Saharan Africa). Inequality in years of schooling remained almost constant in OECD countries at low levels, despite the increase of average education. It is therefore difficult to trace out a unique trend at world level, especially because countries seem to differentiate in the rates of changes as well as in the levels of the variables.

Table 1 Descriptive statistics

Variable	*Variable name*	*Mean (weight=pop)*	*Median (weight=pop)*	*Std.Dev. (weight=pop)*	*Obs.*
Population share without education	HC_n	40.4%	43.1%	0.278	883
Population share with primary education	HC_p	33.8%	32.3%	0.172	902
Population share with secondary education	HC_s	19.8%	17.2%	0.143	916
Population share with higher education	HC_h	5.6%	2.5%	0.077	919
Average duration of primary education	n_p	5.35	5.10	1.153	869
Average duration of secondary education	$n_s - n_p$	4.59	4.58	0.824	929
Average duration of 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 index on educational attainment inequality	*Ginied*	49.32	51.74	23.261	848
Gini index on income inequality	*Gini*	38.01	36.85	8.239	546

Table 2 Mean values (weight=population) across years

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

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 index on educational attainment inequality	20.68	21.41	21.26	22.64	20.75	20.72	20.98	24.21
Gini index on 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 index on educational attainment inequality	85.95	86.03	83.38	83.21	77.70	71.00	64.82	52.71
Gini index on 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 index on educational attainment inequality	82.47	74.39	74.83	72.79	67.08	64.33	63.08	75.35
Gini index on 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 index on educational attainment inequality	86.23	79.67	77.99	76.14	76.71	72.78	69.08	61.49
Gini index on 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 index on educational attainment inequality	50.64	49.02	41.24	39.11	35.33	31.86	31.44	39.27
Gini index on 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 index on educational attainment inequality	49.70	50.75	47.68	45.05	44.27	44.23	39.08	43.22
Gini index on 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 index on educational attainment inequality	33.37	35.72	32.20	56.04	52.86	44.69	35.15	23.12
Gini index on income inequality	===	30.52	27.83	26.72	32.06	30.50	33.37	41.53

Since we are interested in the relationship between educational achievement and income distribution, now we add the dynamics of income inequality to the picture. Here we rely on Deininger and Squire (1996) and on the larger data set on income inequality collected by Wider (WIID); both sources collect from secondary sources a large set of information on inequality measures. Among them, the Gini index on income inequality is the most easily available.[29] In the present case we have available information on 546 observations, corresponding to 113 countries (with an average of 4.8 observations per country). By restricting to the subset of cases where information about both income and education inequality are non-missing, we reduce to 477 observations for 97 countries (with an average of 4.9 observations per country the list of countries is reported in Appendix 1). Table 2 reports the population weighed average for this measure computed on all available information in the data set.[30] We notice that despite a declining trend in educational inequality (reversed only during the 90 s), income inequality at world level start rising after 1975. Looking to figure 1 (that graphs the data reported in table 3), this seems mainly attributable to OECD countries, Latin American countries and formerly planned economies.

[29] See the Appendix 1 for a discussion on corrections introduced in the original data set, including updating to 1995 observations.

[30] Given the fact that the Gini index is not decomposable for subgroup of the population, the trend in the population weighed average has to be taken with caution. See Milanovic 1999 for a more correct picture based on population surveys (albeit considering only two years of observation, 1988 and 1993).

[insert figure 1 about here]

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

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

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 and α is the earning of an individual without formal education; ε_i is an error term assumed to be i.i.d. If we assume that the *individual characteristics* are idiosyncratic in the population and orthogonal with acquired education, population subgroups differ only with average educational achievements (namely the variance within group is constant)[31]: therefore we expect some relationship between the distribution of educational achievements and the distribution of actual incomes. However things are not as easy as they may appear. Inserting equation (8) into (7) and ignoring the (average) individual characteristics, we can obtain the Gini index on log-income inequality as

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

or more synthetically

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

Equation (10) suggests that at a given average in educational achievements, the inequality in education and the inequality in (log)earnings be 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] Things are made 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 inequality measures obtained from levels of the variables and

[31] Actually, Mincer 1996 proves that variance between groups has remained almost constant in earnings distribution in US during the period 1970-90, whereas the variance within groups has expanded after the 80 s.

[32] In a previous version of this paper, we made use of simulations (using the observed values for educational achievements) to analyse the relationship between education and income inequality, under the assumption of constant returns to education. We found that the relation is increasing for countries with low-middle inequality in education (lower than 45%), whereas the relationship become negative for very high inequality in education. This is due to the fact that the Gini concentration index is scale invariant (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 generalised rise in educational achievement (at given inequality in educational attainments) induces a change in income inequality.

corresponding measures computed on their logarithms is not easily ascertained.[33] However, it can be formally proved, under mild assumptions on the distribution of education in the population and under the maintained assumption of a constant rate of return to education, that the relationship between Gini index on actual incomes and average years of education is initially rising and then declining.[34] When both assumptions hold, income inequality, education inequality and average educational inequality are strictly related, as it is 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. Starting from the south-east panel, 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 (south-west panel). If the average educational attainment has a non-linear relationship with income inequality, this necessarily implies a non-linear relationship between income inequality and education inequality (north-west panel). By the same token, we also obtain an inverted U-shaped relationship between income inequality and per capita income, in the Kuznets tradition (north-east panel). The story this graph tells us is a story of transition from an uneducated population to actual level of schooling. When only the élite attends the schools, average human capital in the population is low, whereas inequality in educational achievements and inequality in incomes are high. Lowering access barriers to education leads to an initial increase and to a subsequent decline in both inequality measures, accompanied by a rise in average educational attainments.

[insert figure 2 about here]

A first inspection of our data-set indicates that this story may have some plausibility. Figure 3 gathers all available observations referred to country/year. Income inequality is measured by regression residuals on regional dummies and year dummies, in order to dispense for trends in the variable and/or regional disparities. In addition to a mildly non-linear relationship between inequality in actual incomes and inequality in education (reported in the north-west panel), a similar relationship emerges between the former variable and the (log of) gross domestic product per capita, in the line of Kuznets tradition (north-east panel). Without concern about the direction of causal relationship, we also find evidence of a strict positive correlation between output per capita and educational achievement (south-east panel). Finally, almost by construction, we find an inversely proportional relationship between inequality in education and average educational achievement (south-west panel).[35] However the dispersion of single observations suggests that many other forces be at work. We should not forget

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[33] If we impose more structure to the problem by assuming a specific functional form for the frequency distribution, in some case we are able to determine the relationship among the two. For example, if incomes y s are distributed according to a Pareto distribution $y \sim P(\alpha, \theta),\ \theta > 1$, where α represents the minimum income observed in the distribution, its density function is given by $f(y) = \theta \alpha^{\theta} y^{-(\theta+1)}$ and the associate Gini index is given by the following expression (see Zenga 1984): $Gini_y = \frac{1}{2\theta - 1}$. When we consider a logarithmic transformation $x = \log(y)$, the frequency distribution associated to the logarithmic transformation is given by $f(x) = \theta \alpha^{\theta} e^{-\theta x}$. It can be shown that the associate 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. I am indebted with Fulvia Mecatti for deriving this result.

[34] See Checchi 2000.

[35] It is however crucial how we measure educational inequality. Had we chosen the standard deviation of educational achievements (as done by Ram 1990, Londoño 1996 and Inter-American Development Bank. 1998), the relationship between average educational attainment and educational inequality would have been non-linear:

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

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

that the validity of previous story is conditional on individual incomes being determined according to Becker s theory of human capital investment, under constant (and identical within the population) return to education. In reality, we know that earnings distribution is shaper by many other factors, like technology, union presence, unemployment rates, minimum wages, age composition and so on.[36] Were these factors remaining constant in the sample period, we could consider them as country-specific fixed effect. The problem is that there is no guarantee that these factors remain constant, especially when we take into account the reversal in public policies induced by the transatlantic consensus (Atkinson 2000).

[insert figure 3 about here]

As a consequence, instead of pretending to predict the shape and the evolution of income distribution world-wide, in the sequel we follow the less ambitious aim of showing whether the average educational achievement and its distribution has played any role in determining income inequality. We have already mentioned the fact that other authors (Londoño 1996, Deininger and Squire 1998 and Barro 1999) have proved that the average educational achievement is one of the determinants of actual income inequality. To this result, we add 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 data set as an unbalanced panel with a potential dimension of 752 observations (94 countries time 8 observations per country), which reduces to 454 because of missing data on some variable. Table 4 estimates actual income inequality using fixed effects, whereas Table A1 in Appendix 2 does it using 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 measure are negatively correlated, with a rather low elasticity (−0.049 at sample means): it implies that, in order to reduce the Gini index on income inequality of 1 percent, income per capita has to raise by 2311 US dollars (at 1985 international price). If we replace per capita income with educational variables (third and fourth columns), we notice an increase in explanatory power only if we consider average educational achievement, which that is not surprising given the high correlation with per capita income. Both average educational achievement and educational inequality are significant, but the relationship between the two measures of inequality is opposite to theoretical expectation (being U-shaped and not inverted U-shaped). Finally we jointly consider gdp per capita and educational variables in fifth column. Here we find that output per capita retains a low negative impact, as it does the average human capital with a higher effect: an increase of one average year of education in the population lowers Gini index of income inequality of more than one 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 Gini index on educational inequality, the variable $(1/h_o)$ seems able to capture all the explanatory power contained in the educational distribution variable.[37]

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[36] See Neal and Rosen 1998 for a general presentation of earnings distribution determinants. Higgins and Williamson 1999 find evidence 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 and oths. 1998 show that labour market institutions have changed during the sample period: trade union density and coverage have declined (especially within the Anglo-Saxon world), minimum wages have also declined almost everywhere, and cuts to welfare assistance may have induced lower reservation wages.

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

However the explanatory contribution of the distribution of educational achievements is rather unstable. If we move to repeated cross-section estimation (as it is done in table 5), we find that average educational achievement and the Gini index on educational inequality (in level and squared level) are statistically significant in 5 cases out of 8, but now the non-linear relationship is of inverted U-shaped type (as theoretically expected from human capital investment theory). One potential reason for this instability is due to the different contribution played by possible omitted variables in reverting the trend of income inequality. If we look at 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 (normalised by the coefficient of the initial year) measure a shift in the intercept of the regressions, thus capturing part of the variance left unexplained by the estimated model and that is year specific. In the first half of the sample (until 1975) we witness an increased pressure to compress income distribution (in the order of one point in the Gini index every five year), whereas the same effect disappears during the 80 s. In the 90 s this effect works in the opposite direction, working for a widening of income disparities.

[insert figure 4 about here]

Regional dummies (used in random effect estimation reported in table A1) indicate that the highest inequality is registered in the Latin American and in the Sub-Saharan regions, yielding inequality indexes 6 percent points higher than OECD countries (the reference case see fifth column).[38] Conversely, more egalitarian situations are registered in currently (or previously) centrally planned economies (the Gini index is 12 percent points lower than the OECD area), in South Asia, in North Africa and in Middle East.

Since by definition year/region dummies capture unexplained components, we do not have reliable explanations for these effects that are independent from per capita income and educational achievements. Nevertheless, we have experimented with two additional variables that could capture some differences among countries and/or year. 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 *c teris paribus* we obtain higher return to education wherever physical capital accumulation is more intensive. Thus we expect a higher income inequality whenever and wherever there is intensive investment in physical capital.[39] This variable is introduced in table A2 in Appendix 2 (that reproduces table 4 but loses observations because of missing information) and also in table 5. This variable is hardly significant in fixed effect estimation, but holds a positive and significant sign in repeated cross section estimation (up to 1985). Other things being constant, countries characterised by higher accumulation in physical capital have also higher income inequality: passing from an average k/y ratio of 2 in South Asia to a value of 3 in OECD countries raised Gini index of income inequality of 2.3 (up to 5) percent points, becoming insignificant afterwards.

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 expect a higher human capital per unit of time spent in school wherever educational expenditure is higher. The resources invested in education should account for both public and private expenditure in running educational institutions. In the absence of reliable information about private expenditure, we can utilise the

[38] When comparing to the theoretical achievement in education associated to the stage of development (as measured by the level of GDP per capita) Londoño 1996 estimates that Latin American countries lack about two years of education in the whole population. Mexico and Brazil are the main responsible of this lack of educational achievement. Similar conclusions have been pointed out by Inter-American Development Bank 1998.

[39] This claim is objectionable when we think of ICT (information telecommunication technology), where the capital/output ratio is actually lower than in manufacturing, and notwithstanding earnings differentials are higher.

governmental expenditure in education as a fraction of gross domestic product. An undesirable feature of introducing new controls is the increase in missing observations. Looking at table A3 in Appendix 2, we have reproduced in the first column the fifth column of table 4 for comparability reasons. Using the same specification, we restrict the number of cases to non-missing 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 increases income inequality (even though with a quite low elasticity); all the other variables preserve signs and significance. We now proceed to consider the ratio of (current+capital) governmental expenditure on education to gross domestic product (variable *edgvsh*).[40] The fourth column reduces the sample to country/year observations with non missing values for the *edgvsh* variable, whereas the fifth column introduces it; eventually, the sixth column drop the k/y variable and makes full use of available sample. Even in this case, we observe that countries characterised by higher public expenditure in 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_o) and its distribution (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]

[40] This variable is taken from Unesco 1998. It is missing for the years 1960 and 1965, and a sample mean of 4.25% (std.dev.1.86).

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

Table 4 Estimates of income inequality 1960-1995 94 countries fixed effects
(t-statistics in parentheses)

# countries:	94	94	94	94	94	94
# obs :	454	454	454	454	454	454
Depvar:	gini	gini	gini	gini	gini	gini
intcpt	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)*
gdp²	-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)*
ginied²			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

Table 5 Estimates of income inequality yearly cross sections robust estimates
(t-statistics in parentheses)

Year :	1960	1965	1970	1975	1980	1985	1990	1995
#countries:	40	47	60	53	55	57	65	24
Depvar:	gini	gini	gini	gini	gini	gini	gini	gini
intcpt	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)*
ginied²	-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

Table 6 Additional variance explained by educational variables random effect estimates

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

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

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) and/or in human capital formation (as proxied by the ratio of educational expenditure to gross output) contribute to higher income inequality. These results are robust to alternative specifications, and therefore we go back to our initial (and preferred) specification provided by the fifth column of table 4, and reproduced here for simplicity (yearly dummies not shown)

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

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

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

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

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

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 becomes positively correlated above it. Using the regional averages reported in table 3, we can say that additional education is inequality enhancing in OECD countries (and very recently also in formerly planned economies), whereas it is beneficial with respect to inequality for the other entire world regions.

We now move to see whether these results help us to better account for the temporal evolution of income inequality. In figure 5 we have made use of equation (11) to predict the potential evolution that we would have observed whether the educational achievement (in terms of both average years and distribution) would have remained at 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 in these two regions to reduce income inequality. 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.

[insert figure 5 about here]

The other measure we can provide for the effect of educational variables in explaining income inequality is obtained by measuring the increase in explained variance attributable to them. In table 6 we show the variation in the (multiple) correlation coefficient R^2 that we obtain when we insert the educational variables. Thus it compares the models reported in second and fifth columns of table 4 at regional and yearly level. At the world level, this table suggests that the contribution of educational achievements to explain the total variance of income inequality ranges between 3% and 16% (the last period 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 (1970-75) or increasing (1985-95, especially in the case of OECD countries). Regional variations have to taken with

caution because of the limited degrees of freedom; nevertheless we notice a rising trend in the relative contribution of education to rising income inequality.

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

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

Equation (14) tells us that the one minus the ratio between inequality in (log)incomes and 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 either on individual earnings or individual incomes, and therefore we cannot compute the Gini index on log-earnings as requested by previous equation. However using simulations based on the observed distribution of educational achievements 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 fit declining with the rate of return β assumed in simulation.[42] Using this result, we have computed an (estimated) Gini index on log-income, allowing us to obtain the measure proposed in equation (14), which is depicted in figure 6. From the dynamics of this indicator at regional level, we notice that the educational premium is higher in OECD countries (mainly because they have a higher average educational achievement), followed by Asia and Latin America. In all cases but one this premium is declining in most recent years; on the contrary, in formerly planned economies the return to education seems rising.

[insert figure 6 about here]

4. Conclusions

In this paper we have proposed to measure inequality of educational achievements by constructing a Gini index on educational attainments. We have then used the proposed measure to analyse the relationship between inequality in incomes and inequality in educational achievements (in terms of both the average attainments and its concentration). Even if 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 actual data indicate that average years of education have a stronger negative impact on measured income inequality. Multivariate regressions also prove that, once we take into account the negative correlation between average educational achievement and its dispersion, 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 characterised by higher accumulation and/or greater governmental expenditure in education experience higher income inequality. Looking at relative contribution of education to income inequality, we find that it contributes to explain a portion of

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

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

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

variance enclosed between 3% and 16%, but this fraction is higher in developed countries and shows a rising trend.

Figure 7 replicates figure 3 showing the weighed mean values for each time unit of observation.[43] Looking at the south-west panel, we get the picture that in the post-war period the world has experienced what can called an educational cycle . By investing public resources in education and lowering access barriers to education, different governments were able to increase the average schooling of 2.2 years and to reduce the Gini index on educational inequality of about 9 percent points (mainly in the period 1965-90). This effort was eased by a (median) growth of gross domestic product per capita of 60.9% over the same period (south-east quadrant).
Despite these changes, mean income inequality has almost steadily risen at world level, marking an increase of 2.7 points in the Gini index on income inequality (north-east panel). However, while in a first sub-period (indicatively until 1980) income inequality and educational inequality seem loosely related, in more recent decades a further expansion in schooling of the world population is accompanied by a widening of dispersion in income distribution. The observations referred to 1995 represent a possible further change in the process: average educational achievement keeps on rising (with an additional jump of half year), but inequality in educational achievement instead of declining rises by almost 3 points. Both variations are accompanied by a further increase in income inequality of one additional point. It is not immediate to isolate the potential causes of this change of regime, but some intuition can be grasped by going to regional level (as it is done in figure 8). This graph reports the relationship between income inequality and educational inequality.

[insert figures 7 and 8 about here]

In this case we notice that at least three separate patterns can be identified in the educational cycle at the world level. North African and South Asian countries represent the first one. Most of these countries started from a quite low initial level of educational attainment (around one year of average schooling in the 60 s for North African and South Asian regions), but were quite effective in more than quadrupling it. It is not a case that the same regions are the only ones where we found an inequality reducing effect of education (see figure 5).

A second pattern is represented by East Asian and Sub Saharan countries, that initially followed the previous pattern, but at a slower speed (the average years of schooling passed from 3.7 to 6.4 and from 1.0 to 2.7 respectively in the period 1960-95). An insufficient leap forward in educational attainments (conversely typical of successful countries in the first group) seems unable to modify the basic social structures in these countries. Inequality in education initially declined, but after the 70 s was accompanied by an increase in income inequality, that later on mirrored in a trend reversal in educational inequality.

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

[43] Notice that we have suppressed the initial observation referred to 1960 for ease of reading of the graph (the values are however reported in table 2).

OECD countries represent a story by their own. Being the only world region with average educational attainments above the threshold of 6.5 years, during the entire sample period they experienced a widening of educational differentials, accompanied (after 1975) by a rising income inequality.

A general teaching emerges from previous evidence: *increased access to education reduces income inequality only under two joint conditions: a) if the initial level of educational attainment is sufficiently low; b) if it is able to raise average educational attainment at a sufficient speed.* If one want to speculate on the underlying reasons for these results, one potential explanation is offered by the interaction between supply and demand of human capital, i.e. educational choices of the population and jobs creation by firms.[44] When the average educational level in the population is low, there are very few highly educated people, who are likely to obtain very high salaries. At the same time, firms do not have incentives to create new jobs for skilled workers, since they are factor demand constrained. As long as more and more educated people enter the labour market, the speed of technological innovation goes up, followed by the skilled job creation. More people earn higher wages, and as a consequence income inequality starts declining. When the bulk of the labour force accomplishes at least the primary level of education, technological jumps (like the information telecommunication technology) are possible, because more sophisticated tasks can now be assigned to skilled workers. The rise in productivity for this segment of workers reflect 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 conditional on the stage of technical development.

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

[45] One may object that causality may go in the opposite direction: lower income inequality facilitates access to education, and therefore contributes to reduce inequality in education. However this may be true only in the steady state. In facts, in a related paper (Checchi 1999) it has been shown that income inequality reduces enrolment rates, mainly at the secondary level. But enrolment rates represent the rates of change of existing human capital stock, and therefore affect the *rate of change* of educational inequality. Therefore they cannot affect at the same time the rate of change and the level of the same variable. In our framework, current income inequality is affecting *future* educational inequality, which according to human capital theory will shape *future* income inequality. Therefore, reverse causation may apply only along the intertemporal dimension.

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Appendix 1 Data source

We have taken seriously the recommendation by Atkinson and Brandolini (1999). Data on income inequality are from Deininger and Squire (1996)[46] and from WIID (World Income Inequality Dataset, downloadable at http://www.wider.unu.edu/wiid/wiid.htm.[47] On the whole we have 546 observations referred to 113 countries (with an average of 4.8 observations per country)[48]. While there is no significant differences in Gini indexes when the recipient unit is the (equivalised) 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 ones.[49] We could have introduced a dummy variable controlling for the income definition (as in Deininger and Squire 1998), but in such a case we would have dispensed with all observations for which this information was absent. For this reason, we have preferred to augment the measures based on net incomes of 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 (1993, 1994, 1996, and 1997).[51] In particular, data on 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 who completed that level of education: using Barro and Lee (1996) definitions:[52]

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

When 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 on correspondent enrolment rates for previous three decades.

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[46] Downloaded on 22/10/1998. Among them, 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) referred to 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 reduces to 471 (corresponding to 97 countries with an average of 4.9 observations per country) when we restrict to the cases with non-missing observations on educational variables.

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

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

On the contrary, creating a dummy variable TYPE (equal to 1 when inequality measure is based on gross incomes, and 0 when is based on net income) we get

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

[50] Similar correction was applied to Gini measures based on rural samples (5 observations), that on average resulted higher than national coverage samples by 8.94 points.

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

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

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

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).
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 countries:
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).
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 1960-1995 94 countries random effects
(t-statistics in parentheses)

# countries:	94	94	94	94	94	94
# obs :	454	454	454	454	454	454
Depvar:	gini	gini	gini	gini	gini	gini
intcpt	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)
northafric	-2.161	-1.850	0.160	-1.118	-3.162	-2.840
middleast	*(-0.73)*	*(-0.64)*	*(0.05)*	*(-0.38)*	*(-1.03)*	*(-0.92)*
subsaharan	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)*
southasia	-5.373	-4.606	-1.991	-4.236	-6.749	-7.090
	(-1.52)	*(-1.32)*	*(-0.60)*	*(-1.28)*	*(-1.91)*	*(-2.01)*
eastasia	-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	7.135	7.411	10.291	8.069	6.338	6.340
america	*(3.19)*	*(3.41)*	*(5.26)*	*(3.98)*	*(2.89)*	*(2.91)*
centr.pl.	-13.562	-13.367	-9.255	-9.537	-12.206	-13.339
economies	*(-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

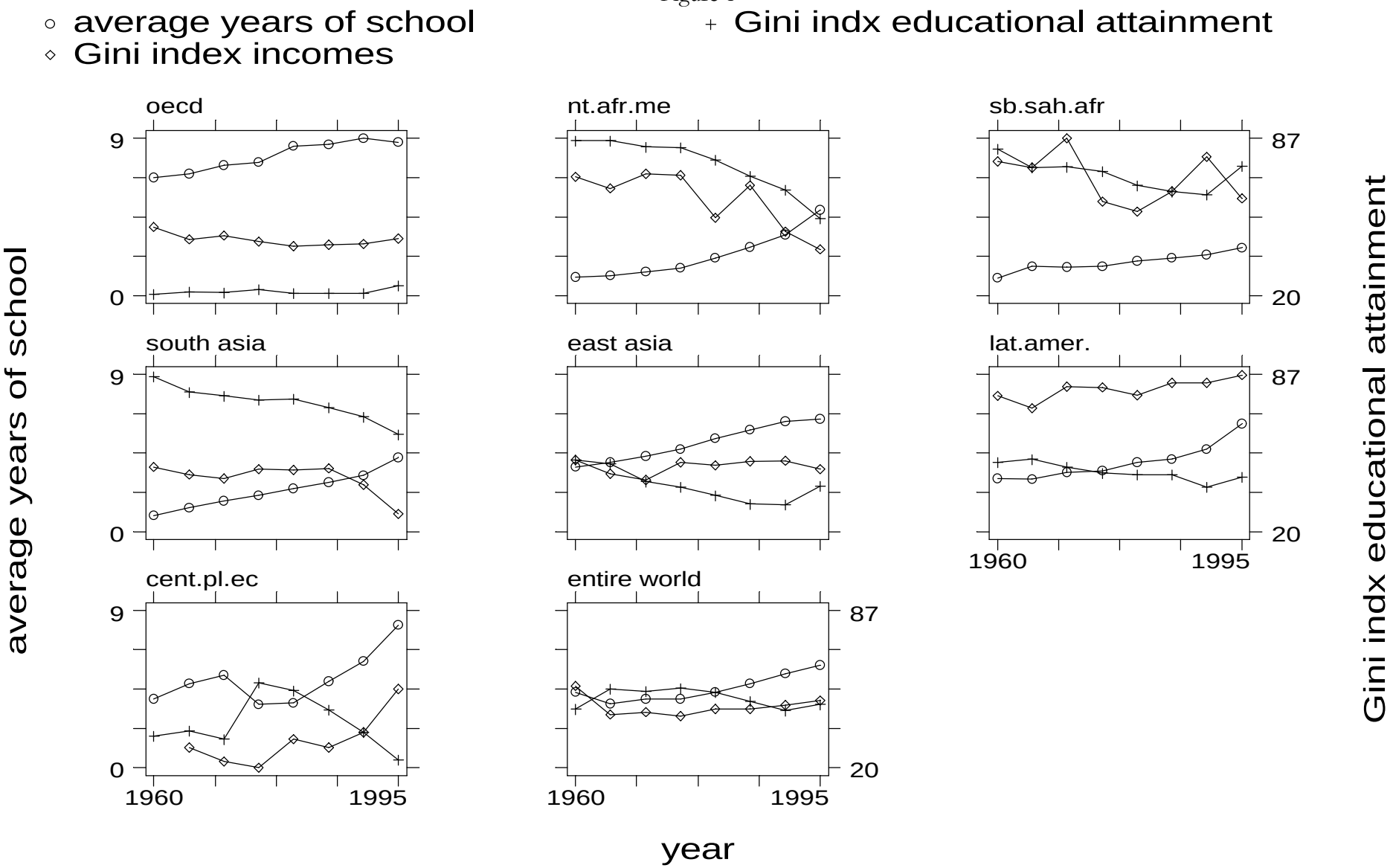
Table A2 Estimates of income inequality 1960-1995 fixed effects - using k/y
(t-statistics in parentheses)

# countries:	76	76	76	76	76	76
# obs :	401	401	401	401	401	401
Depvar:	gini	gini	gini	gini	gini	gini
intcpt	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

Table A3 Estimates of income inequality 1960-1995 fixed effects using educational expenditure
(t-statistics in parentheses)

# countries:	94	76	76	69	69	75
# obs :	454	401	401	241	241	256
Depvar:	gini	gini	gini	gini	gini	gini
intcpt	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)*
ginied²	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
R²(within)	0.084	0.137	0.141	0.194	0.218	0.169

Figure 1



Educational achievements and income inequality

Figure 2

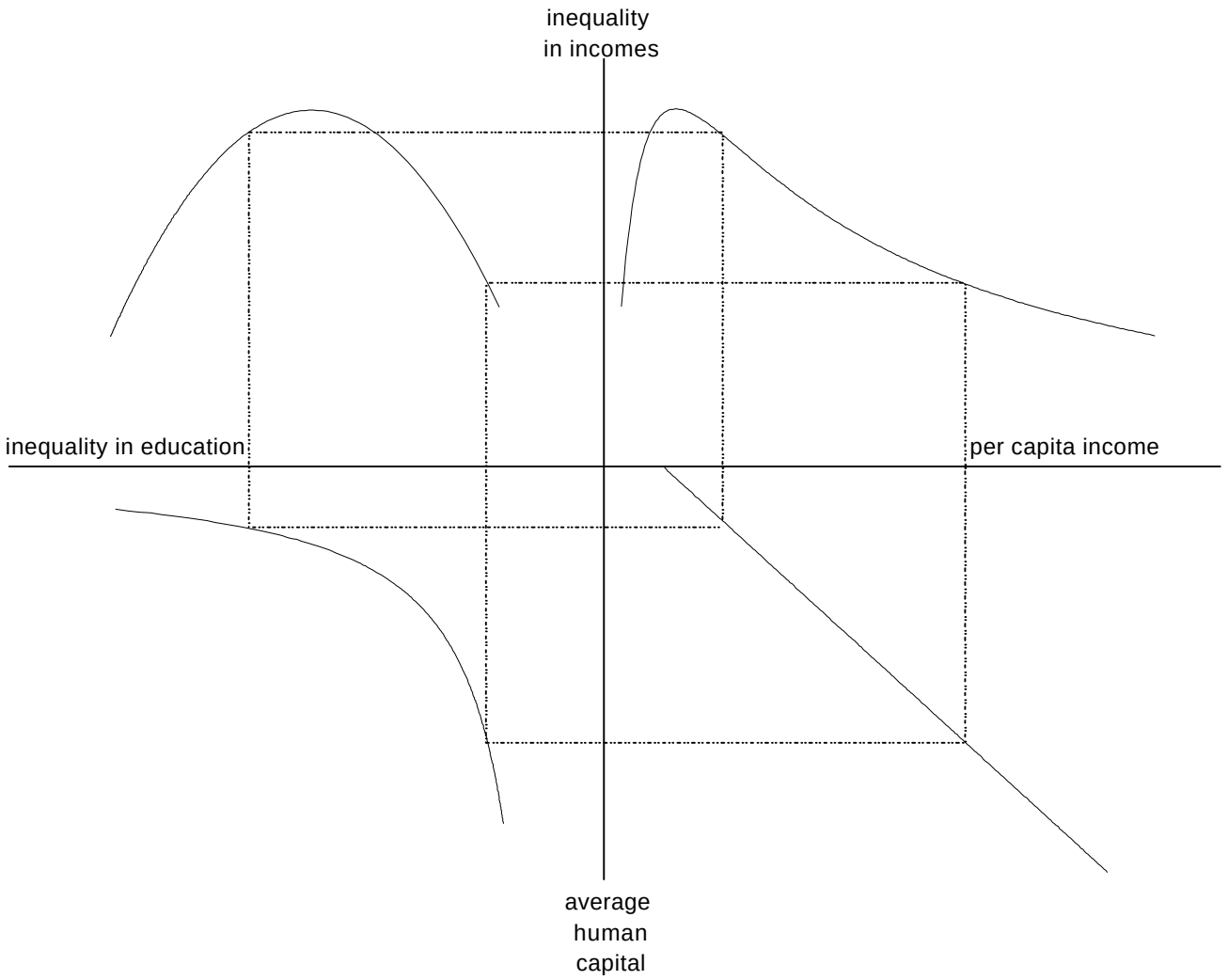
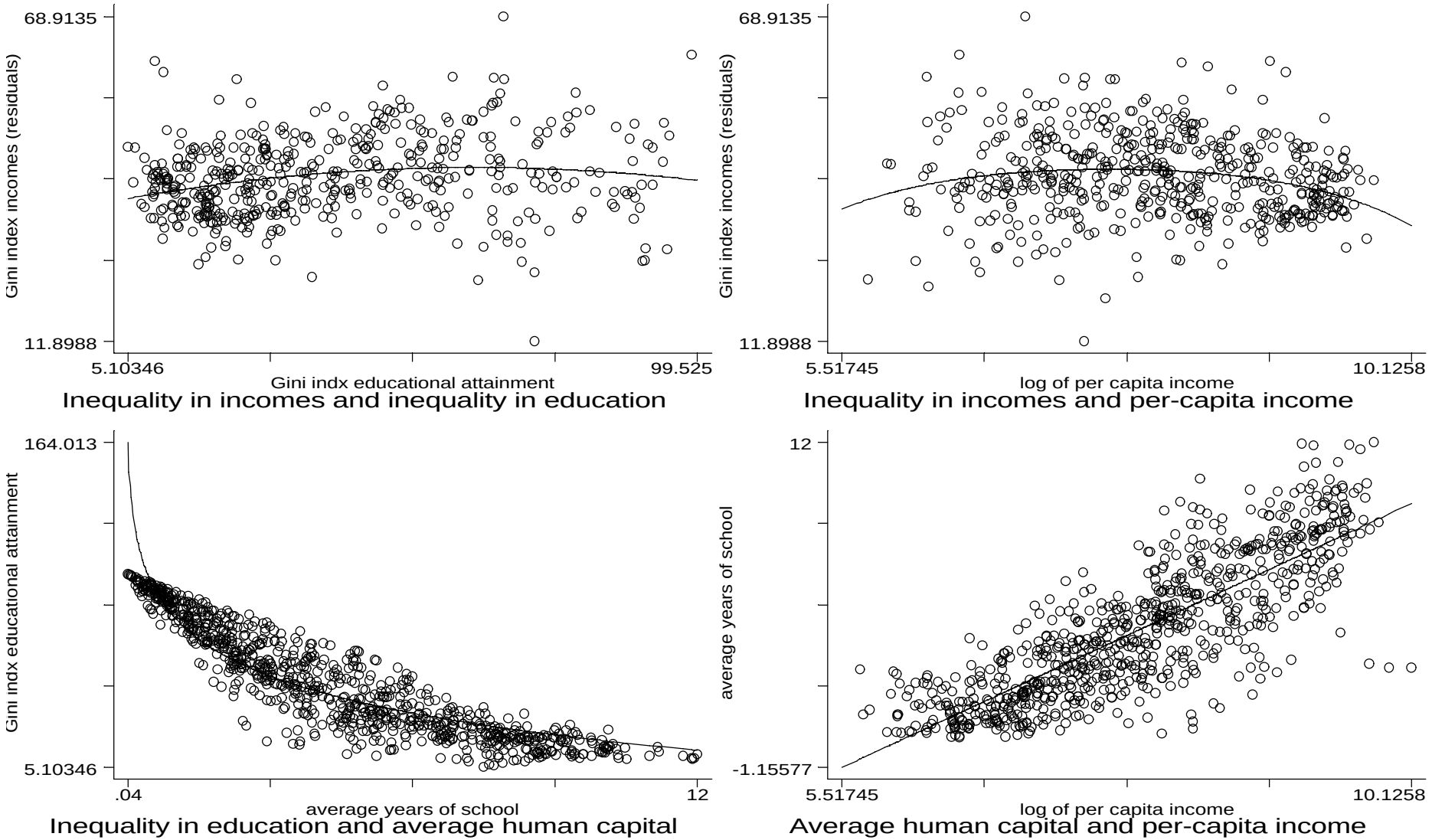

inequality
in incomes
inequality in education
per capita income
average
human
capital

Figure 3



Basic relationships

Figure 4

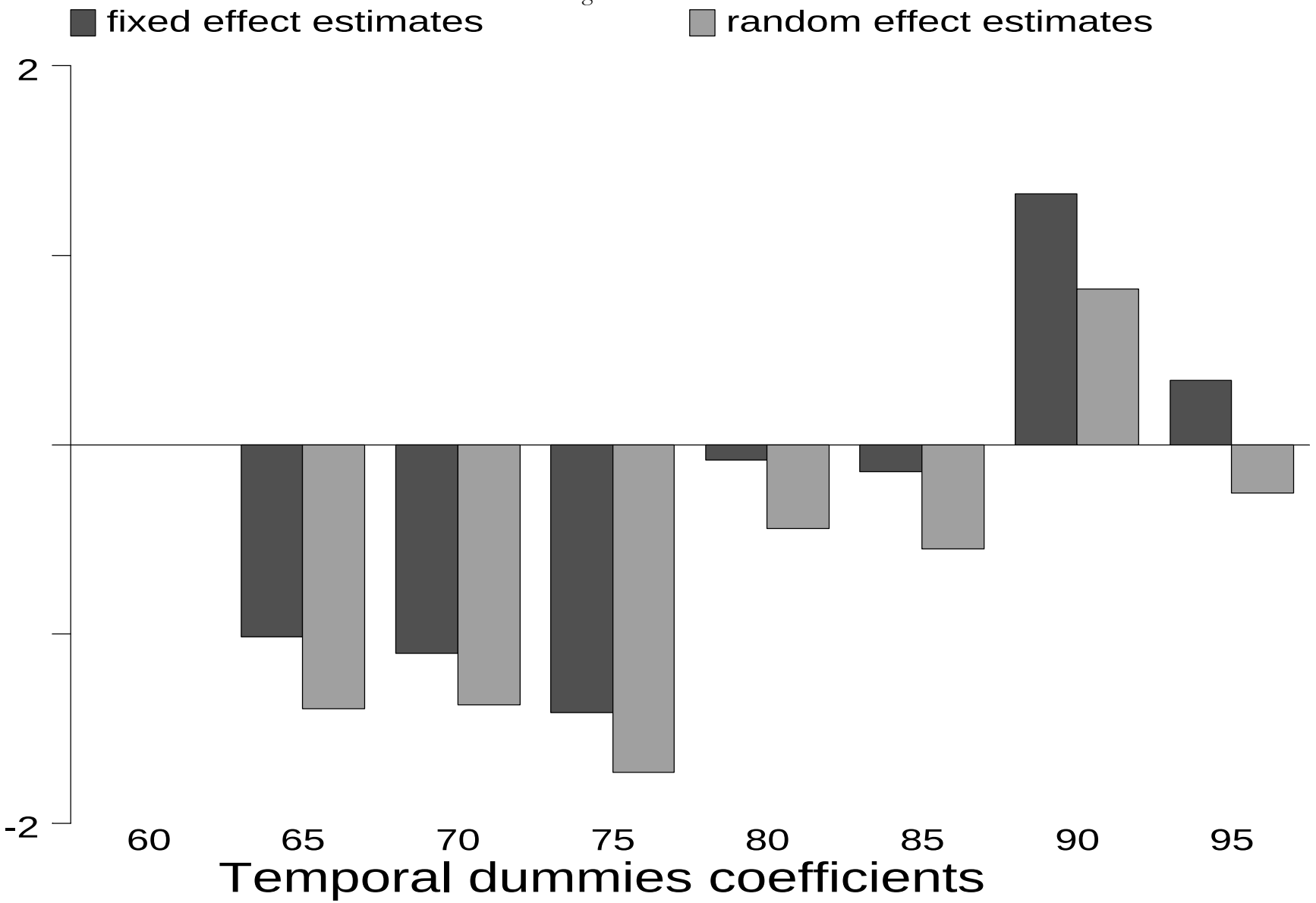

fixed effect estimates
random effect estimates
2
-2
60
65
70
75
80
85
90
95
Temporal dummies coefficients

Figure 5

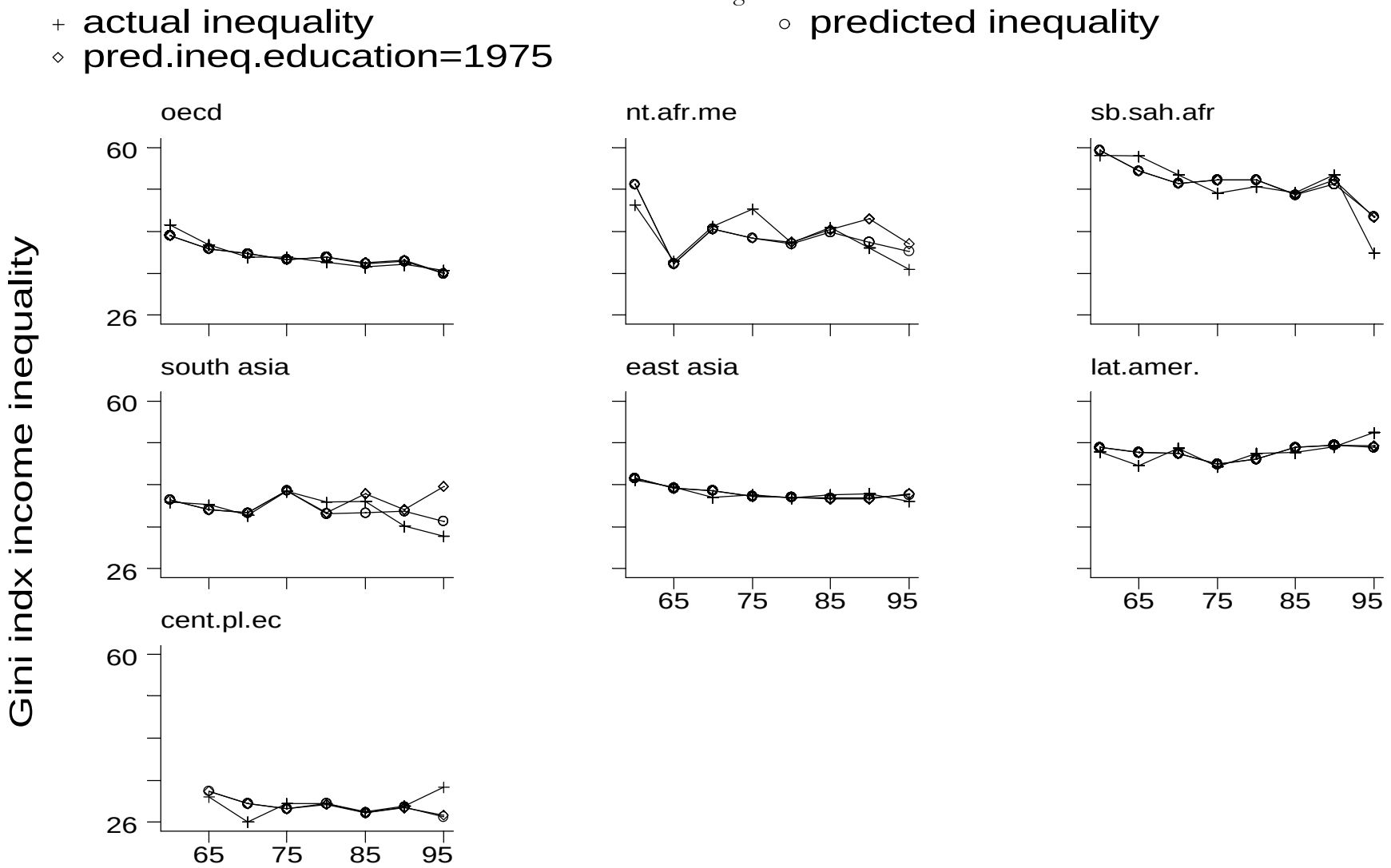

+ actual inequality
○ predicted inequality
◇ pred.ineq.education=1975
oecd
nt.afr.me
sb.sah.afr
south asia
east asia
lat.amer.
cent.pl.ec
60
26
65
75
85
95
Gini indx income inequality
regional means
Income inequality due to education

Figure 6

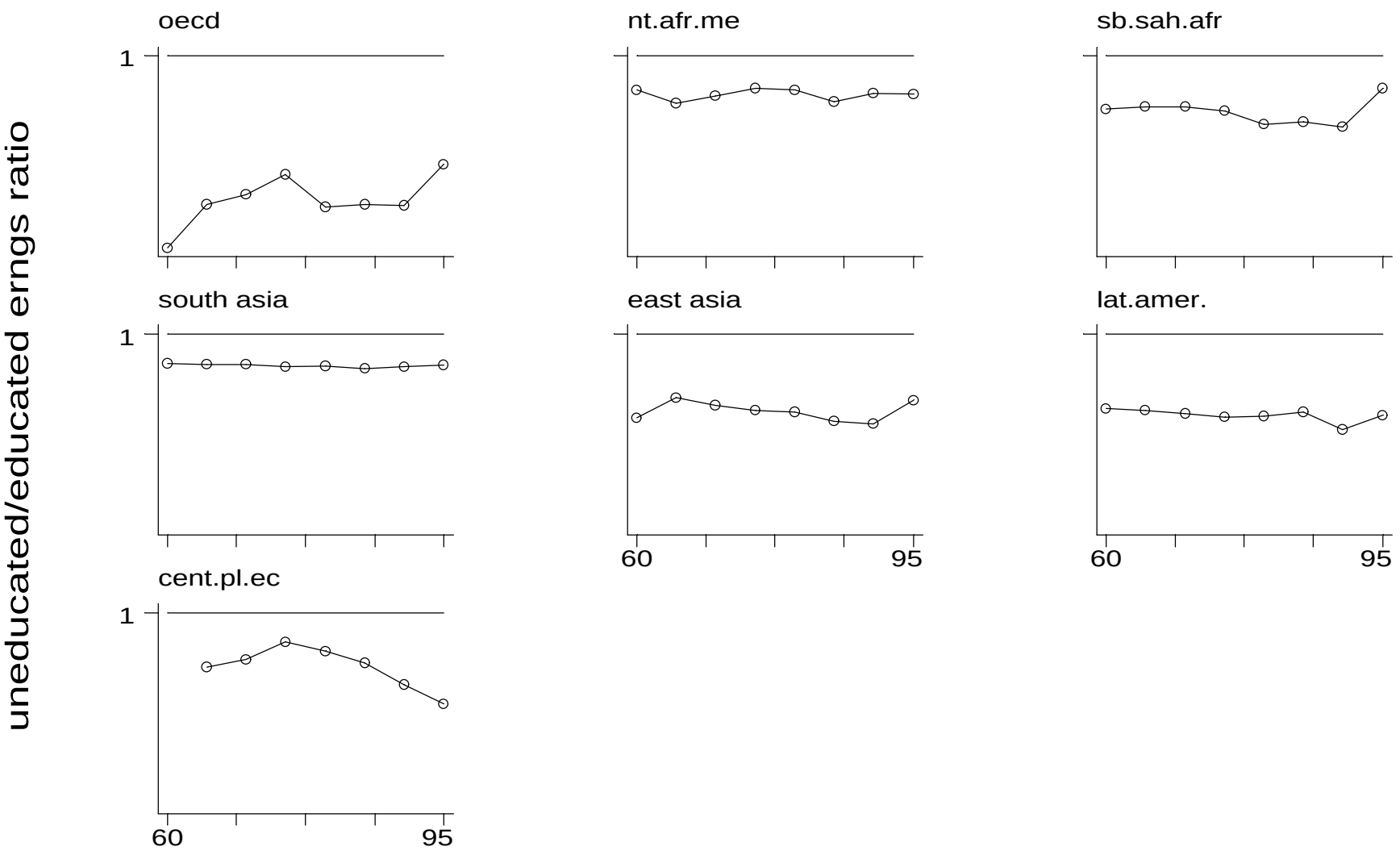
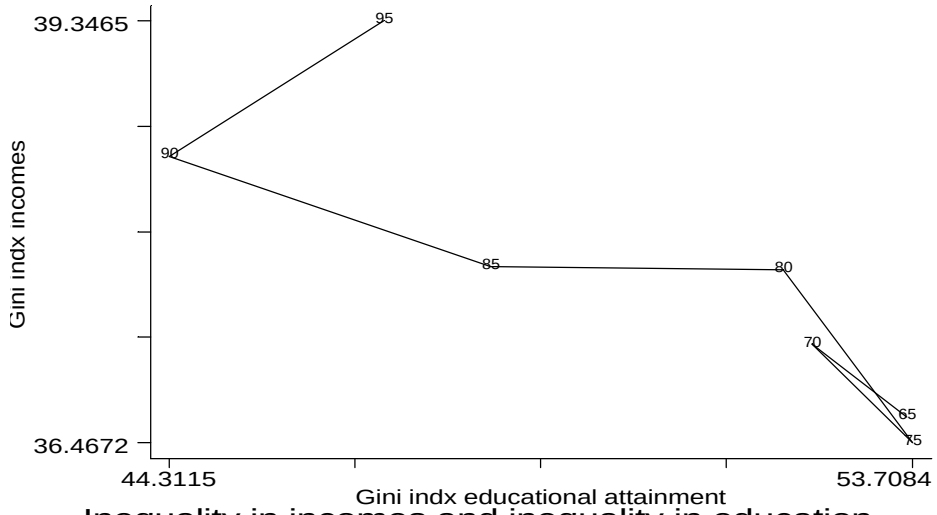
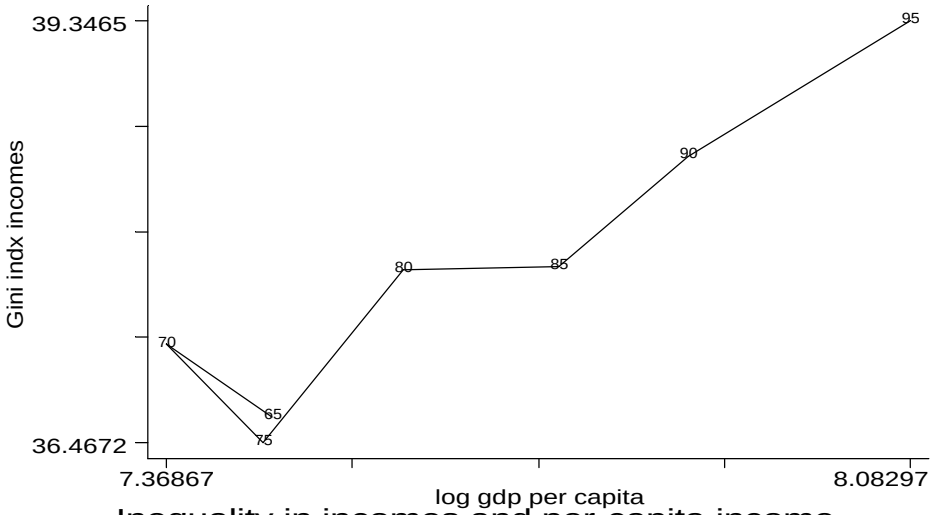

uneducated/educated erngs ratio
oecd
nt.afr.me
sb.sah.afr
south asia
east asia
lat.amer.
cent.pl.ec
1
60
95
reference year
Region/year averages (weights=population)

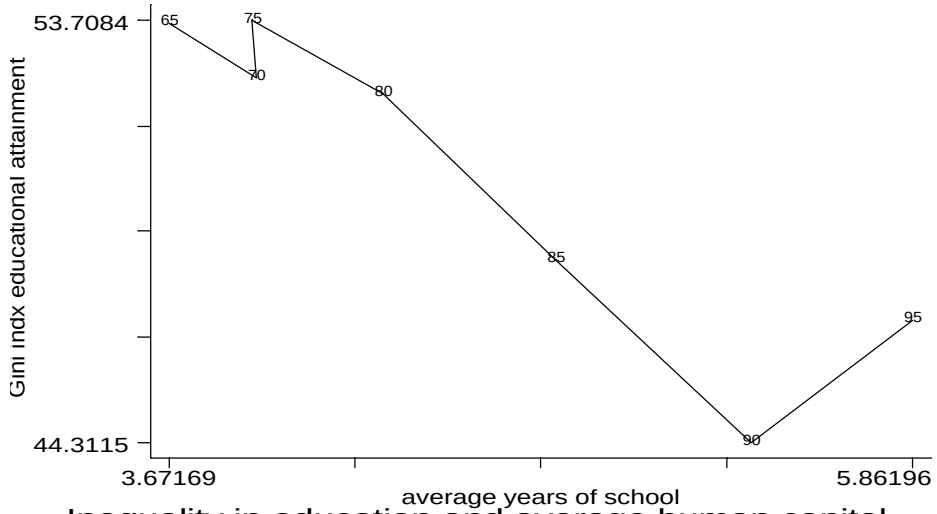
Figure 7



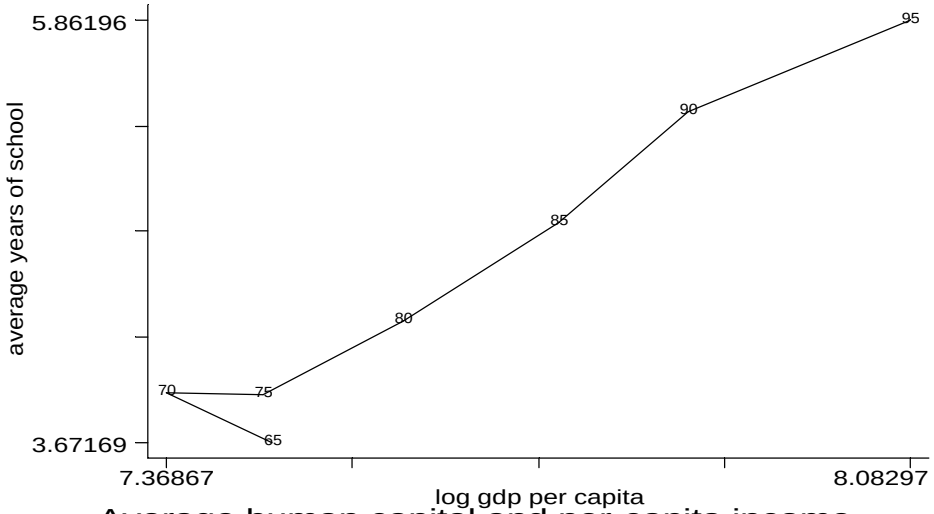
Inequality in incomes and inequality in education



Inequality in incomes and per-capita income



Inequality in education and average human capital

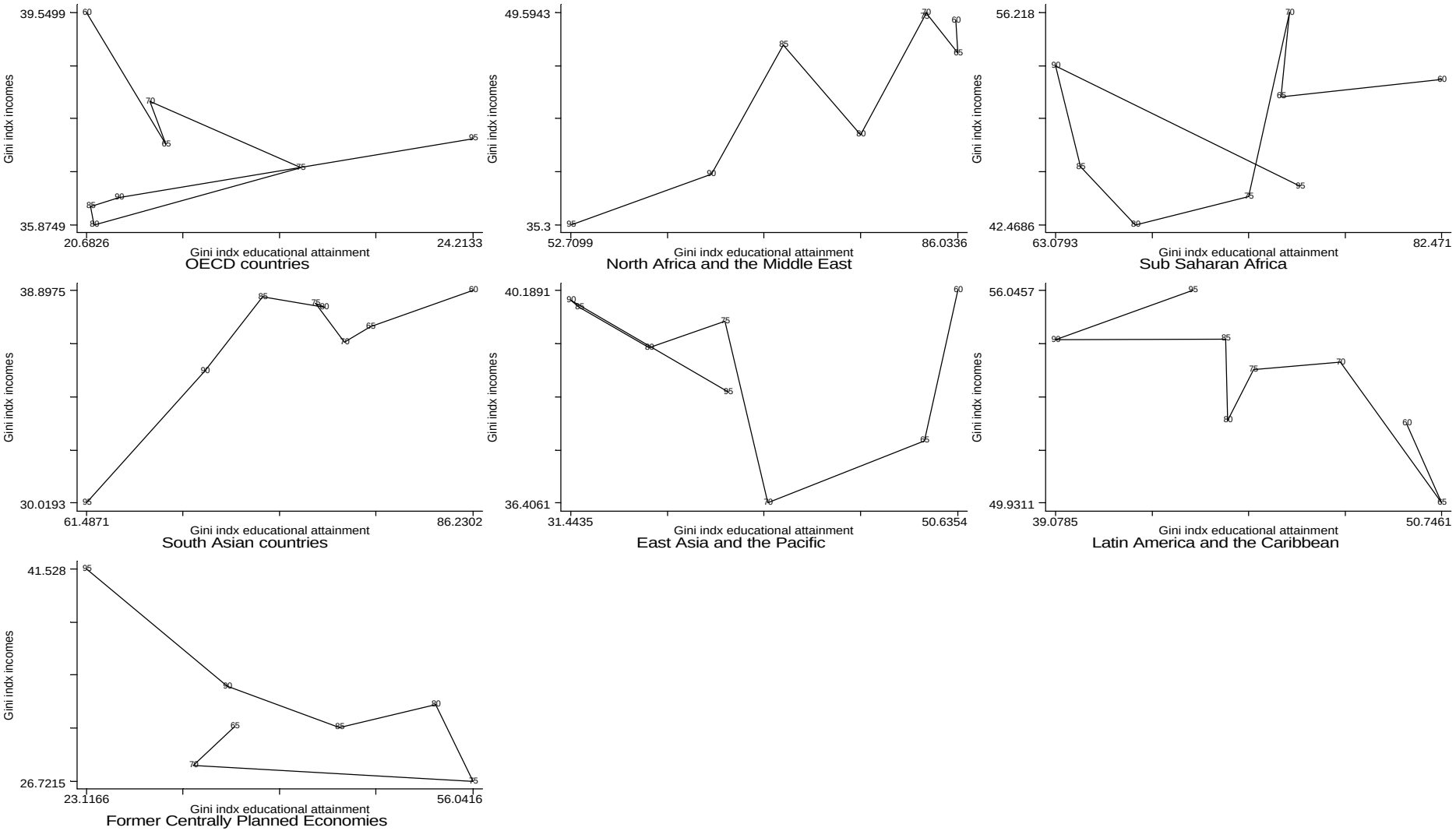


Average human capital and per-capita income

means - weights=population

World inequality in incomes and education

Figure 8



means - weights=population

Dynamics of inequality in incomes and education