

## Education, Social Equality and Economic Growth: A View of the Landscape

Thorvaldur Gylfason and Gylfi Zoega\*

**Abstract:** Education has been one of the key determinants of economic growth around the world since 1965. In this paper, we discuss three different measures of education, and consider their relationship to the distribution of income as measured by the Gini coefficient as well as to economic growth across countries. The three measures are: (a) gross secondary-school enrolment, (b) public expenditure on education relative to national income and (c) expected years of schooling for girls. We show that all three measures of education are directly related to income equality across countries. In a sample of 87 countries at all income levels, we also find that more and better education appears to encourage economic growth directly as well as indirectly through increased social equality and cohesion. Our regression results survive the introduction of regional dummy variables for Africa, Asia and Central and South America. We argue that the empirical relationship between education, on the one hand, and growth and equality, on the other hand, can help account for the positive correlation between the two latter variables that has been documented in the literature. (JEL 128, O15, O40)

### 1 Introduction

It is a widely held view among economists that economic efficiency and social equality are incompatible if not outright mutually exclusive. The perceived but poorly documented trade-off between efficiency and equality is sometimes regarded as one of the main tenets of modern welfare economics. One of the key ideas behind this perception is that increased inequality enhances private as well as social returns to education and to exerting effort in the hope of attaining a higher standard of living. Redistributive policies may then thwart

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\* Research Professor of Economics, University of Iceland; Research Fellow, CEPR and CESifo; and Research Associate, SNS – Swedish Center for Business and Policy Studies, Stockholm. Mail Address: Faculty of Economics and Business Administration, University of Iceland, 101 Reykjavik, Iceland. Phone: 354-525-4533/4500. Fax: 354-552-6806. E-mail: gylfason@hi.is.

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Professor of Economics, University of Iceland; Reader in Economics, Birkbeck College; and Research Affiliate, CEPR. Mail Address: Department of Economics, Birkbeck College, University of London, 7-15 Gresse Street, London W1P 2LL, United Kingdom. Phone: 44-20-7631-6406. Fax: 44-20-7631-6416. E-mail: gzoega@econ.bbk.ac.uk

these tendencies and blunt incentives by penalizing the affluent through taxation and rewarding the poor. Economic efficiency – both static and dynamic – suffers in the process, or so the argument goes.

The revival of economic growth theory in recent years has brought dynamic efficiency to the fore. The empirical testing of the theory has involved estimating reduced-form equations in cross sections (sometimes also panels) of countries where the dependent variable is the average rate of growth of output per capita over a long period and the right-hand side of the equation has initial output per capita – to capture a catch-up effect, or convergence – and a set of other possible explanatory variables among the regressors. More often than not, measures of income equality have turned out to have a positive effect on economic growth across countries. Thus Alesina and Rodrik (1994), Persson and Tabellini (1994) and Perotti (1996) report that equality is good for growth.<sup>1</sup> These empirical results – showing, by and large, that rapid growth tends to go together with more, not less, equality – have helped to inspire a number of authors to attempt an explanation.

Numerous models have been developed to explain the apparent absence of a trade-off between efficiency and equality. First, large inequalities of income and wealth may trigger political demands for transfers and redistributive taxation. To the extent that transfers and taxation distort incentives to work, save and invest, inequality may impede growth. A classic example of the effects of such a system of taxes and transfers is regional transfers in Italy. High taxes in northern Italy are used to subsidize ailing enterprises and public employment in the south, the *Mezzogiorno*. These subsidies have been shown to distort incentives and create inefficiencies in both parts of the country. At a theoretical level, an increase in the rate of redistributive taxation on capital tends to reduce the return to saving and hence lower the long-run rate of growth of output per capita.<sup>2</sup> Moreover, the initial extent of inequality probably makes a difference. An equalization of incomes and wealth in countries with gross inequities, such as Brazil where the Gini coefficient is 60, would seem likely to foster social cohesion and peace and thus to strengthen incentives rather than weaken them, whereas in places like Denmark and Sweden, where the Gini

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<sup>1</sup> Barro (2000) uses a panel of countries over the period from 1965 to 1995 to estimate the relationship between economic growth and equality and finds – by studying the interaction of the Gini coefficient and the initial level of income in a growth regression – that increased equality tends to increase growth in poor countries and retard growth in richer countries, but he finds no support for a relationship between equality and growth in his sample as a whole.

<sup>2</sup> It is not clear, however, that this type of political-cum-fiscal explanation necessarily implies an inverse relationship between inequality and growth, for it is possible that during the redistribution phase increased equality and a drop in growth go hand in hand, especially in panel data that reflect developments over time country by country as well as cross-sectional patterns. However, Perotti (1996) finds little empirical support for this type of explanation.

coefficient is 25 and incomes and wealth are thus already quite equitably distributed by world standards, further equalization might well have the opposite effect. Excessive inequality may be socially divisive and hence inefficient: it may motivate the poor to engage in illegal activities and riots, or at least to divert resources from productive uses, both the resources of the poor and those of the state. Social conflict over the distribution of income, land or other assets can take place through labour unrest, for instance, or rent seeking which can hinder investment and growth (see Benhabib and Rustichini 1996). Also, national saving may be affected by inequality if the marginal propensity to save depends on the level of income, i.e., if the rich have a higher propensity to save than the poor (see Kaldor 1956). In this case inequality may be good for growth in that the greater the level of inequality, the higher is the saving rate and hence also the rate of investment and economic growth.<sup>3</sup> Unfortunately for this line of thought, Barro (2000) finds no empirical evidence of a link between inequality and investment, but we do.

At last, it is easy to think of ways in which increased equality may help strengthen education rather than hurting it as suggested by the political-economy literature reviewed in brief at the beginning of this discussion. If so, increased equality may thereby also encourage economic growth through education. Galor and Zeira (1993), Aghion (1998) and Aghion, Caroli and García-Peñalosa (1999) argue that this outcome is likely in the presence of imperfect capital markets. To see this, imagine that each member of society has a fixed number of investment opportunities, imperfect access to credit and different endowments of inherited wealth. In such a world the rich would end up using up many of their investment opportunities while the poor could only use a few. Therefore, the marginal return from the last investment opportunity of the rich would be much lower than the marginal return of the last investment opportunity of the poor. Redistribution of wealth from the rich to the poor would increase output because the poor would then invest in more productive projects at the margin. This argument can also be applied to investment in human capital if we assume diminishing returns to education. In this case, taking away the last few quarters of the university education of the elite and adding time to the more elementary education of the poor would raise output and perhaps also long-run growth, other things being equal. Income redistribution would reverse the decline in investment in human capital resulting from the credit-market failure.

The main aim of this paper is to explore empirically the possible relationships and interactions among equality, education and economic growth in a sample

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<sup>3</sup> Against this Todaro (1997) suggests that the rich may invest in an unproductive manner – think of yachts and expensive cars.

of 87 industrial and developing countries in the period from 1965 to 1998. The empirical relationship between the initial level of human capital and economic growth is well established and appears to be more robust than the relationship between measures of equality and growth. The paper proceeds as follows. In Section 2, we consider further explanations for the apparent relationship between equality and growth in the data. In Section 3, we present cross-country correlations between three different measures of education, equality and economic growth, and thus allow the data to speak for themselves. In Section 4, we attempt to dig a little deeper and report the results of multiple regression analysis where growth is traced to education and equality as well as a number of other factors commonly used in growth regression analysis, and where some of the determinants of growth, including education and equality, hang together. Section 5 concludes.

## 2 Income distribution, education and growth

We have described several possible explanations for the positive association between equality and growth found in the data. In an accompanying paper (Gylfason and Zoega 2003b), we propose a model that embeds some of the mechanisms described in the previous section in an overlapping-generations context. We will discuss this model briefly here.

Imagine a world where, not unrealistically, parents support their children who then spend their parental allowance on consumption and education and save the rest in the form of physical capital (think of stocks!). They then enter the labour market, endowed with their human capital, or education, as well as their initial savings plus any inheritance left over by their (by now deceased) parents. During their working life their savings are augmented when wage income is only partly spent on consumption, or given to the next generation, the rest being added to savings, hence the capital stock. When this generation finally passes away their capital it is left over to the young. The world continues forever but each individual has a finite lifespan.

This framework presents a familiar picture of parents supporting their children and then leaving the remainder of their wealth to the young generation. The young acquire both human capital – through education – and physical capital – mostly from inheritance – and then make a living as adults, consume, and support the next generation and finally leave their remaining wealth to that generation.

In such a setting endogenous growth can arise because of complementarities between human and physical capital. Diminishing returns to either factor of production never set in because both factors grow together – there is no fixed

factor of production. When schools are improved, and a given amount of spending on education results in more human capital acquired, this causes the expected rate of return on human capital to fall and hence increases the attraction of investing in physical capital, which calls for increased savings and investment. The complementarity of human and physical capital generates an AK production technology where savings and education can sustain growth in the long run.

But how can such a model account for the positive association between equality and growth found in the data? The key lies in the dual effects of education expenditures. If spending a dollar to further the education of the less educated generates more human capital than the same dollar spent on a person with a better educational background, then improving the efficiency of schools providing basic education – at the expense of those giving elite education – will both enhance equality as well as raising the supply of human capital at the national level. The latter will – through a familiar channel – raise the rate of return on physical capital compared with the rate of return on human capital, and this, in turn, generates further saving, investment and growth. The system of education is thus the force that affects both the extent of equality and the pace of growth: improvements in the general level of education enhance both equality and growth. Moreover, increased equality will equalize bequests, thereby promoting equality in education and income further still, and higher rates of economic growth.

### 3 Cross-country patterns in the data

The empirical question that we address in this section is this: Does education encourage growth also by enhancing economic and social equality? – provided that equality is also good for growth.

Let us begin by looking at the cross-country pattern of inequality, economic growth and investment. Figure 1a shows a scatterplot of the annual rate of growth of gross national product (GNP) per capita from 1965 to 1998 (World Bank 2000, Table 1.4) and the inequality of income or consumption as measured by the Gini coefficient (same source, Table 2.8).<sup>4</sup> The growth rate has been adjusted for initial income: the variable on the vertical axis is that part of economic growth that is not explained by the country's initial stage of development, obtained as a residual from a regression of growth during 1965–1998

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<sup>4</sup> Our sample does not include any transition economies because, for them, there is no information available on natural capital, which is one of the key determinants of growth in our framework. See Gylfason and Zoega (2001).

on initial GNP per head (i.e., in 1965) as well as natural capital, taken from World Bank (1997).<sup>5</sup> This adjustment obviates the need to view high-income countries and low-income countries separately. Even so, if rich countries and poor are considered separately, a similar pattern is observed in both groups (not shown). The 75 countries shown in the figure are represented by one observation each.<sup>6</sup> The regression line through the scatterplot suggests that an increase of about 12 points on the Gini scale from one country to another – corresponding, for example, to the difference in income distribution between India (Gini = 38) and Zambia (Gini = 50) – is associated with a decrease in per capita growth by one percentage point per year on average. The relationship is statistically significant (Spearman's rank correlation  $r = -0.50$ ).<sup>7</sup> A reduction in a country's annual per capita growth rate by one percentage point is a serious matter because the (weighted) average rate of per capita growth in the world economy since 1965 has been about 1½ percent per year.

Figure 1b displays a scatterplot of average gross domestic investment from 1965 to 1998 and the Gini coefficient in the same 75 countries as before. Here again we see an inverse correlation, albeit not as strong as in Figure 1a. The regression line through the plot suggests that an increase of about 10 points on the Gini scale from one country to another is associated with a decrease in investment by one percent of gross domestic product (GDP). The relationship is statistically significant ( $r = -0.28$ ). The outlier in the northeast corner of the scatter is Lesotho<sup>8</sup>; if we exclude Lesotho from the regression, the rank correlation rises in absolute value to  $-0.32$  and the slope of the regression line increases from  $-0.10$  to  $-0.15$ , in which case an increase in the Gini coefficient by 10 points from one place to another goes along with a decrease in investment by 1½ percent of GDP.

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<sup>5</sup> The Gini coefficient measures the extent to which income (or, in some cases, consumption) among individuals or households deviates from a perfectly equal distribution. A Gini coefficient of zero represents perfect equality (all individuals receive the same income) while a Gini coefficient of 100 means perfect inequality (the national income accrues to one individual). While Gini coefficients based on net (i.e., after-tax) incomes are preferable in principle as measures of income inequality, the Gini coefficients published by the World Bank are more often than not based on gross (i.e., before-tax) incomes. Hence, the equalizing effects of taxes and transfer schemes on the distribution of income are not fully reflected in the Gini coefficients used here. The data come from nationally representative household surveys and refer to different years between 1983-85 and 1998-99. See World Bank (2000), Table 2.8.

<sup>6</sup> All countries for which the requisite data are available are included in Figures 1-4, without exception.

<sup>7</sup> Elsewhere, we have reported similar cross-country correlations between economic growth and both land inequality ( $r = -0.37$ ) and gender inequality ( $r = -0.32$ ). In our data, the distribution of income and land is highly correlated ( $r = 0.57$ ) whereas the distribution income and educational opportunities of the sexes is not ( $r = -0.04$ ). See Gylfason and Zoega (2003a).

<sup>8</sup> We could be excused for excluding Lesotho because its singularly high investment rate can be explained by a single gigantic project, the Lesotho Highlands Water Project.

Figure 1a

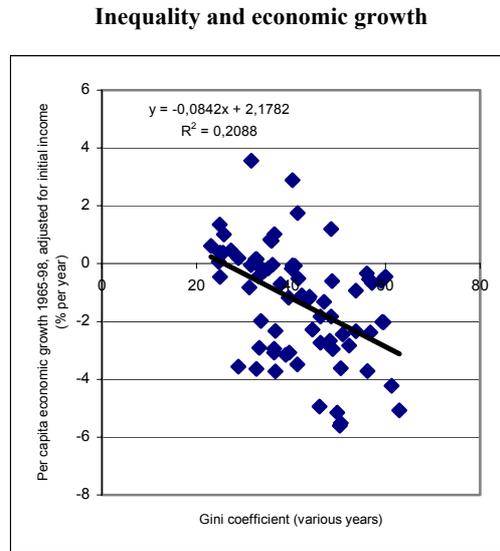
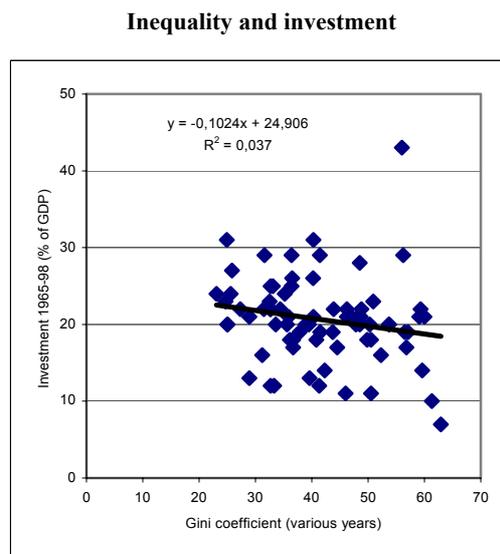


Figure 1b



In sum, the data seem compatible with the view that increased inequality in the distribution of income goes hand in hand with less investment and less rapid economic growth across countries. These patterns are economically as well as statistically significant. Even so, we are aware that two-dimensional correlations do not allow us to distinguish cause from effect. We intend the correlations presented in this section merely to describe the data in ways that are consistent with the results of the multiple regression analysis in Section 5 where several possible determinants of growth are taken into account side by side.

Let us now consider three different measures of education inputs, outcomes and participation and how they vary with inequality and economic growth. Figure 2 shows scatterplots of public expenditure on education from 1980 to 1997 as reported by UNESCO (see World Bank 2000, Table 2.9) and (a) inequality and (b) growth as measured above. Public expenditure on education varies a great deal from country to country. In the 1990s, some countries have spent as little as 1 percent of their GNP on education (Haiti, Indonesia, Myanmar, Nigeria and Sudan). Others have spent between 8 percent and 10 percent of their GNP on education, including St. Lucia, Namibia, Botswana and Jordan, in descending order. Public expenditure is admittedly an imperfect measure of a nation's commitment to education, not least because some nations spend more on private education than others.<sup>9</sup>

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<sup>9</sup> Moreover, public expenditure on education may be supply-led and of mediocre quality, and may thus fail to foster efficiency, equality and growth, in contrast to private expenditure on education, which is generally demand-led and thus, perhaps, likely to be of a higher quality. Even so, this yardstick should reflect at least to some extent the government's commitment to education.

Figure 2a

**Expenditure on education and inequality**

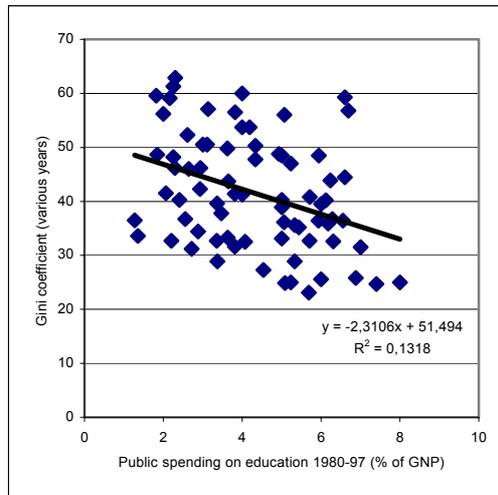
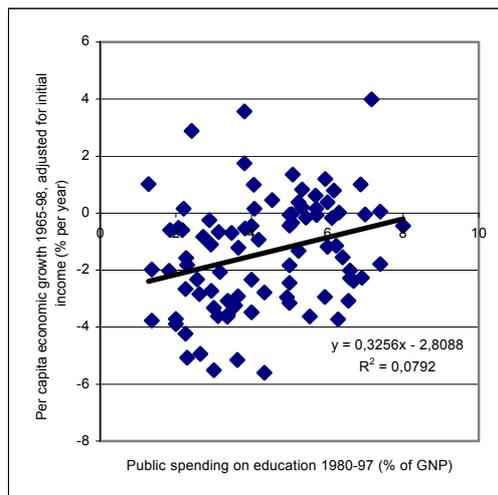


Figure 2b

**Expenditure on education and economic growth 1965 – 1998**



The regression line through the 75 observations in Figure 2a suggests that an increase in public expenditure on education by one percent of GNP from one country to the next is associated with a decrease of 2.3 points on the Gini scale.<sup>10</sup> This pattern can be interpreted either as a sign of the equalizing effects of more public education expenditure or of the education-enhancing effects of less dispersion of education and income, or both. The relationship is statistically significant ( $r = -0.36$ ). The regression line through the 87 observations in Figure 2b suggests that an increase of about 3½ percentage points in public expenditure on education relative to GNP from one country to the next is associated with an increase in per capita growth by one percentage point. This relationship is also statistically significant, even if it is not particularly strong ( $r = 0.29$ ). Taken together, the two plots suggest that an increase in education spending by the equivalent of 3½ percent of GNP goes hand in hand with an eight point decrease in the Gini coefficient and a one percentage point increase in per capita growth on average, thus helping explain the observed cross-country relationship between inequality and growth in Figure 1a. These results are consistent with the theoretical explanation proposed in Section 2 above. A third variable, education expenditures, contributes to both increased equality as well and higher growth.

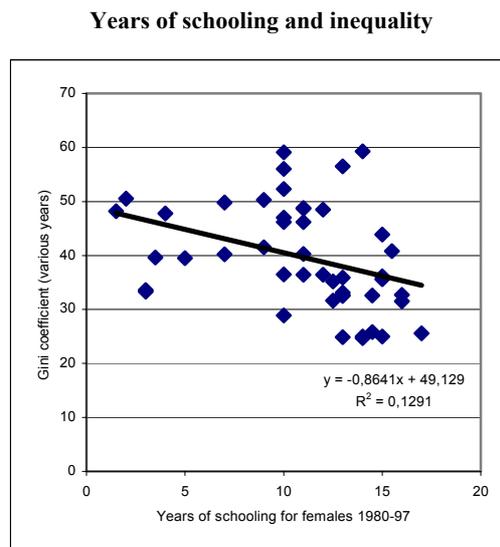
Figure 3 shows scatterplots of the expected number of years of schooling for females from 1980 to 1997 and (a) inequality and (b) growth as before. This indicator of schooling is intended to reflect the total education resources, measured in school years, that a girl will acquire over her lifetime in school or as an indicator of an education system's overall state of development. We stress female education not because using male education would produce weaker results – in fact, the results we get from our sample are virtually the same for both genders (not shown). Rather, we stress the education of girls because the early empirical literature on education and growth did not detect economically and statistically significant effects on growth of female education at any level. In Figure 3a, the regression line through the 46 observations, one per country, suggests that an increase by one year of the schooling that an average girl at the age of school entry can expect to receive is associated with a decrease in the Gini coefficient, i.e., increased equality, by almost one point. The relationship is statistically significant ( $r = -0.49$ ). Unlike the relationship in Figure 2a, the one in Figure 3a is significantly non-linear (not shown), suggesting that the marginal effect of increased education on equality is rising in the level of enrolment – that is, there may be increasing returns to schooling in

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<sup>10</sup> Here, unlike in Figures 1a and 1b, Gini coefficients based on the distribution of gross income rather than net income are the most relevant measures of inequality because more and better education can be expected to equalize income before taxes and transfers (see footnote 5).

terms of equality.<sup>11</sup> The corresponding relationship for males (not shown) is virtually the same as for females. Figure 3b shows the cross-country relationship between growth and years of schooling. The regression line through the 49 observations suggests that an extension of schooling by about four years is associated with an increase in annual economic growth by one percentage point. The relationship is significant ( $r = 0.50$ ). Between them, the two charts suggest that an extension of schooling by about four years goes hand in hand with a four point decrease in the Gini coefficient and a one percentage point increase in per capita growth on average, thus again helping explain the inverse relationship between inequality and growth in Figure 1a.

**Figure 3a**



<sup>11</sup> Sen (1999), among others, emphasizes the importance of educating girls in developing countries.

Figure 3b

Years of schooling and economic growth 1965 – 1998

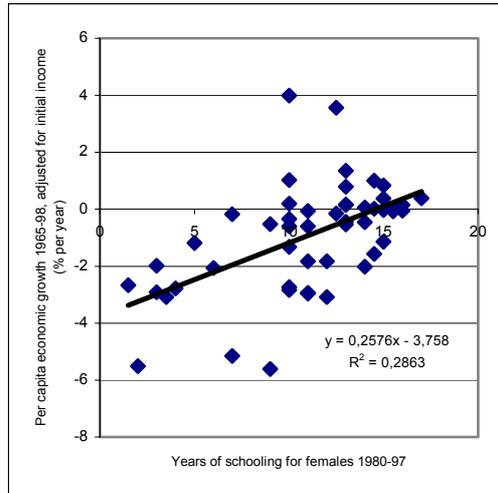


Figure 4a

School enrolment and inequality

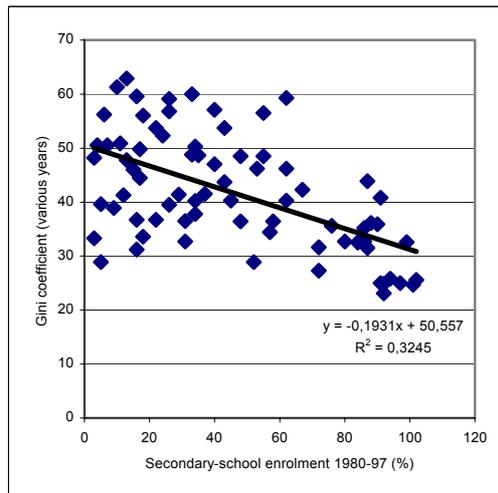
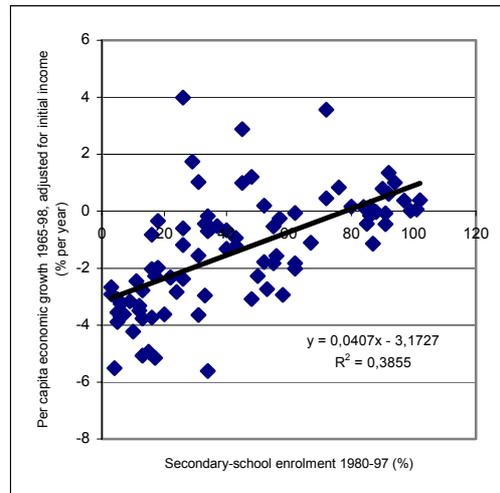


Figure 4b

## School enrolment and economic growth 1965 – 1998



Secondary-school enrolment is probably the most commonly used indicator of education in empirical growth research. Figure 4 shows scatterplots of gross secondary-school enrolment for both genders from 1980 to 1997 and (a) inequality and (b) growth as before. The regression line that passes through the 75 observations in Figure 4a suggests that an increase in the secondary-school enrolment rate by about five percentage points from one place to another goes along with a decrease by one point on the Gini scale. The regression is statistically significant ( $r = -0.54$ ). Like the relationship in Figure 3a, the one in Figure 4a is significantly non-linear (not shown). At last, Figure 4b shows the cross-country relationship between growth and school enrolment. The regression line through the 87 observations suggests that an increase in secondary-school enrolment by 25-30 percentage points is associated with an increase in annual per capita growth by one percentage point. Unlike the relationships in Figures 2b and 3b, the one in Figure 4b is significantly non-linear (not shown), as might be expected from diminishing returns to education. In any case, the relationship is highly significant ( $r = 0.69$ ), more so than in Figures 2b and 3b. Of the three indicators used here, secondary-school enrolment is the one that is most closely correlated with economic growth. Together, the two charts suggest that an increase in secondary-school enrolment by 25–30 percentage points goes hand in hand with a six point decrease in the Gini coefficient and a

one percentage point increase in per capita growth on average, thus, once more, illuminating the inverse relationship between inequality and growth in Figure 1.

We now turn to multivariate regression analysis of education, inequality, investment and growth.

#### 4 Regression analysis

Table 1 reports seemingly unrelated regression (SUR) estimates of a system of four equations for the 87 countries in our sample for the years 1965 – 1998.

The first equation shows how economic growth depends on

- i. the logarithm of initial per capita income (i.e., in 1965), defined as income in 1998 divided by an appropriate growth factor,
- ii. the share of natural capital in national wealth (which comprises physical, human and natural capital),
- iii. the share of gross domestic investment in GDP in 1965-1998,
- iv. the logarithm of the secondary-school enrolment rate (the logarithm in order to capture diminishing returns to education) and
- v. the Gini coefficient.

The second equation shows the relationship between the investment rate and the logarithm of the enrolment rate in accordance with the results derived from the model sketched in Section 2 where we argued that education encourages investment in physical capital. Investment also depends on the natural capital share; the underlying reason is that the more abundant are natural resources in relation to GDP, the smaller the share of physical capital in GDP and the weaker is the incentive to save and invest by the Golden Rule (Gylfason and Zoega 2001).

The third equation shows how the enrolment rate depends on initial income (because wealthy countries can afford to spend more on education) as well as on natural capital (as in Gylfason 2001, and Gylfason and Zoega 2001; the idea behind this formulation is that the natural-resource-intensive sector may use workers with fewer skills than the manufacturing sector).

The fourth and last equation shows the relationship between the Gini coefficient and the enrolment rate that we documented in Section 3. The recursive nature of the system and the conceivable correlation of the error terms in the four equations make SUR an appropriate estimation procedure (Lahiri and

Schmidt 1978). However, the fact that ordinary least squares (OLS) estimates of the system (not shown) are almost the same as the SUR estimates shown in Table 1 indicates that the correlation of errors terms across equations is of minor consequence.

**Table 1****Regression results: Baseline scenario**

Dependent variable	Initial income	Natural capital	Investment rate	Enrolment rate	Gini coefficient	R <sup>2</sup>	Countries
Economic growth	-1.07 (5.62)	-0.06 (4.06)	0.10 (4.15)	0.83 (3.10)	-0.03 (2.64)	0.66	75
Investment rate		-0.13 (2.08)		1.42 (1.92)		0.22	87
Enrolment rate	20.89 (12.50)	-0.70 (4.39)				0.72	87
Gini coefficient				-0.16 (5.10)		0.32	75

Note: t-ratios are shown within parentheses. Constant terms, statistically significant throughout, are not reported.

In our system of equations, we treat economic growth, investment, education and income distribution as endogenous variables. Given the recursive nature of the system, endogeneity bias should not emerge if the specification is correct and if natural resource intensity can be viewed as exogenous, as we assume. The recursive structure of our model allows us to solve the system sequentially so that the need for instrumental variables does not arise.<sup>12</sup>

All the coefficient estimates shown in Table 1 are economically as well as statistically significant with one exception: the effect of enrolment on investment is marginally insignificant at the 0.05 level. The coefficient on initial income in the growth equation suggests that the speed of convergence is about

<sup>12</sup> In nonrecursive equation systems, it is difficult, if not impossible, to find instruments that are correlated with the regressors but not with economic growth. This problem stems from the inherent endogeneity of macroeconomic variables, as Temple (1999) illustrates. However, this problem could be solved in part by using, for example, the Arellano-Bond GMM estimator, but doing so could give rise to new and possibly more serious statistical problems.

1 percent per year. The direct effect of natural capital on growth is  $-0.06$  and the indirect effect through investment and education is  $-0.13 \cdot 0.10 - 0.70 \cdot (0.83/E) - 0.70 \cdot (1.42/E) \cdot 0.10 \approx -0.03$ , the latter evaluated at the median value of the enrolment rate,  $E = 35$ . The total effect of natural capital on growth is thus about  $-0.09$  for given initial income.

Of greater interest here, however, are the effects of education and inequality on growth. The first equation in Table 1 shows the direct effect of education on growth to be  $0.83/E \approx 0.02$  at the median value of the enrolment rate; this means that an increase in the enrolment rate by five percentage points from one country to another increases growth by one-tenth of a percentage point. Combining the results reported in the first and fourth row in the table, we see that an increase in the enrolment rate by six points reduces the Gini coefficient by one point and this, in turn, increases growth further by 0.03 percentage points. Further, combining the results reported in the first and second row in the table, we see that an increase in the enrolment rate by 25 points increases investment by one ( $\approx 25 \cdot 1.42/35$ ) percent of GDP and this, in turn, increases growth further by 0.1 percentage points. In sum, the total effect on growth of an increase in the enrolment rate by, say, 30 percentage points – a dire necessity in many developing countries – is about one percentage point, with the indirect effects through increased equality and increased investment accounting for about one-fourth of the total. However, the direct effect of distribution on growth, while significant throughout, is not very large: according to our estimate, it would take an increase of 33 points on the Gini scale from one country to another – corresponding to the difference in income distribution between Norway (Gini = 26) and South Africa (Gini = 59), thus extending from one end of the scale to the other – to produce a decrease in per capita growth by one percentage point per year on average.

Next we want to explore the possibility of interaction between inequality and other determinants of growth, such as initial income, education and investment. The question here is this: Does inequality affect the responsiveness of growth to variations in its main determinants? We begin by replacing the Gini coefficient in the growth equation in Table 1 by the multiple of the Gini coefficient and initial income. We see in Table 2 that the results remain virtually the same as in Table 1 except for the changes in the coefficients of initial income and the new interaction variable.<sup>13</sup> The speed of conditional convergence now depends on inequality: the composite coefficient of initial income is now  $-0.92 - 0.004 \cdot Gini \approx -1.08$  for given education, given the median value of the Gini coefficient in the sample ( $Gini = 40.3$ ). Taking the effect of initial income

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<sup>13</sup> Because the Gini index and the interaction term are highly correlated, we did not enter both of them in the growth regression.

on education into account, we see that the speed of absolute convergence is considerably lower, or  $-0.92 - 0,004 \cdot 40.3 + (0.85/35) \cdot 20.90 \approx -0.57$ . The results in Table 2 also suggest that changes in the distribution of income have stronger effects on growth in rich countries than in poor ones. Moreover, our cross-country data support the notion of a Kuznets curve (see Gylfason and Zoega 2003a): Inequality tends to increase with income at low levels of income and to decrease with income at higher levels of income.

**Table 2****Further results: Gini interacts with initial income**

Dependent variable	Initial income	Natural capital	Investment rate	Enrolment rate	Gini times initial income	R <sup>2</sup>	Countries
Economic growth	-0.92 (4.62)	-0.06 (4.15)	0.10 (4.05)	0.85 (3.17)	-0.004 (2.68)	0.66	75
Investment rate		-0.13 (2.08)		1.42 (1.92)		0.22	87
Enrolment rate	20.90 (12.50)	-0.70 (4.39)				0.72	87
Gini coefficient				-0.16 (5.10)		0.32	75

Note: t-ratios are shown within parentheses. Constant terms, statistically significant throughout, are not reported.

How about education? In Table 3 we have replaced the Gini coefficient from Table 1 with the multiple of the Gini coefficient and the secondary-school enrolment rate. Again, the results are virtually the same as in Table 1 except for the changes in the coefficients of the enrolment rate and the new interaction variable. The direct effect of education on growth is now  $1.25/E - 0.01 \cdot Gini/E \approx 0.02$ , evaluated at the median values of  $E$  and  $Gini$ . This suggests that increased inequality in the distribution of income reduces the contribution of increased education to growth and also that the more educated the population, the stronger the adverse effect of increased inequality on economic growth.

Table 3

## Further results: Gini interacts with education

Dependent variable	Initial income	Natural capital	Investment rate	Enrolment rate	Gini times enrolment rate	R <sup>2</sup>	Countries
Economic growth	-1.11 (5.88)	-0.06 (4.30)	0.10 (3.97)	1.25 (4.50)	-0.010 (2.82)	0.67	75
Investment rate		-0.13 (2.08)		1.42 (1.92)		0.22	87
Enrolment rate	20.90 (12.50)	-0.70 (4.39)				0.72	87
Gini coefficient				-0.16 (5.10)		0.32	75

Note: t-ratios are shown within parentheses. Constant terms, statistically significant throughout, are not reported.

A similar pattern emerges when we replace the multiple of the Gini coefficient and the secondary-school enrolment rate in Table 3 by the multiple of *Gini* and the investment rate (not shown). The effect of investment on growth varies inversely with the Gini coefficient, which implies that large inequalities tend to spoil the efficiency of investments in physical as well as human capital. Also, high investment, like high school-enrolment, exacerbates the effect of inequality on growth.

When we replace the multiple of the Gini coefficient and the secondary-school enrolment rate in Table 3 by the multiple of *Gini* and our natural capital variable, both the natural capital variable and the new interaction variable turn insignificant (not shown). This suggests that inequality does not affect growth through natural resources. On the other hand, we have elsewhere reported evidence of interaction between inequality and natural capital in our growth equation suggesting that natural resources matter for growth through the distribution of income, among other channels (Gylfason and Zoega 2003a).

We also examined the possibility of interaction between initial income and education. Our results remained essentially unchanged except now the growth effect of increased secondary-school enrolment varied directly and significantly with initial income while the speed of convergence varied inversely

with enrolment (not shown). Our estimates of other linkages, reported in Tables 1–3, were not affected by this change in specification.

**Table 4****Further results: Dummy for Africa**

Dependent variable	Initial income	Natural capital	Investment rate	Enrolment rate	Gini coefficient	R <sup>2</sup>	African dummy
Economic growth	-1.02 (5.53)	-0.05 (3.65)	0.10 (4.18)	0.46 (1.58)	-0.03 (2.84)	0.68	-1.08 (2.70)
Investment rate		-0.12 (1.90)		0.36 (1.54)		0.22	-0.62 (0.40)
Enrolment rate	19.71 (10.58)	-0.63 (3.68)				0.73	-5.84 (1.30)
Gini coefficient				-0.17 (4.21)		0.32	-0.30 (0.11)

Note: t-ratios are shown within parentheses. Constant terms, statistically significant throughout, are not reported. The number of countries is the same as in Tables 1–3.

Our last experiment involves regional dummy variables. We want to make sure that the relationship between inequality and growth that we have documented here survives the introduction of dummies for Africa, Central and South America, and last but not least Asia. When we introduce a dummy for Africa into our model, either on its own or interacting with the Gini coefficient in the growth equation, the only material effect of this extension on our results is that our estimates of the effects of school enrolment on growth and of natural capital on investment become insignificant in a statistical sense. The results in Table 4 suggest that African countries have grown less rapidly than the rest of the world, invested less and sent fewer youngsters to secondary school, but only the growth effect is statistically significant. There is, in particular, no evidence that the Gini coefficient has been different in Africa than elsewhere.

When we repeat the experiment for Central and South America, we get the results shown in Table 5. Again, we find that the Central and South American countries have grown slightly less rapidly than the rest of the world, invested less, sent far fewer youngsters to secondary school and have had a vastly more unequal distribution of income – equivalent to 10 extra points in the Gini scale! However, only the last two effects are statistically significant. In other

respects, the results in Table 5 are similar as in Table 1 except the direct effect of the Gini coefficient on growth becomes marginally insignificant.

**Table 5**  
**Further results: Dummy for Central and South America**

Dependent variable	Initial income	Natural capital	Investment rate	Enrolment rate	Gini coefficient	R <sup>2</sup>	Central & South American dummy
Economic growth	-1.05 (5.56)	-0.06 (4.18)	0.10 (3.94)	0.85 (3.14)	-0.03 (1.78)	0.67	-0.25 (0.71)
Investment rate		-0.14 (2.34)		1.54 (2.11)		0.26	-2.43 (1.93)
Enrolment rate	21.32 (13.62)	-0.79 (5.27)				0.77	-16.00 (4.29)
Gini coefficient				-0.17 (6.08)		0.49	10.22 (5.08)

Note: t-ratios are shown within parentheses. Constant terms, statistically significant throughout, are not reported. The number of countries is the same as in Tables 1–3.

At last, we do the same for Asia. In Table 6, once again, our results do by and large remain unchanged. Now the regional dummy is significant in all four equations of our system. The Asian economies have grown faster, invested more, sent more of their youths to secondary school, and have tolerated less inequality in the distribution of income than the world at large. Thus, our results on inequality and growth around the world cannot be traced to Africa or Central and South America, nor, perhaps more surprisingly, can they be attributed to Asia's remarkable combination of rapid economic growth and greater equality in the distribution of income than has been achieved elsewhere in the developing world.

**Table 6****Further results: Dummy for Asia**

Dependent variable	Initial income	Natural capital	Investment rate	Enrolment rate	Gini coefficient	R <sup>2</sup>	Asian dummy
Economic growth	-0.81 (3.61)	-0.06 (4.22)	0.10 (3.89)	0.62 (2.24)	-0.03 (2.31)	0.67	0.82 (2.07)
Investment rate		-0.11 (1.87)		1.60 (2.22)		0.28	3.71 (2.55)
Enrolment rate	22.24 (12.96)	-0.63 (3.99)				0.75	15.33 (3.18)
Gini coefficient				-0.17 (5.57)		0.36	-5.44 (2.14)

Note: t-ratios are shown within parentheses. Constant terms, statistically significant throughout, are not reported. The number of countries is the same as in Tables 1–3.

## 5 Conclusion

We have described intuitively how endogenous growth can arise in an overlapping-generations model of education and growth and used it to argue that more and better education financed by public expenditure can encourage economic growth and reduce inequality in the distribution of income as well. We looked at data for 87 countries around the world and showed that, across countries, (i) economic growth varies inversely with inequality; (ii) three different measures of education intended to reflect education inputs, outcomes and participation are all inversely related to inequality; and (iii) economic growth varies directly with all three measures of education. We then used seemingly unrelated regression analysis to demonstrate that both education and inequality have a significant, independent impact on growth, even if education and inequality are closely correlated. Our conclusion is that education seems likely to encourage economic growth not only by increasing and improving human capital but also physical capital and social capital – that is, by reducing inequality. If so, the inverse association between inequality and economic growth since the mid-1960s that has been reported in the literature may in part reflect the favourable effects of more and better education on both economic growth and social equality.

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