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Where Has All the Education Gone?

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Cross-national data show no association between increases in human capital attributable to the rising educational attainment of the labor force and the rate of growth of output per worker. This implies that the association of educational capital growth with conventional measures of total factor production is large, strongly statistically significant, and negative. These are "on average" results, derived from imposing a constant coefficient. However, the development impact of education varied widely across countries and has fallen short of expectations for three possible reasons. First, the institutional/governance environment could have been sufficiently perverse that the accumulation of educational capital lowered economic growth. Second, marginal returns to education could have fallen rapidly as the supply of educated labor expanded while demand remained stagnant. Third, educational quality could have been so low that years of schooling created no human capital. The extent and mix of these three phenomena vary from country to country in explaining the actual economic impact of education, or the lack thereof.

To be a successful pirate one needs to know a great deal about naval warfare, the trade routes of commercial shipping; the armament, rigging, and crew size of potential victims; and the market for booty.

To be a successful chemical manufacturer in early twentieth century United States required knowledge of chemistry, potential uses of chemicals in different intermediate and final products, markets, and problems of large scale organization.

If the basic institutional framework makes income redistribution (piracy) the preferred economic opportunity, we can expect a very different development of knowledge and skills than a productivity-increasing (a twentieth century chemical manufacturer) economic opportunity would entail. The incentives that are built into the institutional framework play the decisive role in shaping the kinds of skills and knowledge that pay off.

—*Douglass North* (1990)

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People with more education have higher wages. This is probably the second (after Engel's law) most well-established fact in economics. It would seem to follow naturally that if more individuals are educated, average income should rise; if there are positive externalities to education, average income should rise by even more than the sum of the individual effects. The belief that expanding education promotes economic growth has been a fundamental tenet of development strategy for at least 40 years.[1] The post–World War II period has seen a rapid, historically unprecedented expansion in educational enrollments. Since 1960, average developing country (gross) primary enrollments have risen from 66 to 100 percent, and (gross) secondary enrollments from 14 to 40 percent.

How has this experiment in massive educational expansion turned out? Is there now strong evidence of the growth-promoting externalities to education? This is an area where growth theory and empirical estimates are potentially important. Positive externalities should mean that the impact of education on aggregate output is greater than the aggregation of the individual impacts. To test for externalities, we need macroeconomic and microeconomic models of education's impacts that are consistent. The augmented Solow model is just such a model because it predicts that the "no externality" impact of education should be the share of educational capital in factor income. This impact can be estimated from microeconomic evidence on the wage increments to capital. Within the augmented Solow model, the estimated growth impact of education is consistently *less* than would be expected (rather than more) from the individual impacts. The cross-national data suggests *negative* externalities and present something of a "micro-macro" paradox.

The path to resolving this paradox begins with an acknowledgment that the impact of education on growth has not been the same in all countries (Temple 1999). I discuss three possibilities for reconciling the macro and micro evidence and explaining the differences across countries. The first possibility is North's (1990) metaphorical piracy: Education has raised productivity, and there has been sufficient demand for this more productive educated labor to maintain or increase private returns, but the demand for educated labor comes, at least in part, from individually remunerative yet socially wasteful or counterproductive activities. In this case, the relative wage of each individual could rise with education (producing the micro evidence), even while increases in average education would cause aggregate output to stagnate or fall (producing the macro evidence). The second possibility is that expansion of the supply of educated labor when demand is stagnant could cause the rate of return to education to fall rapidly. In this case, the average Mincer returns (Mincer 1974) estimated in the 1960s and

1. The idea that either the "new" growth theory or the "neoclassical revival" has "discovered" the importance of human capital is belied by even a casual reading of Kuznets (1960), Lewis (1956), or Dennison (1967). Gunnar Myrdal's (1975) *Asian Drama*, written mostly in the late 1950s, already treats the importance of human capital along with physical capital in development as the conventional wisdom.

1970s overstated the actual marginal contribution to output from educational expansion in those instances where the demand for educated labor did not expand rapidly enough. Third, schooling quality may be so low that it does not raise cognitive skills or productivity. This could even be consistent with higher private wages if education serves as a signal to employers of some positive characteristics, such as ambition or innate ability.

I. Expansion of Education and Growth-Accounting Regressions

The first approach is to do what we would do if we did not know it was not going to work. That is, we will take the standard production function specifications of growth at the macroeconomic level, build aggregate measures of education capital from microeconomic data on education and its returns, and then examine the relationship between them.

How Much Should Education Matter? The Augmented Solow Model

Mankiw and others (1992) extend the Solow aggregate production function framework to include educational capital:

$$Y_t = A(t) * K_t^{\alpha k} * H_t^{\alpha h} * L_t^{\alpha l}, \tag{1}$$

assuming constant returns to scale ($\alpha_k + \alpha_h + \alpha_l = 1$), normalizing by the labor force, and taking natural logs to produce a linear equation in levels. But this "linear in log levels" specification can also be expressed in rates of growth. Because estimation in levels raises numerous problems (to which I return below), I focus on the relationship among percent per annum growth of output per worker ($\hat{y} = d\ln (Y/L)/dt$), growth of physical capital per worker, and educational capital per worker:[2]

$$\hat{y} = \hat{a} + \alpha_k * \hat{k} + \alpha_h * \hat{h}. \tag{2}$$

In the context of this model, $\hat{a}$ is the growth rate of the growth-accounting residual—and I will reluctantly follow convention and call this total factor productivity (TFP), even though it is not (Pritchett 2000a).

$$\hat{TFP} = \hat{y} - \alpha_k * \hat{k} - \alpha_h * \hat{h}. \tag{3}$$

The extended Solow approach facilitates simple nonregression-based estimates of how much the expansion of educational capital "ought" to matter. Because

2. Growth for each variable is calculated as the logarithmic least squares growth rate over the entire period for which the data are available. This makes the estimates of growth rates much less sensitive to the particular endpoints than if changes from the beginning period to the end period were calculated. This means the time period over which I calculate the growth rate does not always correspond exactly to the time period for the education data, but because both are per annum growth rates, this difference does not matter much.

the weights in the aggregate Cobb-Douglas production function represent the factor shares of national income, the coefficient on educational capital in a growth-accounting regression ought to be equal to the share of educational capital in gross domestic product (GDP) that can be estimated based on microeconomic data.

With constant returns to scale, labor share is one minus the physical capital share. A physical capital share of around 0.4 is somewhat high, but is consistent with a variety of evidence—the estimates from national accounts and from regression parameters—and with capital output ratios (if the capital-output ratio, K/Y, is 2.5 and the rate of return to capital is 16 percent, then the share of capital, rK/Y, is 40 percent). This implies a labor share of 0.6.

How much of the labor share is due to human (or educational) capital? One simple way of estimating the share of the wage bill attributable to human capital is to use the ratio of the unskilled—or "zero human capital"—wage, w_0, to the average wage, w:

$$\text{(4)} \qquad \textit{HUMAN CAPITAL SHARE (FROM WAGES)} = 1 - w_0 \,/\, w.$$

A calculation based on the distribution of wages in Latin America estimates a human capital share of wages of between 50 and 75 percent. Mankiw, Romet, and Weil (1992) use the historical ratio of average to minimum wages in the United States to estimate that half of wages are due to human capital.[3] Either of these calculations suggests a human capital coefficient (α_h) of at least 0.3.

Another approach to estimating the educational capital share is to assume a wage increment to education (taking the micro evidence discussed below at face value), and then use data on the fraction of the labor force in each educational attainment category to derive the educational capital share. Table 1 shows the results of two calculations. The top half shows the fraction of the labor force in various educational attainment categories in various regions. One can calculate the share of the wage bill due to educational attainment by assuming a wage premium for each attainment category and applying equation 5:

$$\text{(5)} \qquad \textit{EDUCATIONAL CAPITAL SHARE OF WAGES BILL} = \frac{\sum_{i=0}^{K} (w_i - w_0) * \gamma_i}{wL}$$

where i represents each of the seven educational attainment categories and γ_i are the shares of the labor force in each educational attainment category.

3. Using data on the distribution of workers' earnings (World Bank 1993a), we take the ratio of the average wages up to the 90th percentile (to exclude the effect of the very long tails of the earnings distribution) to the wage of those workers in either the 20th or 30th percentile (to proxy for the wage of a person with "no" human capital). The estimates of human capital share of the wage bill are 62 and 47 percent, respectively. If the top 10th percentile is included (and I take the ratio of average wages to the 20th or 30th percentile), the estimates of human capital share are even higher—74 and 63 percent, respectively. Although these are considerably higher that other estimates, they are estimates of all human capital, not just educational capital. In the United States, the ratio of the average to the minimum wage (taken as a proxy for the "unskilled" wage) has hovered around 2.

TABLE 1. Share of Educational Capital in Wage Bill

	Wage premia by educational attainment under assumption set:		Share of work force by educational attainment, 1985 (percent except where noted)				
	A	B	Developing countries	Sub-Saharan Africa	Latin American and Caribbean	South Asia	OECD
No schooling	1.00	1.00	49.7	48.1	22.4	69.0	3.3
Some primary	1.40	1.56	21.3	33.2	43.4	8.9	19.4
Primary complete	1.97	2.44	10.1	8.5	13.2	4.8	18.3
Some secondary	2.77	3.42	8.7	7.7	8.4	8.8	20.7
Secondary	3.90	4.81	5.9	1.6	5.5	5.3	20.1
Some tertiary	5.47	6.06	1.4	0.2	2.5	0.9	7.7
Tertiary	7.69	7.63	3.0	0.8	4.6	2.3	10.5
Average years of schooling			3.56	2.67	4.47	2.81	8.88
Calculated share of wage bill due to educational capital across regions under each assumption (percent)							
Assumption set A			36	26	43	30	62
(wage increment is constant at 10 percent)							
Assumption set B			49	38	56	42	73
(wage increments are: primary 16 percent, secondary 12 percent, tertiary 8 percent)							

Source: Data on educational attainment by region from Barro and Lee (1993).

Under assumption set A (constant wage increment of 10 percent per year of schooling), the educational share of the wage bill varies across regions, from 26.3 percent in Sub-Saharan Africa (SSA) to 62.1 percent in the Organisation for Economic Cooperation and Development (OECD); and it is 36.4 percent for developing countries as an aggregate. Under assumption set B (wage increments are proportionately higher for a year of primary than for a year of secondary, and higher for secondary than for tertiary, at 16, 12, and 8 percent, respectively), the share of educational capital in the total wage bill averages 49 percent—almost exactly half—for all developing economies, varying from 38 percent in SSA to 73 percent in OECD. Both methods suggest that the educational capital share of the wage bill should be between 0.35 and 0.7. Hence the growth-accounting regression coefficient on educational capital (α_h) ought to be between 0.21 and 0.42—with 0.3 in the middle of the range.

Data and Specification for Physical and Educational Capital

Using two recently created cross-national time-series data sets, I create estimates of the growth rate of per worker educational capital. The two data sets use different methods to estimate the educational attainment of the labor force. Barro and Lee (1993) estimate the educational attainment of the population age 25 and above using census or labor force data where available and create a full panel of five yearly observations over the period 1960–85 for a large number of countries by filling in the missing data using enrollment rates. Nehru and others (1995) use a perpetual inventory method to cumulate enrollment rates into annual estimates of the stock of schooling of the labor force–aged population, creating annual observations for 1960–87.

From these estimates of years of schooling of the labor force, I create a measure of *educational* capital from the microeconomic specification of earnings used by Mincer (1974). I assume the natural log of the wage (or more generally, earnings per hour) is a linear function of the years of schooling:

$$\ln(w_N) = \ln(w_0) + r * N, \tag{6}$$

where w_N is the wage with N years of schooling, N is the number of years of schooling, and r is the wage increment to a year's schooling. The value of the *stock* of educational capital at any given time, t, can then be defined as the discounted value of the wage premia due to education:

$$HK(t) = \Sigma_t^T \delta^t * (w_N - w_0), \tag{7}$$

where w_0 is the wage of labor with no education. Substituting the formula for the educational wage premia (equation 6) into the definition of the stock (equation 7) and taking the natural log gives equation 8 for the log of the stock of educational capital, we get

$$\ln(HK(t)) = \ln(\sum_{t=0}^{T} \delta^t) + \ln(w_0(t)) + \ln(e^{rN} - 1). \tag{8}$$

Therefore, the proportional rate of growth of the stock of educational capital is approximately[4]

$$hk\dot{}(t) \cong d\ln(\exp^{RN(t)} - 1) / dt. \tag{9}$$

Based on existing surveys of the large number of micro studies,[5] I calculate the growth of educational capital using equation 9, the data on years of schooling from either Barro and Lee (1993) or Nehru and others (1995), and an assumed r of 10 percent constant across all years of schooling.[6]

In addition to the measures of educational capital, I use two series created by a perpetual inventory accumulation of investment and an initial estimate of the "capital" stock, based on an estimate of the initial capital-output ratio (King and Levine 1994; Nehru and Dhareshwar 1993). As I have argued elsewhere, series constructed in this way cannot be treated as estimates of the physical capital stock relevant to the production function, because there is no underlying theoretical or empirical justification for doing so when governments are the main investors. Hence, they should be called by a purely descriptive acronym: *cudie* (CUmulated, Depreciated Investment Effort) (Pritchett 2000a). The two CUDIE series are highly correlated and give similar results, with the principal difference being that King and Levine (1994) use investment data from the Penn World Tables, Mark 5 (PWT5; Summers and Heston 1991), while Nehru and Dhareshewar (1993) use investment data from the World Bank.

The dependent variable is growth of GDP per worker from PWT5. This is conceptually more appropriate in growth-accounting regressions than GDP per person or per labor force–aged person (but, as argued below, the findings are robust).[7]

4. There are two reasons this formula is only an approximation. First, the discount factor is assumed constant and hence is factored out in the time rate of change. It does depend on the average age of the labor force (because the discount is only until time T, retirement), which certainly varies systematically across countries, but I am assuming that changes in this quantity over time are small. The second, potentially more serious problem is that I dropped out the growth rate of $\ln(w_{0(t)})$—the evolution of the unskilled wage term. This means my growth rate of human capital is really that component of the growth of human capital due to changes in years of schooling. For instance, Mulligan and Sala-i-Martin (1997) estimate a human capital stock in which increases in unskilled wages reduce human capital; this is technically correct, but certainly counterintuitive.

5. A survey by Psacharopoulos (1993) shows wage increments by region: SSA 13.4 percent; Asia 9.6 percent; Europe, Middle East, and North Africa 8.2 percent; Latin America 12.4 percent; OECD 6.8 percent; and an unweighted average of 10.1. In any case, the cross-national differences in the growth rate of educational capital are very robust to variations in the value of r.

6. One confusion (among many) in this literature is between the wage increment and the rate of return to education. The often-repeated assertion that "returns are higher to primary schooling" (as reported, for example, by Psacharopolous [1993]) seems true not because the increment to wages from a year of primary school is *higher* than for other levels, but because the opportunity cost of a year of primary schooling is much *lower*. This is due to the fact that the typical forgone wage attributed to a primary-age unschooled child is very low (Bennell 1996). What is relevant to growth accounting is the increment to wages, not the cost-inclusive return.

7. This output variable does raise one problem. My estimates of human capital are based on estimates of the educational capital of the labor force–aged population, whereas my output is output per estimated labor force (although not corrected for unemployment), so that systematic differences in the

Regression Results for Growth and TFP

The results for estimating the growth-accounting equation (2) for the entire sample of countries[8] are reported in column 1 of Table 2. The partial scatter plot is displayed as figure 1. The estimates for cumulated physical investment (CUDIE) correspond reasonably well to national accounts-based estimates of the capital share (although 0.52 is somewhat on the high side) and are strongly significant (t = 12.8). Very much on the other hand, the estimate of the impact of growth in educational capital on growth of per worker GDP is *negative* (–0.049) and insignificant (t = 1.07). Adding the initial level of GDP per worker (column 2) has no impact on the negative estimates of the effect of education (–0.038).

Columns 8 and 9 of table 2 show the results of regressing TFP growth on the growth of physical CUDIE and educational capital. In column 9, the assumed factor shares used in creating TFP are 0.4 (physical) and 0.3 (educational). The growth of educational capital shows a large, statistically very significant (t = 6.91) and *negative* (–0.338) effect on TFP growth. In column 10, I make the educational capital share as small as is consistent with growth accounting by assuming the physical capital share is on the high side (0.5) and the share of educational capital in the wage bill is on the low side ($0.\bar{3}\bar{3}$), so that the educational capital share is as low as it can reasonably be ($1/2 \times 1/3 = 0.167$). It is still the case that educational capital accumulation is strongly statistically significant and *negatively* related to TFP growth. Of course, except for fixing the physical capital share, this TFP regression is equivalent to a t-test that finds the estimated human capital share equal to 0.167. Using the results of column 1, this hypothesis is easily rejected ($t = [-0.049 - 0.167] / 0.046 = 4.72$).

These TFP results are a simple arithmetic trick, but this trick is useful because it changes a typically uninteresting "failure to reject" to a convincing rejection of an interesting and policy-relevant hypothesis. The findings are not a "low-powered" failure to reject zero—they are a "high-powered" failure to reject, because although the data do not reject zero, they do in fact reject a wide range of interesting hypotheses—including the hypothesis that the growth impact is as large as the microeconomic data would suggest. After all, the primary reason to use aggregate data to estimate the impact of schooling is to find out whether the

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evolution of the labor force versus the labor force–aged population (say, through differential female labor force participation) could affect the results. The question of whether or not *changes* in female labor force participation (cross-national level differences would not affect the results) are an important part of the story is beyond the scope of this article. With the currently available gender-disaggregated data, this is an active research question, with some arguing that female education is more important for growth, and others arguing that it is less important, than male schooling.

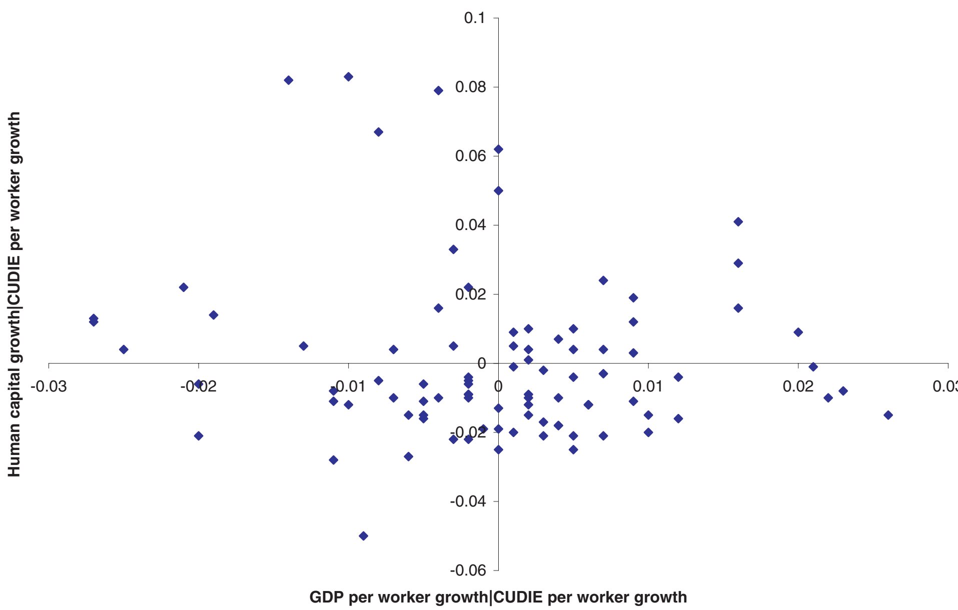
8. Four countries have been dropped from all regressions because of obvious data problems: Kuwait, because PWT5 GDP data are bizarre; Gabon, because labor force data (larger than the population) are clearly wrong; Ireland, because the Nehru and others (1995) data report an average of 16 years of schooling (immigration has distorted these numbers); and Norway, because Barro and Lee (1993) report an impossible increase of 5 years in schooling over a period of 5 years.

TABLE 2. Growth-Accounting Regressions of GDP per Worker Growth with Educational Capital and CUDIE per Worker Growth

	Per annum growth of GDP per worker (GDPPW)						Level GDPPW	TFP as defined in text	
Dependent variable	1 OLS (entire sample)	2 OLS (with initial GDPPW)	3 OLS (on just IV sample)	4 IV (w/ Nehru and others [1995] educ. capital data)	5 IV (w/ similar country)	6 OLS (sample of countries with test scores)	7 OLS (on level in 1985, whole sample)	8 OLS (factor shares, $\alpha_K = 0.4$, $\alpha_H = 0.3$)	9 OLS (factor shares, $\alpha_K = 0.5$, $\alpha_H = 0.167$)
Growth of education capital per worker[a]	–0.049 (1.07)	–0.038 (0.795)	–0.091 (1.61)	–0.120 (1.42)	–0.088 (0.593)	0.058 (0.229)	0.136 (1.97)	–0.338 (6.91)	–0.205 (4.19)
Growth of CUDIE per worker[a]	0.524 (12.8)	0.526 (12.8)	0.458 (10.19)	0.460 (10.18)	0.527 (12.42)	0.592 (6.78)	0.612 (14.88)	0.126 (3.08)	0.026 (0.651)
ln (initial GDP per worker)		0.0009 (0.625)						0.0009 (0.625)	0.0009 (0.0625)
Test score (normalized, mean = 1)						0.014 (1.31)			
Test score * EK						–0.485 (1.27)			
Number of countries	91	91	70	70	77	25	96	91	91
R^2	0.653	0.655	0.611	—	—	0.71	0.909	0.419	0.205

Note: t-statistics in parentheses.
[a]Except in column 7, which uses levels.
Source: Author's calculations.

FIGURE 1. Partial Scatterplot of Growth of GDP per Worker and Educational Capital per worker, Conditioned on CUDIE per Worker



impact is higher (or lower) than expected from the microeconomic data, and hence to provide some indication of the presence (or absence) of externalities. But to speak to this question, growth regressions using aggregate data must demonstrate not only that the educational capital coefficient is not zero but that it is higher than the value expected, given the microeconomic evidence applied to the same growth model. This is a seemingly modest standard, but one that has never been met.

Before proposing explanations of this apparent micro-macro paradox of negative externalities, I first show that this result is robust to sample, data, and technique and that it is not the result of "pure" measurement error or failure to account for school quality.[9]

The estimated coefficient is not the result of a peculiar sample or a few extreme or atypical observations. To ensure robustness against outliers, individual observations identified as influential were sequentially deleted up to 10 percent of the sample size, with no qualitative change in results.[10] The negative

9. I do not show that the results are robust to the introduction of other covariates (Levine and Renelt 1992). This is because I am interested in growth accounting within a specific growth model that takes a production function approach. Thus there is no scope to introduce other covariates arbitrarily, as in the "reduced form" literature.

10. An observation is identified as influential based on the difference in the estimate with and without the observation included (Belsley and others 1980). Temple (1999) working on a different data set,

coefficient on schooling growth persists if (a) only developing countries are used, (b) all observations from SSA are excluded, or (c) regional dummies are included.

The results are also robust to variations in the data used for education, CUDIE, or GDP. All the regressions in table 2 were also estimated using Nehru and others' (1995) estimates of educational capital, and the educational capital coefficient estimates are similar: consistently negative.[11] Changing the data on growth and using World Bank growth rates of GDP in constant prices in local currency instead of the PWT5 GDP data gives similar results. Using growth of GDP per person or per labor force–aged population produces an even larger negative estimate for education. Relaxing the assumption of constant returns to scale does not alter the negative estimate on educational capital. Using weighted least squares with either (log of) population, GDP per capita, or total GDP because the weights also gives nearly identical results.

The finding using *level-on-level* specifications of the augmented Solow equation in table 2, column 7 shows a coefficient of 0.13 (t = 1.97)—which continues to reject $H_0 : \alpha_h = 0.3$, $t = 2.37$. However, there are good reasons to believe level-on-level coefficients will be biased upward. If this educational capital coefficient is biased upward by as much as the CUDIE results appear to be (by about 0.1), then the small negative coefficient in the *growth-on-growth* regressions are consistent with the small positive coefficients in the level-on-level regressions.

Although both sets of educational attainment data have been roundly criticized on a number of legitimate grounds (Behrman and Rosenzweig 1993, 1994), I use two different instruments to show that this particular result on educational capital is not the result of pure measurement error in the estimates of years of schooling. Using the growth of Nehru and others' (1995) educational capital as an instrument for Barro and Lee's (1993) educational capital (the correlation of the two series' growth rates is.67), the coefficient becomes slightly more negative: –0.12 (column 4 of table 1) versus –0.091 for ordinary least squares (OLS) in the same sample (column 3). In addition, I also match each country with a similar country, usually picking the geographically closest neighbor, based on the idea that educational capital growth rates in similar countries are likely to be correlated (the actual correlation was $\rho = 0.316$), whereas the pure measurement error in similar countries' reported enrollment and attainment rates is plausibly uncorrelated (and certainly less than perfectly correlated). This IV coefficient in table 2, column 5 is also negative (–0.088). Correcting for pure

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finds that there is substantial parameter homogeneity and that a significant fraction the sample must be dropped to recover a significant positive coefficient on education. I take this to indicate not a lack of robustness but substantial parameter heterogeneity—a point to which I return below.

11. These are reported in Pritchett (1996), an earlier version of this article. In that paper, the basic ordinary least squares regression using the other data set was $\hat{y} = c + 0.501\hat{k}_{(15.4)} - 0.104_{(2.07)}\hat{h}$, $N = 79$, $r^2 = 0.557$ (t-statistics in parentheses).

measurement error makes the estimates more negative (which is to be expected, as measurement error produces attenuation bias), and hence only deepens the puzzle.[12]

Recently, Krueger and Lindahl (2000) have criticized Benhabib and Spiegel (1994), based on the latter's older estimates of educational stocks. Krueger and Lindahl (2000) claim that Benhabib and Spiegel's (1994) findings are not robust to pure measurement error. However, this criticism is not relevant to the present article (for which much of the work was done several years before the Krueger and Lindahl paper) for three reasons. First, I use newer data sets, not the Kyriacou (1991) data used in Benhabib and Spiegel (1994). Second, my use of IV to correct to measurement error is exactly the same conceptual approach as Krueger and Lindahl's (2000), and I do not find that IV reverses any findings. Third, Krueger and Lindahl (2000) focus particularly on the measurement error of growth rates over short (e.g., five-year) periods, and argue, rightly, that measurement error is a larger concern in differenced data. In any case, the results in Krueger and Lindahl's (2000) table 5, column 5, which are the most similar to those presented here (in that they control for physical capital with an unconstrained coefficient and instrument for the education variable), find an empirically modest but statistically insignificant impact of schooling (t = 0.41). The bound of two standard deviations on Krueger and Lindahl's estimate of the aggregate equivalent of the Mincerian rate of return ranges from *negative* 44 percent to *positive* 67 percent. The major difference between our results is that I use the percentage rate of growth in the value of educational capital (which is essentially a logarithmic specification; see equations 6–9), whereas they use absolute change in the years of schooling.

A different, deeper notion of measurement error is that while the years of schooling are correctly measured, the true problem is that years of schooling do not reflect learning. However, while differences in educational quality can account for *heterogeneity* in the impact of schooling, it should not explain a low *average* impact. In fact, due to the "general underlying positive covariance between quantity and quality of schooling" (Schultz 1988), one would expect that excluding quality would bias the estimated return *upward*, as more schooling is accumulated where quality is high.[13] For lack of quality adjustment to explain the results or quantities in the aggregate, there would have to be a very strong inverse cross-national relationship between quality and the expansion of quantity—a relationship for which there is no evidence.

The quality of schooling across countries is impossible to measure without internationally comparable test examinations of comparable groups of students,

12. Using instruments for physical CUDIE and educational capital simultaneously, to correct for measurement error in both has very little impact on the estimates of educational capital.

13. For instance, Behrman and Birdsall (1983) have shown, for Brazil, that not controlling for school quality leads to *overestimating* the impact of years of schooling by a factor of two.

and these, unfortunately, exist for very few countries.[14] Hanushek and Kim (1995) use test score data to show that test score performance has a positive and statistically significant coefficient as an independent variable in a growth regression.[15] However, in this case the interest is in the impact of an increase in educational capital, and the expected functional form when schooling quality matters would be an interactive effect: the impact of an additional unit of educational capital is higher when the quality of schooling is higher. I estimate this functional form using a single observation on test scores for each of the 25 countries used by Hanushek and Kim (1995), normalized to a mean of one, to interact with the growth of the educational capital stock. As shown in table 2, column 7, while the estimated impact of education is higher with higher quality (although the interactive coefficient is statistically insignificant), it is still the case that, evaluated at the average level of quality (test score = 1), the education impact is substantially less than zero (0.06 – 0.48 = –0.42). This suggests that, as expected, the lack of control for quality causes an *upward* bias, so the negative estimates that do not control for quality are not negative enough.

Relationship to Other Empirical Results on Schooling

As surprising as these negative results may seem, they are similar to what other researchers have found when they examined the relationship between education and growth using either growth-on-growth or level-on-level regressions. Benhabib and Spiegel (1994) and Spiegel (1994) use a standard growth-accounting framework that includes initial per capita income and estimates of years of schooling from Kyriacou (1990), and find a negative coefficient on growth of years of schooling.[16] Lau and others (1991) estimate the effects of education by level of schooling (primary versus secondary) for five regions and find that primary education has an estimated negative effect in Africa and Middle East North Africa,

14. One possible way out of the lack of quality measures is to use proxies for quality. However, there is no particular reason to believe that physical indicators (such as teacher-to-pupil ratio or resources expended per student) will adequately proxy quality, and many reasons to believe they will not. Hanushek and Kim (1995) explore the connections between these indicators and test scores to extrapolate a quality when it is not available, but with little success. Because schooling is typically publicly provided, there is no reason to believe that dollars spent will be closely associated with output (that is, one cannot apply the usual theory about the relationship between inputs and outputs derived from production theory of profit maximizers). There is a huge amount of literature on the impact on achievement of various physical and financial measures of resources expended per student, with generally ambiguous results (see, for example, Filmer and Pritchett [1999]).

15. However, one could easily suspect that any variable—for example, test scores—on which countries such as Singapore (the highest, 72.1) and Hong Kong (71.8) do well and countries such as Nigeria (38.9) and Mozambique (27.9) do poorly, might well be capturing more in a growth regression than just labor force quality.

16. Spiegel (1994) shows that the finding of a negative effect of educational growth is robust to the inclusion of a wide variety of ancillary variables (e.g., dummies for SSA and Latin America, size of the middle class, political instability, share of machinery investment, inward orientation), and to the inclusion of samples.

insignificant effects in South Asia and Latin America, and positive and significant effects only in East Asia. Jovanovich and others (1992) use annual data on a different set of capital stocks and Nehru and others' (1995) education data and find negative coefficients on education in a non-OECD sample. Behrman (1987) and Dasgupta and Weale (1992) find that changes in adult literacy are not significantly correlated with changes in output. The World Bank's *World Development Report* on labor also reports the lack of a (partial) correlation between growth and education expansion (World Bank 1995, figure 2.4). Newer studies using panels to allow for country-specific effects consistently find *negative* signs on schooling variables (Islam 1995; Caselli and others 1996; Hoeffler 1999).[17]

Some very early studies used enrollment rates in growth regressions (Barro 1991; Mankiw and others 1992), but this approach had and has two deep problems. First, especially in Mankiw and others (1992), secondary enrollment rates alone were used—but without any clear or compelling reasoning as to why both primary and tertiary enrollment rates should have been excluded. Second, enrollment rates are a terrible proxy for growth in years of schooling.[18] The assumption that current (or average) enrollment rates adequately proxy a country's steady-state stock is true only if enrollment rates are constant over time across countries—but this is contradicted by the massive recent expansion of schooling in developing countries (Schultz 1988). The correlation between the growth of educational capital and secondary enrollment rates is –0.41. This is because the *growth* of educational attainment depends not on the current enrollment rate but on the *difference* in the enrollment rate between the cohort leaving the labor force and the cohort entering the labor force.[19]

17. However, these studies are susceptible to the Krueger and Lindahl (2000) critique about exacerbation of measurement error in short (five-year) panels. Moreover, the dynamic properties of the educational series, which tend to have little time series variation within countries, make it difficult to identify impacts of education in any case (Pritchett 2000b).

18. This does raise the question of why, if they are not a valid proxy for accumulation of schooling, initial secondary enrollment rates are a reasonably robust correlate of subsequent growth rates. My conjecture is the nature of "conditional convergence" regressions—that is, both the initial level of income and initial secondary enrollment rate are on the right-hand side of the equation with growth on the left-hand side. It is not unreasonable to assume that high secondary enrollment rates conditional on income level *may* signal something good about a country's growth prospects (e.g., the government's provision of good schools might mean it does other things well, the country has a substantial middle class, or people anticipate the country will do well; but it could also mean income is temporarily low), quite independent of the impact via accumulation of educational capital.

19. Comparing Korea and Great Britain provides a simple illustration. Korea's secondary enrollment rate in 1960 was 27 percent, while Great Britain's was 66 percent. But the level of schooling of Great Britain's labor force in 1960 was 7.7 years, and the level of Korea's was 3.2 years. Subsequently, Great Britain's enrollment rate increased to 83 percent by 1975 and then remained relatively constant, whereas Korea's enrollment rate increased from 27 to 87 percent by 1983. Given these differences in initial stocks and the large changes in enrollment rates, Korea's average years of schooling expanded massively from 3.2 to 7.8 by 1985, but Great Britain's expanded only modestly from 7.7 to 8.6, even though Great Britain's enrollment rate was higher than Korea's for most of the period.

Another section of the literature uses the initial *level* of the stock of education to explain *growth* of output per capita. Benhabib and Spiegel (1994) show that if the initial *level* of education is added to a growth-accounting regression, the initial *level* of education is positive, whereas the mildly negative impact of the *growth* of educational capital persists. This finding of a level effect is actually much more puzzling than is generally acknowledged, as the spillover effects of knowledge that might be captured by an effect of the level of education in the endogenous growth literature should be *in addition to* rather than *instead of* the usual direct productivity effects. Finding *only* a spillover impact is grossly inconsistent with the microdata: If the entire return to education at the aggregate level is spillover effects, then why is the wage premium observed at the individual level?

Moreover, a regression with growth rates on the left-hand side and level of education on the right-hand side is either misspecified or a complicated way of imposing parameter restrictions. The obvious fact that growth rates are stationary (without drift) while the stock of education is nonstationary and secularly increasing implies there cannot be a stable relationship between the *growth* of output and the *level* of education (Jones 1995).[20] Growth regressions that include initial levels of both education and output are only justified if education levels (nonstationary) are cointegrated with levels of income (nonstationary). But in that case, this specification still begs the original question, because to fully implement the error correction model one must still estimate the cointegrating relationship.

II. Why (and Where) Has Schooling Contributed to Growth?

So there is an apparent micro-macro contradiction. The microeconomic evidence is commonly (if naively) taken to mean that substantial wage increments from additional schooling are nearly universal and that additional schooling will lead to growth. The macroeconomic data in an entirely standard growth accounting model suggest that education has not uniformly had the growth impact the microeconomic data would suggest. The obvious resolution is that the impact of education has varied widely across countries (Temple 1999).[21] The question

20. Ben-David and Papell (1994) use Angus Maddison's historical data and find that growth rates are stationary after allowing for one structural break. This criticism applies to all endogenous growth models that make growth rates a function of any nonstationary variable (such as the magnitude of research and development or the stock of knowledge) while growth rates are stationary (Jones 1995).

21. Not surprisingly, the data, when unconstrained, do not say that schooling has contributed to output to exactly the same degree in Korea, Zaire, Paraguay, and Hungary. Parameter homogeneity does not change the fact that the unconstrained estimates are well below the expected level, on average. Hence, there must be a number of countries for which education appears to have had less than the expected "standard augmented Solow model no externality" growth impact if wage increments were on the order of 10 percent.

is why. In those countries that have had substantial improvements in educational attainment of the labor force yet still face declining real wages and slow economic growth, the question must be asked: Where has all the education gone? I do not propose a single answer, but put forward three possibilities that could account for the results:

- The newly created educational capital has gone into piracy; that is, privately remunerative but socially unproductive activities.
- There has been slow growth in the demand for educated labor, so the supply of educational capital has outstripped demand and returns to schooling have declined rapidly.
- The education system has failed, so a year of schooling provides few (or no) skills.

These possibilities are not mutually exclusive; all are likely to be present to varying degrees in every country. I will discuss each briefly, with some indication of the evidence that would support or contradict each approach in a given country. (For a more extensive discussion, see Pritchett 1996.)

Are Cognitive Skills Applied to Socially Productive Activities?

> Rent seeking in our [African] economies is not a more or less important phenomenon, as would be the case in most economies. It is the centerpiece of our economies. It is what defines and characterizes our economic life.
>
> —*Meles Zenawi, Prime Minister of Ethiopia, September 5, 2000*

One way to reconcile high wage increments to schooling with a small (and differential) macroeconomic impact of education is to argue that social and private rates of return to education diverge due to distortions in the economy. North's (1990) powerful metaphorical comparison of piracy and chemical manufacturing in the introduction suggests the problem. Rent seeking and directly unproductive activities can be privately remunerative but socially dysfunctional and reduce overall growth. If the improved cognitive skills acquired through education are applied to piracy, this could explain both the micro returns (rich pirates) and small macro impact (poor economies). Several pieces of evidence suggest this is at least part of the puzzle.

In many developing economies, the public sector has accounted for a large share of the expansion of wage employment in the 1960s and 1970s (table 3). This is not to equate government or the magnitude or growth of government employment with the magnitude of rent seeking. Nor am I saying that the expansion of education in government is necessarily unproductive. On the contrary, the most successful of developing countries have had strong and active governments and highly educated civil servants hired through a very competi-

Table 3. Share of Wage Employment Growth Accounted for by Public Sector Growth in Selected Developing Countries

Country	Period	Average growth of wage employment (percent per annum)			Public sector (percentage of total increase)
		Public	Private	Total	
Public sector employment growth positive, private wage employment growth zero or less					
Ghana	1960–78	3.4	–5.9	–0.6	
Zambia	1966–80	7.2	–6.2	0.9	418
Tanzania	1962–76	6.1	–3.8	1.6	190
Peru	1970–84	6.1	–0.6	1.1	140
Egypt	1966–76	2.5	–0.5	2.2	103
Brazil	1973–83	1.4	0	0.3	100
Public sector employment growth more than half of total wage employment growth					
Sri Lanka	1971–83	8	0.9	3.9	87
India	1960–80	4.2	2.1	3.2	71
Kenya	1963–81	6.4	2	3.7	67
Public sector growth faster, but less than half of total wage employment growth					
Panama	1963–82	7.5	1.8	2.7	45
Costa Rica	1973–83	7.6	2.8	3.5	34
Thailand	1963–83	6.3	5.5	5.7	33
Venezuela	1967–82	5.1	3.4	3.7	27
Unweighted mean		5.5	0.3	2.4	

Source: Derived from Gelb and others (1991), table 1.

tive process (World Bank 1994).[22] The question is not *whether* educated labor flows into the government, but *why* the government hires educated workers (actual need versus employment guarantee) and *what* they do once they are in the government (productive versus unproductive or rent-seeking activities).

Murphy and others (1991) present a simple model of the allocation of talent in which, if returns to ability are the greatest in rent seeking, then economic growth is inhibited by drawing the most talented people away from productive sectors into rent seeking. Anecdotal evidence that rent seeking attracts educated labor abounds. There is the possibly apocryphal (but nevertheless instructive) story of one West African nation with an employment guarantee for all university graduates. In a year when the exchange rate was heavily overvalued (and hence, there was a large premium on evading import controls), 60 percent of university graduates in all fields designated the customs service as their preference for government employment.

Explicit or implicit government guarantees of employment for the educated have been common and have led to large distortions in the labor market. In Egypt,

22. Wade (1990) asserts that college graduates are as likely to enter government service in Korea and Taiwan as in African economies.

government employment guarantees led to notoriously overstaffed enterprises and bureaucracies. In 1998, the government and public enterprises employed 70 percent of all university graduates and 63 percent of those with education at the intermediate level and above (Assaad 1997). Gersovitz and Paxson (1995) calculate that in 1986–88 in Côte d'Ivoire, 50 percent of all workers between age 25 and 55 that had completed even *one grade* of postprimary education worked in the public sector. Gelb and others (1991) built a dynamic general equilibrium model in which government responds to political pressures from potentially unemployed educated job seekers and becomes the employer of last resort for educated labor force entrants. They show that when both employment pressures are strong and the government is highly responsive to those pressures, the employment of surplus educated labor in the public sector can reduce growth of output per worker by as much as 2 percent a year (from a base case growth of 2.5 percent).

Stagnant Demand for Educated Labor

A second explanation for smaller growth returns from expanding education than from wage increments might suggest that the *marginal* return to adding an additional year of schooling economy-wide can be dramatically different from the *average* returns estimated from a cross-sectional Mincer (1974) regression on wage employment at a single point in time. Depending on the shift in the demand for and supply of educated labor, and on the mechanism of labor market adjustment, the wage premia can rise or fall. In different countries there is evidence of rising, falling, stable, or vacillating returns to schooling. Mincer coefficients in the United States have increased (at the median) from 0.063 to 0.096 (Buchinksy 1994). The returns to schooling in Egypt fell significantly in the 1980s (Assaad 1997). Funkhouser (1994) shows quite stable Mincer returns for five Central American countries over several years. Montenegro (1995) shows that the Mincer coefficient in Chile varied from 0.095 to 0.167 between 1960 and 1993—falling, then rising, then falling again over this period.

There are two basic stories to explain the demand for educated labor (including by the self-employed). One is that education conveys skills that make labor more productive. In this case, the demand for educated labor will rise when the skill intensity of the economy rises. The second is that more educated individuals are able to adapt more quickly to disequilibrium (Schultz 1975). In this case, the demand for educated labor will rise when there are greater gains to adapting to disequilibrium. These two stories of the source of returns to education are difficult to distinguish empirically, but both suggest that growth of educational capital would have a larger impact on output growth when policies are in place to ensure either that sectoral shifts lead to higher skill intensity, or that the creation or assimilation of knowledge is higher (even within the same sector), or both.

One can easily imagine a scenario in which a Mincer regression based on wage employment shows very high returns and yet, in the absence of expansion of the wage employment sector (assume, for now, this is the skill-intensive sector), these returns could fall very fast so that the marginal return to additional education is very small. Table 4 (adapted from Bennell 1996) shows that in many African countries, expansion of the number of newly educated laborers has often exceeded expansion of wage employment by more than an order of magnitude. Under these conditions, the returns to education could fall very fast.

Even without sectoral shifts, the returns to education would be higher where technological progress was rapid, thus requiring constant adaptation to technologically induced disequilibrium. Schultz (1975) argues that in a technologically stagnant agricultural environment the production gains from education would be zero, as even the least educated could eventually reach the efficient allocation of factors. In this case, only when new technologies and inputs are available does education pay off, and then only in transition to the new equilibrium. Foster and Rosenzweig (1996) find that the return to five years of primary schooling versus no schooling in the average Indian district studied was a modest 11 percent (an average increase of 446 rupees in farm profits). However, returns to schooling were higher in those districts where agricultural conditions were intrinsically conducive to the adoption of Green Revolution technologies (which they proxy by the exogenous increase in average farm profits). In a district where farm profits are one standard deviation above the average due to technical

Table 4. Growth of Enrollments and of Wage Employment in Selected Sub-Saharan African Countries

Country	Change in enrollments (thousands)	Change in wage employment (thousands)	Ratio, expansion of enrollment to wage employment	Wage employment as percentage of total labor force
Enrollment growth positive, wage employment falling				
Zambia	446	–4.3	—	13.1
Côte d'Ivoire	323	–7.7	—	9
Enrollment growth exceeds wage employment growth by an order of magnitude				
Sierra Leone	257	8.9	29	4.9
Uganda	225	13.2	17	4.7
Ghana	1312	80	16	3.8
Burkina Faso	351	35.4	10	3.8
Lesotho	142	14.9	10	5.4
Enrollment growth higher by factor of 4				
Senegal	180	45.4	4.0	5.5
Kenya	1709	436	3.9	14.1
Malawi	546	143	3.8	13.7
Rough equality of enrollment and wage sector growth				
Botswana	157	122	1.3	50.4
Zimbabwe	135	111.1	1.2	36.6

Note: Growth rates of enrollments and wage sector growth are calculated from the beginning date of the study estimating Mincerian return to 1990 (or the most recent data).

Source: Bennell (1996), table 5.

progress, the return to primary schooling was 32 percent—almost three times higher. However, the converse of high returns with rapid progress is that the estimated returns to schooling were *negative* in those districts in which progress was low.[23]

Rosenzweig (1996) uses data across districts of India to show the pitfalls in cross-sectional regressions when technological progress varies exogenously. In a cross-section of Indian districts, education is correlated with economic growth. But Rosenzweig (1996) shows that once varying exogenous technical progress is introduced, this technological progress explains both the higher economic growth and higher returns to education (and the higher returns lead to greater expansion in the amount of education). Although schooling has paid off handsomely where the Green Revolution brought technological advances, education has not been an important determinant of local growth in technologically stable areas, and the apparent impact of education from cross-district regressions disappears.

If some countries' policies are more conducive to the creation or assimilation of technical progress or to development patterns that are skill intensive, then one could expect that the output impact of a given expansion of schooling could be higher or lower. For instance, many argue that more open trade regimes in developing countries would facilitate catch-up and lead to more rapid technical progress, and that the returns to education would depend, at least in part, on complementary policies such as reasonable outward orientation (World Bank 1994).

Did Schooling Create Skills?

Direct evidence from internationally comparable examinations shows substantial variation in schooling quality—and that children in some developing countries lag far behind OECD and East Asian countries. Low quality of schooling is consistent with the macroeconomic evidence and is obviously consistent with the household evidence of little or no wage increment from additional schooling.

However, in countries where there is a reliably demonstrated microeconomic return but no apparent macroeconomic impact of schooling, a more sophisticated "low quality" explanation of the paradox is needed. A signaling model of the labor market is consistent with schooling that creates few skills and yet substantial observed wage impacts. If workers with high initial (or innate) ability have an easier time staying in school than workers with low initial ability, employers will pay more for schooled workers even though schooling has no impact on skills or productivity (Spence 1976).

23. When average district farm profits were more than two-thirds of a standard deviation below the country average, the point estimate of education was *negative*. This explanation of the interaction of demand and supply for education due to different rates of technological progress might suggest the reason education appears not to have paid off in such places as SSA. Several recent studies have found very little return to education in farming in Africa (Gurgand 1995; Joliffe 1995). If there has been little exogenous change in the technical production functions appropriate for more educated farmers to adopt, it is because Green Revolution innovations were not appropriate for African agriculture.

There is mixed evidence of a signaling function of schooling. "Sheepskin" effects—in which the completion of a level of education has substantially more labor market impact than would be expected from the skills acquired at that level—are common and can be taken as indication of schooling as a filter. However, there are at least three sources of evidence against an argument that the *entire* wage impact of schooling is signaling. First, several studies from developing countries with data on ability, skills, and schooling suggest that signaling effects are small (Knight and Sabot [1990], containing data on Kenya and Tanzania; Glewwe [1991] with data on Ghana; and Alderman and others [1996], with data on Pakistan). Second, the limited evidence of the impact of education on the productivity of farmers (Jamison and Lau 1982) or the self-employed is harder to explain by signaling. Finally, even for SSA countries, where one might suspect low educational quality, evidence from the Demographic and Health Surveys shows a 24 percent lower child mortality rate where women have a primary education as opposed to no education (Hobcraft 1993). This is hard to explain if schooling has no impact on knowledge.[24]

III. Conclusion

In the decades since 1960, nearly all developing economies have seen educational attainment grow rapidly. The cross-national data show, however, that on average, education contributed much less to growth than would have been expected in the standard augmented Solow model. Where did all the education go?

There are three possible explanations for the differences across countries in the impact of schooling on growth in economic output:

- In some countries, schooling has created cognitive skills and these skills have been in demand, but to do the wrong thing. In other countries, the institutional environment has been sufficiently bad that the bulk of newly acquired skills has been devoted to privately remunerative but socially wasteful or counterproductive activities—that is, the expansion of schooling has meant the country just has better-educated pirates.
- The rate of growth of demand for educated labor (due in part to different sectoral shifts, in part to policies, in part to exogenous differences in technological progress) has varied widely across countries, so countries with the same initial individual returns and equal subsequent expansions in the supply of educated labor could have seen the marginal returns to education fall dramatically, stay constant, or rise.
- In some countries, schooling has been enormously effective in transmitting knowledge and skills, while in others it has been essentially worthless and has created no skills.

24. But it is not impossible to explain, as the education–health linkage might be entirely the result of intergenerationally correlated endowments or preferences.

No two countries follow exactly the same pattern, and each explanation contributes a different amount to explaining the overall impact of schooling on growth in different countries.

None of the arguments in this article suggest that governments should invest less in basic schooling, for many reasons. For one thing, most (if not all) societies believe that at least basic education is a *merit* good, so that its provision is not and need not be justified on economic grounds at all—a position with which I strongly agree. To deny a child an education because of a small expected economic growth impact would be a moral travesty. In addition, schooling has a large number of direct beneficial effects beyond raising economic output, such as lower child mortality. All education can raise cognitive skills, with everything that implies. The implication, therefore, of a poor past aggregate payoff from increased cognitive skills in a perverse policy environment is not "don't educate," but rather "reform *now* so that investments (past and present) in cognitive skills will pay off."

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