Educational Expansion
Evidence and Interpretation

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Abstract

This paper documents the vast expansion of schooling over the past several decades as well as convergence in schooling measures across countries. It makes the observation that poor countries today have higher average education levels than countries at the same level of economic development used to have in the past. A simple model is proposed which suggests that these trends can be attributed to the intertemporal expansion of the world technological frontier, which enhances the demand for schooling. The empirical analysis supports the view that the educational expansion has occurred because of the increase in demand, especially in open economies, and not because of cost reducing improvements in the education sector.

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1. Introduction

This paper attempts to evaluate and interpret the expansion of education around the world in its relationship to economic development. Accumulation of human capital, alongside with that of physical assets, has been widely viewed as a central component of development. The incentive to invest in human capital derives, partly at least, from the objective of putting it to use in mastering existing knowledge. Thus, skill formation can be considered as being derived from complementary inputs, the knowledge frontier and schooling. Because promotion of knowledge has public goods components (Romer 1986, Lucas 1988), research and development efforts leading to it have been dominated by advanced countries; but its spillover effects across national borders provide impetus for schooling in developing world. To take just one recent example, while major advances in information technology, say, the internet, have been made in the United States, its outreach spreads far beyond the national borders creating incentives to study this technology and related subjects it elsewhere in the world. Such technology diffusion has become more prevalent than ever before as a result of a global and more interconnected world economy.

Indeed, the last several decades have witnessed a remarkable expansion of schooling around the world. The increase in various measures of schooling in particular, at the primary and secondary level, has been rapid and steady. In particular, the average years of schooling for the adult population (15 years old and above), grew from 3.7 years in 1960 to 5.0 in 1980 and to 6.3 in 2000. The average gross enrollment rate at the primary (secondary) level increased from about 79 in 1970 to 92 in 1980 to 101 in 2000; the figures for secondary schooling are 32, 51, and 70, respectively.[1]

Incomes per capita have also grown. Between 1960 and 1980 the average real GDP per capita grew from about $2,247 to $4,150, the average annual growth rate of 9.2 percent. Between 1980 and 2000 it continued to grow, albeit at a slower rate of 6.4 percent annually, reaching the level of $5,084 in 1999. Moreover, there has not been much convergence in incomes across countries. While the debate about the interpretation of the evidence in this regard is still very much on, some researchers (Berry and others 1983, Milanovic 2002, Pritchett 1997) suggest that, in fact, the last several decades have witnessed income divergence and an increase in global inequality, whereas others (Sala-i-Martin 2002) argue for more caution in interpreting the available data.

Summarizing the evidence on human capital convergence across countries, we observe that there has been convergence in attendance, as well as in the total number of schooling years. Thus, the coefficient of variation in the total number of years of schooling has decreased by almost 50 percent in the period 1960–2000. Moreover, convergence has taken place at all levels of schooling, not only at the primary level which has become a social norm in many parts of the developing world, but even at the tertiary

[1] Gross enrollment rate is the ratio of total enrollment, regardless of age, to the population of the age group which officially corresponds to the given level of education.

level. And it has not been confined to a particular world region, although the progress in some has been faster than in other regions (see also Pritchett, 2003, for a detailed survey of the evidence).

Somewhat related but different finding is that the demand for schooling has increased over time. More precisely, schooling has increased at a faster pace than income growth, implying that nowadays income "buys" more schooling than before. Alternatively, a developing country has now a better educated labor force than its advanced counterpart at a similar level of development used to have in the past.

This can be attributed to either cost reduction (hence, supply increase) or increase in the demand for schooling. Following some earlier research (Hanushek 1997, in the U.S. context; Gundlach and others 2001, in the OECD context) we find no evidence for the former: if at all, the cost of schooling has increased over time. This implies that there must have been an increase in demand.

To help us interpret these empirical regularities, we construct a simple model where advances in technological knowledge increase the returns to schooling. This view goes back to Nelson and Phelps (1966) and has recently received empirical support in Bartel and Lichtenberg (1987) in the U.S. context, and in Foster and Rosenzweig (1996) in the context of India. Specifically, it is assumed that a higher level of aggregate skills generates productivity improvements, thus pushing the world technology frontier. This then increases the demand for schooling in the next generation, more so the more open an individual country is. It is argued that this simple model broadly accounts for the empirical regularities associated with the evolution of schooling over time.

Earlier research in a related field has detected convergence in health indicators across time, which is even more pronounced than the convergence in educational measures. Becker and others (2003) update the calculations of world inequality taking this into account, indicating that the aggregate welfare measure based on income and health has converged over time. In a more related contribution, Dutta and Seabright, (2001) suggest that the convergence in health indicators is due to technological improvements and innovations in medical care and its delivery, which has caused a significant decrease in the marginal cost. In contrast, we find that education does not seem to have exhibited much of technological improvement; instead, our interpretation of the data suggests that most of the convergence is due to an increased secular demand for education. Thus, while both health and education indicators have exhibited apparent convergence, its roots are quite different between the two sectors.

Finally, a comment is in order on the measures of human capital used in this paper. Throughout, quantitative measures (years of schooling and enrollment) are being used. Test results, in particular, in math and science, would be one possible alternative. Recently, internationally comparable test results have become available for selected samples of (typically advanced) countries. Hanushek and Kimko (2002) for example,

argue that they constitute better proxies for schooling quality and illustrate their significant contribution to economic growth.

One methodological difficulty with using test results is that they are not available as a panel. Internationally comparable testing has been introduced relatively recently and only for a relatively small group of countries. Another, more substantive issue is that it is far from clear that they represent a better measure of schooling quality than attendance figures. For one, basic literacy and math proficiency may only be part of what makes schooling quality, and additional components of school experience could be relevant. Moreover, the operational concept of school quality may differ across countries, which makes any statistical analysis very tentative. For example, it is conceivable that knowledge of foreign languages is a potentially important output of schooling, especially in open economies. Or, knowledge of national history may be essential in some countries, particularly those engaged in nation building, but less so in other countries (see Miguel 2003, who shows the importance of a national curriculum for nation-building efforts by contrasting the experiences of Kenya and Tanzania). Schooling may instill social norms, develop work habits, and inculcate values (see Gradstein and Justman 2002, and references therein). As has been noted in the literature, these factors may have various beneficial effects, such as on crime reduction, better informed fertility choices, political participation, etc., see Haveman and Wolfe (1984). These arguments suggest that standard measures such as school attendance may also have an appeal as quality-related. This is perhaps one of the reasons for their adoption as human capital indicators by international development agencies.[2]

The rest of the paper proceeds as follows. Section 2 sets the stage by describing the intertemporal trends in schooling, educational spending, and incomes. Section 3 then presents a closer look at the data noting that income growth was hardly commensurate with schooling expansion. Section 4 constructs a dynamic model to conceptualize the observed intertemporal trends. Section 5 contains an empirical analysis of its main implications, and Section 6 concludes with brief remarks.

2. Expansion of Schooling: Some Background

One basic fact is that schooling has increased significantly over the past several decades. From 1960 to 2000, the mean of years of schooling went up by more than 70 percent, and the increase has been remarkably steady (see figure 1a); moreover, the increase has been universal across the world's regions (see figure 1b).

[2] Indeed, an ambitious program for economic and social world development, the Millennium Development Goals, includes achieving universal primary education by the year 2015 as one of its objectives.

Figure 1a: Average number of years of schooling for population of 15+ year-olds, 1960–2000

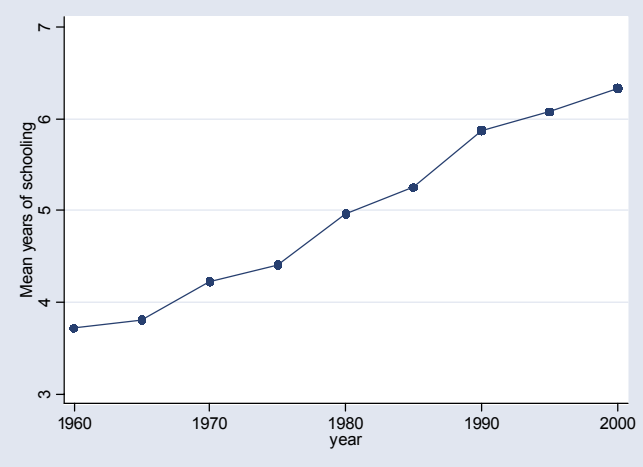
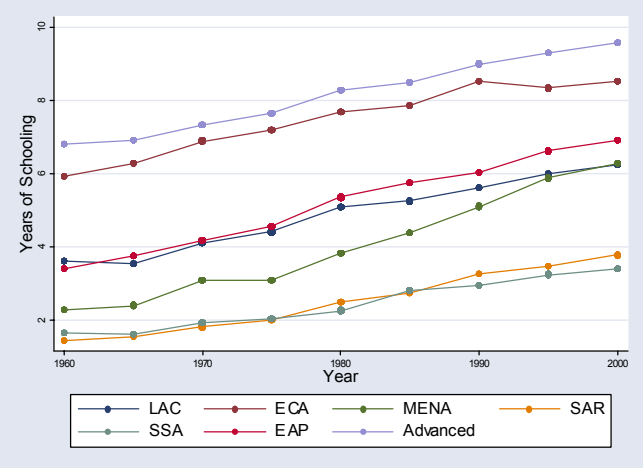
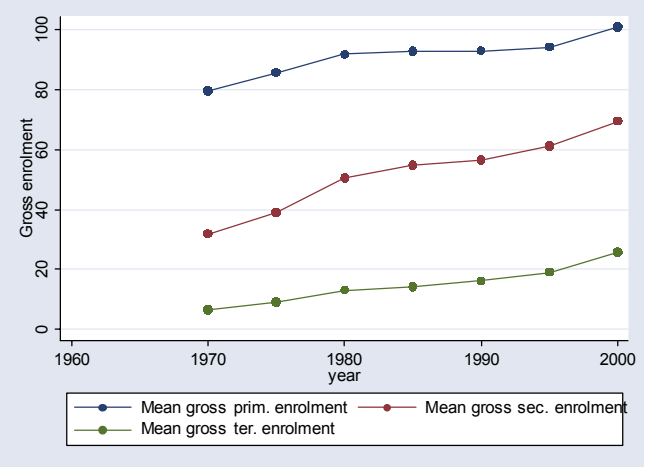


Figure 1b: Average number of years of schooling for population of 15+ year-olds, 1960–2000, by the world regions



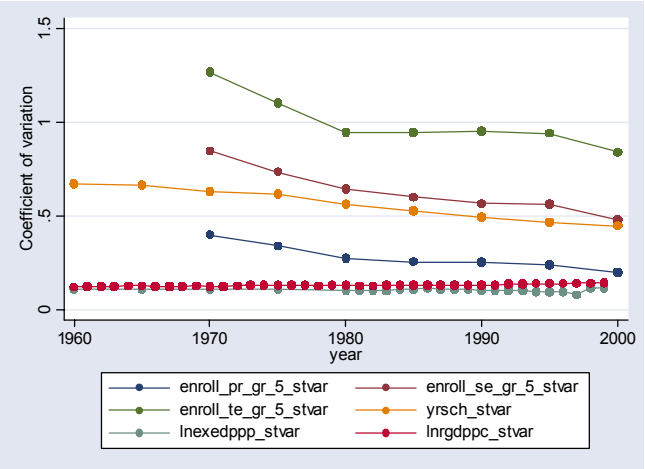
The expansion has occurred at all levels, as is evident from figure 1c which presents the increases in gross enrollment from 1970–2000. In percentage terms, the higher the level of schooling the steeper the increase; thus, between 1970 and 2000, the average enrollment in secondary education went up by nearly 180 percent (from around 33 to 70 percent) while the enrollment rate in tertiary education nearly quadrupled (from less than 7 to 26 percent).

Figure 1c: Gross enrollment at primary, secondary, and tertiary levels, 1970–2000



Moreover, figure 2 clearly indicates a converging trend in educational attainment across time, while at the same time providing no indication for convergence in incomes or in public spending on education. This suggests a secular convergence in educational attainment.

Figure 2: Convergence in Measures of Educational Attainment, Income per Capita, and Public Expenditure on Education: Coefficient of Variation



Note: For each period, coefficient of variation is calculated as a ratio of the standard deviation to the mean. In other words, figure 3 reports changes in the standard deviation, weighted by the inverse of the mean.

Concomitantly, spending on education has also grown. Figure 3a indicates that the absolute value of public spending on education grew fairly consistently between 1960 and 1999 except for a short period of decline in early 1980s; over the forty-year period our data cover, it grew by almost 500 percent.

Figure 3a: The Evolution of Public Spending on Education, 1960–1999

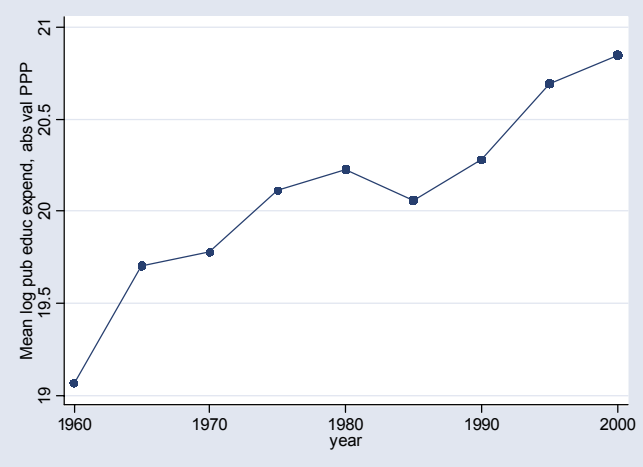


Figure 3b indicates an increase in public spending on education in per capita terms, and figure 3c illustrates the evolution of public spending on education per pupil.

Figure 3b: The Evolution of Per Capita Public Expenditure on Education, 1970–1999

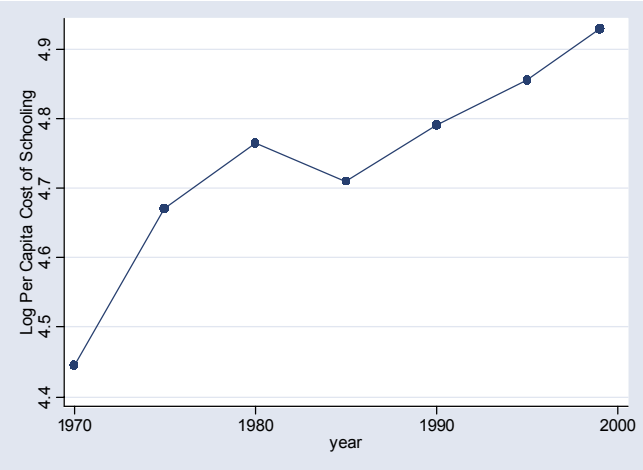
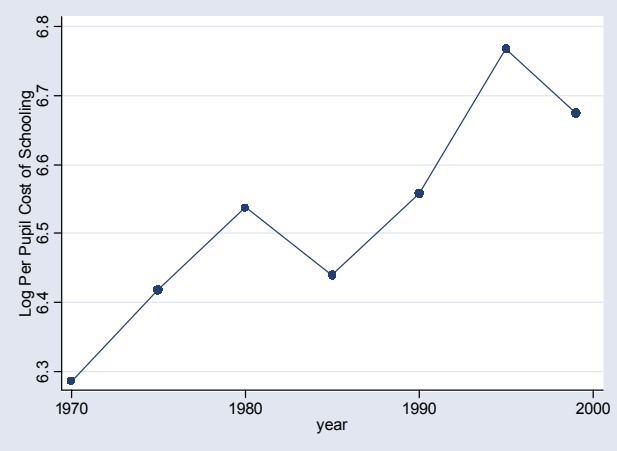


Figure 3c: The Evolution of Per Pupil (Primary and Secondary) Public Expenditure on Education, 1970–1999

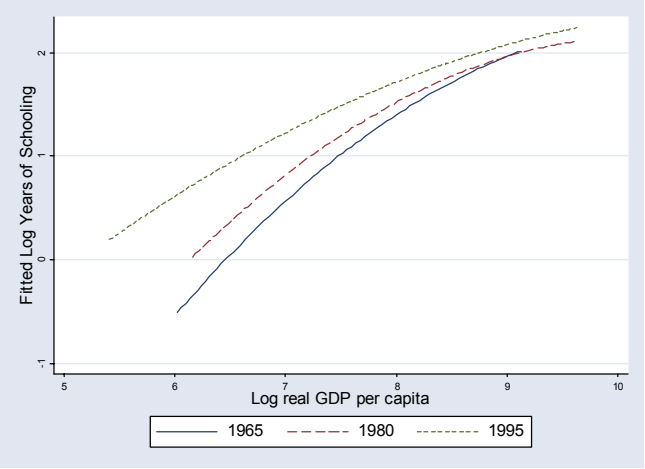


While none of the above constitutes an ideal measure of the evolution of costs of schooling—the former because of the different dynamics of population growth and enrollment, and the latter because the lack of data on tertiary enrollment—they suggest an increase in spending on education when accounting for enrollment.

3. Expansion of Schooling: A Deeper Look

Comparing figures across time reveals an interesting fact: controlling for income, the pace of educational enrollment has increased quite significantly. In other words, a currently advanced country at an earlier phase of its development had much lower educational enrollment than its modern developing counterpart. This can be seen from figure 4 below, which shows that, with time, income "buys" more educational attainment.

Figure 4: Educational Expansion over Time



This finding can be interpreted in at least two ways. Either the productivity of school spending has increased, decreasing the marginal cost of enrollment; or the demand for schooling has grown over time; or a combination of the two.

Existing evidence, however, suggests that the productivity of education spending has not increased. Thus, Gundlach and others (2001), find that, in a sample of OECD countries between 1970 and 1994 it actually decreased, for many countries quite substantially and even more so than the "productivity collapse" in the U.S. schools diagnosed in Hanushek (1997). They interpret this finding as being in line with the Baumol's (1967) cost-disease model, which indicates a relative cost increase in the service sector.

To confirm this in our sample, we ran a regression of the average years of schooling on public spending for different years, both in logarithms; the regression coefficient is thus interpreted as the elasticity of years of schooling with respect to spending. The elasticity has been steadily decreasing over time, from .24 in 1965, to .19 in 1975, to .14 in 1990. Furthermore, research done by Hanushek strongly indicates that the quality of a year at school has not improved (see, e.g., Hanushek 1997), suggesting that spending productivity has decreased over time. Thus, the reason for a massive

increase in enrollment over time seems to be the increase in demand, not of the supply of schooling.

4. Conceptual Framework

In this section a formal conceptual framework is developed. The simple model below illustrates how schooling, education spending, and income evolve over time. The obtained results will provide the basis for the subsequent empirical analysis.

4.1 The Model

Consider an economy indexed J populated by a measure one of identical households indexed by i, each consisting of a parent and child, operating in discrete time t; for simplicity we assume that the economies are also of measure one. The initial level of household i's income residing in country j is exogenously given at y_{jo}, and the income level in period t, y_{jt} is determined endogenously. In each period every household is also endowed with one unit of time. In each period, the households' income is allocated between consumption and investment in human capital; and the unit of time is allocated between studying and leisure consumption (or, alternatively, work as a manual laborer).

As all individuals in a country will be assumed identical, their choices will be identical as well.[3] We thus let c_{jt} denote consumption; e_{jt+1} the amount of investment in education; q_{jt+1} individual household's allocation of time on education; and n_{jt+1} the amount of leisure in a country j in period t. As most education spending in all countries is public, we assume that the decision in this regard is public and is financed by taxes. Given the uniformity of incomes, this then implies that the tax rates are identical across the households. Letting T_{jt} denote the common tax paid by every household in country j in period t and normalizing the prices to one, the budget constraint then is

$$y_{jt} = c_{jt} + T_{jt} \tag{1}$$

The time constraint is:

$$1 = q_{jt} + n_{jt} \tag{2}$$

Education spending and effective time devoted to schooling generate human capital through the following production function:

$$s_{jt+1} = T_{jt}^{\alpha}\, q_{jt}^{\gamma},\ \alpha, \gamma > 0, \quad \alpha + \gamma < 1 \tag{3}$$

We note that adding physical capital to the model would not change the main thrust of its analysis.

The income production function in an individual country has the quality of human capital as its input:

[3] We will omit the individual household's index for notational simplicity.

$$y_{jt} = A\, s_{jt}^{\beta_j g(S_t)},\ 0 < \beta_j < 1 \tag{4}$$

Here $A > 0$ is the standard productivity parameter; $\beta_j g(S_t)$ is the productivity parameter of human capital, which depends on the average level of human capital across countries S_t; $g' > 0$, $g_j(0) = g_o$, $0 < g_o < 1$. The dependence of productivity on the average level of human capital, while reminiscent of endogenous growth theories, has somewhat different flavor here. In particular, because it affects marginal productivity of human capital, the equilibrium accumulation of human capital will also be affected by it.[4] In addition, the differences in β_j imply that the marginal productivity of human capital may vary across countries depending on their level of interaction with the rest of the world. Thus, the degree of access to the world technology differs in general across countries; it may be represented by measures of countries' openness.

Each parent's preferences derive from private good consumption as well as from the consumption of leisure and amount of income accrued to the child. Assuming for simplicity symmetric logarithmic preferences, we write the expected utility:

$$V(c_{jt}, y_{jt+1}) = \ln(c_{jt}) + \ln(n_{jt}) + \ln(y_{jt+1}) \tag{5}$$

The spillover effect embodied in (4) captures the essence of complementarity between innovation activities in advanced countries and the accumulation of human capital in less advanced ones. Electricity, the internal combustion engine, motorization, fertilizers, the computer technology have all been invented in the former; yet, after some time they increased the demand for skilled labor in the latter. Globalization should then have been a catalyst for the adoption of new technologies by the less developed countries. A more complete microfounded model, presented in Acemoglu and Zilibotti (2001) has two types of labor, skilled and unskilled. It focuses on the possible mismatch between technological inventions made in advanced countries and the labor force composition of the less advanced countries. The abundance of unskilled labor in the latter implies a much less efficient use of technological innovations than in the advanced countries, the end result of which is productivity differences across the countries, which Acemoglu and Zilibotti (2001) emphasize. But this then implies that the demand for skilled labor in less advanced countries should increase as in the above implied specification. The derivations below focus on the implications of the complementarity between the knowledge frontier and skills for human capital accumulation.

4.2 Analysis and Empirical Implications

Maximization of the utility function with respect to the time devoted to study yields:

$$q_{jt} = [\gamma/(1+\alpha+\gamma)]\ \beta_j g(S_t)/[1 + \beta_j g(S_t)] \tag{6}$$

[4] It is conceivable that productivity entails a random element, so that β also depends on random factors, such as the likelihood of innovation, success in adopting a new technology, etc. As these are not our main focus here, we chose to ignore them for simplicity.

Thus, in a given cohort a constant share is devoted to study, but this share positively depends on the aggregate amount of schooling in the period.

Maximization of the utility function with respect to the amount of investment in human capital yields:

$$T_{jt} = [\alpha/(1+\alpha+\gamma)]\ \beta_j g\ (S_t)/[1 + \beta_j g\ (S_t)]y_{jt} \tag{7}$$

In particular, richer and more open countries are expected to invest more resources in human capital.

The next-period levels of schooling are then given by

$$s_{jt+1} = C\ \{\beta_j g\ (S_t)/[1 + \beta_j g\ (S_t)]\}^{\alpha+\gamma}\ y_{jt}^{\ \alpha+\gamma}$$

$$= C\ \{\beta_j g\ (S_t)/[1 + \beta_j g\ (S_t)]\}^{\alpha+\gamma}\ A\ s_{jt}^{\ (\alpha+\gamma)\beta_j g(S_t)} \tag{8}$$

where $C = [\alpha/(1+\alpha+\gamma)]^{\alpha}\ [\gamma/(1+\alpha+\gamma)]^{\gamma}$; the second equation follows from substituting the production function.

And the aggregate level of human capital in the next period is

$$S_{t+1} = C\ A\ E\{\beta_j g\ (S_t)/[1 + \beta_j g\ (S_t)]\}^{\alpha+\gamma}\ s_{jt}^{\ (\alpha+\gamma)\beta_j g(S_t)} \tag{9}$$

Differentiation of (9) reveals that future aggregate level of schooling increases with the degree of openness; it also increases with the current aggregate level of human capital—which implies, from (6), that school attendance also grows over time. Moreover, the pace of the intertemporal increase is higher the higher is the degree of economy's openness, β_j. And equation (7) implies that the same is true with regard to the amount of resources spent on schooling.

Thus, we have

Proposition 1. School attendance and the amount of school resources increase over time, more so the more open is the economy.

Substitutions reveal the next-period income levels:

$$y_{jt+1} = A\ C\{[\beta_j g\ (S_t)]/[1 + \beta_j g(S_t)]\}^{\ \beta_j g(S_t)}\ y_{jt}^{\ \beta_j g(S_t)} \tag{10}$$

Clearly, openness promotes higher future income. Suppose now that income is positively correlated with a country's degree of openness, β_j. This then may well imply divergence in income levels. Alternatively, suppose that the degree of openness is identical across countries, $\beta_j = \beta$. Further, suppose first that the aggregate level of human capital is low so that $\beta g(S_t) < 1$. Then from (8) and (10), both schooling and incomes converge. Note, however, that at high enough aggregate levels of human capital, so that

$\beta g(S_t) > 1$, incomes still diverge. Yet, from (8), this may be accompanied by a convergence in human capital across countries, provided that $(\alpha+\gamma)\beta g(S_t) < 1$.[5]

To sum up,

Proposition 2. When the countries differ in their degree of openness, so that openness is positively correlated with income, then incomes may diverge over time. When the degree of openness is identical across countries and the aggregate level of human capital is low, both human capital and income levels converge across countries; however, when the aggregate level of human capital is high enough, incomes may diverge because of the high marginal productivity of the world technology, while human capital still converges.

Differences in total factor productivity across countries have been documented in many recent studies (see e.g., Caselli, Esquivel, and Lefort 1996; Hall and Jones 1999; Pritchett 1997, 2001). Much of the literature attributes these differences to differential access to technological opportunities, which is also found to play a potentially important role here.[6] The second part of the proposition is more in line with Acemoglu and Zilibotti (2001) which shows that, equal access to technologies notwithstanding, productivity differences may still arise.

The next section is devoted to the empirical testing of the above results.

5. Empirical Analysis

To test the implications of the above model we run several panel cross country regressions, distinguishing between fixed and between-country effects. We first describe the data and the variables used and then go on to present the results.

5.1 Data Sources and Variables

The data on the average years of schooling for the population 15 years old and older come from Barro and Lee (1993, 2001).[7] Gross enrollment rates as well as the data on share of public expenditure on education in GDP, and the total number of students in primary and secondary schools come from World Bank's WDI (World Development Indicators) data base.[8] The GDP data come from the Penn World Tables, version 5, and are reported in 1985 constant PPP-adjusted prices; population is from the same source; openness is from the newer Penn World Tables, version 6.1 and is measured as the share of the sum total of imports and export of the GDP. Appendix tables A1.1 and A1.2 contain statistical description of the main variables of interest.

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[5] In particular, note that the lower the productivity of education spending, α, the more likely this is to hold.

[6] Another important strand of the literature exemplified in Hall and Jones (1999) stresses institutional differences as the source of productivity differentials.

[7] Also available from http://sima.worldbank.org/edstats/td10.asp.

[8] WDI database was last updated in August 2003 and can be accessed at http://sima.worldbank.org/.

5.2 Schooling Regressions

The basic regression specification is as follows:

$$SCHOOL_{jt} = \beta_0 + \beta_1 GDP_{jt} + \beta_2 GDP_{jt}^2 + \beta_3 SPEND_{jt} + \varepsilon_{jt} \quad (11)$$

where

$SCHOOL_{jt}$–the average of years of schooling in country j in period t (in logarithms);

GDP_{jt}–the average GDP per capita in 1985 constant PPP-adjusted prices in country j in period t (in logarithms);

GDP_{jt}^2–the square of the GDP above;

$SPEND_{jt}$–a PPP-adjusted total public spending on education (in logarithms);

$\square_{jt}$ - random component.

We would expect a positive sign of the coefficient of GDP_{jt}; a negative sign of the coefficient of GDP_{jt}^2 to indicate a concave relationship; and a positive sign of the coefficient of $SPEND_{jt}$.[9] Column 1 in table 1 presents the results of this basic (OLS) specification. All coefficients are highly significant. They indicate a positive and concave relationship between income and educational attainment and a positive association between the latter and public spending on education. The regression explains almost 60 percent of the variation in the years of schooling. The breakdown into fixed cross country effects and the between country effects in columns 2 and 3 shows that most of the relationship between schooling and spending has to do with changes across time, whereas most of the association between schooling and income has to do with cross country differences. The coefficient of public education spending in the fixed effects specification implies that a doubling in spending is associated with a 40 percent increase in the number of years of schooling over time.

The results are robust to the inclusion of additional control variables, such as the population size and the regional dummies. Columns 4–6 present regression results (OLS which is then decomposed into fixed and between-countries' effects) where the population size is included. The main results remain unchanged. It is worth noting that, in a fixed effects regression the population size variable is positively associated with schooling, whereas in the between countries specification its sign is negative. These results may have to do with the effects of fertility on schooling which we do not study here.

[9] In what follows we will avoid any causal interpretation of the relationship between spending and schooling; unfortunately, there exist no good instrument which would allow us to confront this issue directly.

Table 1: Schooling expansion, 1960–2000

	1	2	3	4	5	6	7	8	9
	OLS	FE	BE	OLS	FE	BE	OLS	FE	BE
Dependent variable: log years of schooling									
Log real GDP per capita	2.185	0.593	2.829	1.979	0.301	2.443	1.356	0.301	1.35
	[6.96]**	[1.79]	[3.77]**	[6.44]**	[1.11]	[3.23]**	[3.86]**	[1.11]	[1.52]
Sq. log real GDP per capita	–0.105	–0.05	–0.145	–0.111	–0.02	–0.138	–0.082	–0.02	–0.082
	[5.32]**	[2.54]*	[3.06]**	[5.74]**	[1.26]	[2.96]**	[3.78]**	[1.26]	[1.50]
Log real pub. spending	0.041	0.407	0.027	0.283	0.102	0.263	0.371	0.102	0.349
	[3.47]**	[15.29]**	[1.09]	[6.83]**	[3.51]**	[2.47]*	[8.81]**	[3.51]**	[3.18]**
Log population				–0.25	0.897	–0.24	–0.349	0.897	–0.34
				[6.08]**	[15.80]**	[2.28]*	[8.02]**	[15.80]**	[3.11]**
LAC							0.047		0.019
							[0.66]		[0.11]
ECA							0.319		0.324
							[3.44]**		[1.91]
MENA							–0.432		–0.498
							[5.39]**		[2.75]**
SSA							–0.252		–0.357
							[2.78]**		[1.79]
SAR							–0.284		–0.339
							[2.72]**		[1.31]
EAP							0.186		0.106
							[2.44]*		[0.60]
Constant	–10.044	–8.428	–12.275	–9.048	–15.995	–10.699	–6.098	–15.995	–5.705
	[8.02]**	[6.60]**	[4.16]**	[7.37]**	[13.89]**	[3.59]**	[4.33]**	[13.89]**	[1.65]
Observations	633	633	633	633	633	633	633	633	633
R-squared	0.59	0.51	0.61	0.61	0.67	0.63	0.67	0.67	0.72
Number of countries		117	117		117	117		117	117

Absolute value of t statistics in brackets
* Significant at 5 percent; ** significant at 1 percent.

Columns 7–9 present same results for the full regression specification:

$$SCHOOL_{jt} = \beta_0 + \beta_1\, GDP_{jt} + \beta_2\, GDP_{jt}^2 + \beta_3\, SPEND_{jt} + \beta_4\, POP_{jt} + \beta_5\, LAC + \beta_6\, ECA + \beta_7\, MENA + \beta_8\, SSA + \beta_9\, SAR + \beta_{10}\, EAP + \varepsilon_{jt} \quad (12)$$

where

POP_{jt}–population size in country j in period t;

LAC, ECA, MENA, SSA, SAR, EAP–regional dummies.[10]

Again, all coefficients have anticipated signs. The negative effect of the MENA dummy on schooling now seems to dominate causing the disappearance of income effects; still, education spending remains significantly correlated with schooling.

We have also used total enrollment in primary and secondary education as a measure of educational attainment. The results (see table A2 in the appendix) by and

[10] Based on the classification used by the World Bank: LAC–Latin America and the Caribbean; ECA–East Europe and Central Asia; MENA–North Africa and Middle East; SSA–Sub-Saharan Africa; SAR–South Asia Region; EAP–East Asia and Pacific.

large are consistent with the above, except that in this specification the income effect dominates the regional dummy effects.

5.3. Openness

Another implication of the analytical framework is a positive effect of the degree of the economy's openness on education spending and schooling. The index of openness—defined as the combined share of imports and exports relative to the GDP—varies significantly across countries and time. For example, in 1960 the most open country was Singapore with the openness index of more than 300 percent, whereas the least open was Uganda, where the index was 4 percent; in 2000 Hong Kong was the most open and Brazil was the least open. Significant changes in the degree of openness, in both directions, have taken place over the studied period in many countries. For example, South Korea is the country with the most improvement in openness, and Ghana is the one which has deteriorated the most, alongside with some other African nations.

We now test the model's predictions. First we run the following regression:

$$SPEND_{jt} = \beta_0 + \beta_1 GDP_{jt} + \beta_2 GDP_{jt}^2 + \beta_3 OPEN_{jt} + \beta_4 POP_{jt} + \varepsilon_{jt}$$

where

$OPEN_{jt}$–the openness of economy j in period t, measured as the share of the sum total of imports and export of the GDP (in logarithms).

The estimation results of a fixed effects regression (the covered period is 1960–2000, 155 countries, 2129 observations) are as follows:

$$SPEND_{jt} = -9.32 + 1.16GDP_{jt} + 0.11\ OPEN_{jt} + 1.27\ POP_{jt} + \varepsilon_{jt} \qquad (13)$$

[19.95] [43.43] [11.00] [38.67]

(absolute value of *t* statistics in brackets, all coefficients are highly significant at 1 percent; R-squared = .77).

Thus, the elasticity of spending with respect to income per capita is slightly larger than unity, 1.16; and the marginal increase in the openness index results in 11 percent increase in education spending. Interestingly, the elasticity of education spending with respect to the population size exceeds unity, possibly indicating the outcome of political pressure to provide more schooling resources when population is relatively younger.[11]

[11] When the squared GDP component is included the substance of the results remains basically unchanged:

$$SPEND_{jt} = -13.56 + 2.27GDP_{jt} - 0.068GDP_{jt}^2 + 0.11\ OPEN_{jt} + 1.26\ POP_{jt} + \varepsilon_{jt}$$

[13.95] [10.14] [11.00] [11.16] [38.43]

Again, all coefficients are highly significant with R-squared = .78.

Thus, openness has a significant positive effect on education spending, which is consistent with our model's implications. To consider the effect of openness on schooling the following (fixed country effects) regression was run:

$$SCHOOL_{jt} = \beta_0 + \beta_1 GDP_{jt} + \beta_2 GDP_{jt}^2 + \beta_3 OPEN_{jt} + \beta_4 OPEN_{jt}^2 + \beta_4 POP_{jt} + \varepsilon_{jt}$$

The results (112 countries, 767 observations) are as follows:[12]

$$SCHOOL_{jt} = -16 + .17\ GDP_{jt} + .39\ OPEN_{jt} - .04\ OPEN_{jt}^2 + .98\ POP_{jt} + \varepsilon_{jt} \qquad (14)$$

[17]** [.78] [4.0]** [3.53]** [28.4]**

where the double asterisks indicate statistical significance at 1 percent.

As can be seen from (14), the direct effect of openness on schooling is substantial and very significant statistically. The quadratic term, negative and significant, indicates the concave functional form of schooling with respect to openness. Increased access to technological innovation, for which openness proxies in our framework, indeed corresponds to improvements in schooling outcomes.

6. Concluding Remarks

This paper's central message is that the demand for education in developing countries is driven by the world's technological progress which—because of spillover effects—increases the returns to skill investment. While we find no evidence for a decrease in cost of schooling, the vast expansions of schooling and in education spending are attributed to the secular increase in the demand for human capital accumulation. Among the factors positively associated with educational expansion is openness, which is interpreted here as an improved access to technological opportunities.

Our analysis also shows that, probably because of the technological spillover effect, measures of schooling are more likely to converge across countries than national incomes. In other words, it may be easier to achieve relative progress in developing countries in education than with respect to incomes. This may indicate that focusing solely on education as a developmental objective does not necessarily guarantee achievement of other goals such as improvement in living standards or elimination of poverty.

[12] The coefficient of the quadratic term of the GDP is insignificant, close to zero, and is not reported here.

Appendix

A1: Statistical Data Summary

Table A1.1: Summary of relevant variables for the entire sample (all available observations)

Variable	N	Mean	Std. Dev.	Min	Max
Enrollment, primary	2292	93.56	24.05	3.01	165.96
Enrollment, secondary	2212	57.92	34.21	0.00	160.76
Enrollment, tertiary	2166	17.59	17.36	0.02	97.35
Years of schooling	1018	4.99	2.87	0.09	12.05
Real GDP per capita, PPP	5944	3852.31	4003.99	196.26	21841.57
Real Public Expenditure on Education, PPP	2458	6035.57	22388.27	1.05	302286.00
Population	7874	22.44	89.39	0.01	1246.51
Openness	5194	70.4692	51.16297	4.31E-09	440.5004

Note: Population and expenditure are reported in millions

Table A1.2: Summary of variables used in regressions with respect to years of schooling.

	Variable	Obs	Mean	Std. Dev.	Min	Max
All Years	Years of schooling	633	5.12	2.79	0.12	11.86
	Real GDP per capita, PPP	633	4509.21	4216.54	313.00	19192.67
	Real Public Expenditure on Education, PPP	633	5916.76	21366.87	1.05	230079.20
	Population	633	35.84	122.66	0.04	1200.27
1960	Years of schooling	60	3.93	2.60	0.12	9.73
	Real GDP per capita, PPP	60	2790.79	2489.96	313.00	9895.00
	Real Public Expenditure on Education, PPP	60	2287.16	10652.48	1.05	82058.18
	Population	60	20.08	60.97	0.04	434.83
1965	Years of schooling	71	4.04	2.59	0.17	9.74
	Real GDP per capita, PPP	71	3402.57	2959.94	409.00	11649.02
	Real Public Expenditure on Education, PPP	71	3897.89	16749.52	13.80	138753.20
	Population	71	22.19	62.58	0.19	487.34
1970	Years of schooling	77	4.37	2.61	0.20	10.24
	Real GDP per capita, PPP	77	3730.92	3351.54	418.00	12963.00
	Real Public Expenditure on Education, PPP	77	5110.23	22801.73	3.70	196432.90
	Population	77	23.65	67.80	0.05	547.57
1975	Years of schooling	80	4.74	2.71	0.35	11.27
	Real GDP per capita, PPP	80	4185.29	3764.19	416.00	13681.99
	Real Public Expenditure on Education, PPP	80	6334.08	25169.45	11.81	216892.60
	Population	80	37.65	124.09	0.20	916.40
1980	Years of schooling	87	5.16	2.76	0.54	11.86
	Real GDP per capita, PPP	87	4964.28	4451.58	505.00	19192.67
	Real Public Expenditure on Education, PPP	87	6700.35	25955.67	6.96	229913.60
	Population	87	38.05	129.42	0.04	981.24
1985	Years of schooling	83	5.58	2.65	0.61	11.57
	Real GDP per capita, PPP	83	5171.69	4541.89	518.00	16569.99
	Real Public Expenditure on Education, PPP	83	7411.97	22949.18	20.19	189519.80
	Population	83	42.47	142.75	0.07	1051.01
1990	Years of schooling	97	6.13	2.72	0.82	11.74
	Real GDP per capita, PPP	97	5131.51	4782.12	483.19	18054.02
	Real Public Expenditure on Education, PPP	97	7001.47	24483.65	26.57	230079.20
	Population	97	43.35	145.00	0.26	1133.68
1995	Years of schooling	78	6.40	2.62	0.76	11.70
	Real GDP per capita, PPP	78	5952.51	5246.55	423.50	18040.29
	Real Public Expenditure on Education, PPP	78	7100.59	12671.51	42.97	60429.41
	Population	78	51.68	170.98	0.27	1200.27

Note: Population and expenditure are reported in millions.

A2: Regression Results with Respect to Enrollment

Table A2: Enrollment (N Pupils) with Respect to Public Spending on Education and Per Capita Income, 1960–2000

	1	2	3	4	5	6	7	8	9
	OLS	FE	BE	OLS	FE	BE	OLS	FE	BE
Dependent variable: number of students in primary and secondary education									
Log real GDP per capita	1.254	0.48	0.411	2.444	1.086	2.377	2.148	1.086	2.024
	[5.88]**	[1.58]	[0.69]	[19.23]**	[5.63]**	[6.60]**	[13.54]**	[5.63]**	[4.26]**
Log real pub. spending	0.979	0.573	0.954	0.125	0.119	0.059	0.199	0.119	0.136
	[124.13]**	[26.93]**	[47.00]**	[6.76]**	[6.65]**	[1.16]	[10.64]**	[6.65]**	[2.55]*
Sq. log real GDP per capita	–0.143	–0.062	–0.087	–0.156	–0.082	–0.146	–0.141	–0.082	–0.129
	[10.78]**	[3.42]**	[2.32]*	[20.07]**	[7.07]**	[6.66]**	[14.44]**	[7.07]**	[4.39]**
Log population				0.863	1.291	0.911	0.798	1.291	0.851
				[47.79]**	[38.96]**	[18.21]**	[43.41]**	[38.96]**	[16.49]**
LAC							0.214		0.224
							[5.62]**		[1.93]
ECA							–0.124		–0.068
							[3.16]**		[0.58]
MENA							0.062		0.085
							[1.73]		[0.74]
SSA							0.08		0.09
							[1.89]		[0.72]
SAR							0.116		–0.002
							[2.15]*		[0.01]
EAP							0.19		0.229
							[4.88]**		[1.91]
Constant	–6.775	2.499	–3.134	–11.52	–12.073	–11.01	–10.66	–12.073	–10.048
	[7.80]**	[2.07]*	[1.32]	[22.31]**	[14.17]**	[7.67]**	[17.19]**	[14.17]**	[5.59]**
Observations	1184	1184	1184	1184	1184	1184	1184	1184	1184
R-squared	0.93	0.46	0.93	0.98	0.78	0.98	0.98	0.78	0.98
Number of countries		169	169		169	169		169	169

Note: Absolute value of t statistics in brackets
* significant at 5 percent; ** significant at 1 percent.

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