# Education as a Determinant of Economic Growth

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Since the late 1980s, much of the attention of macroeconomists has focused on long-term issues, notably the effects of government policies on the long-run rate of economic growth. This emphasis reflects the recognition that the difference between prosperity and poverty for a country depends on how fast it grows over the long term. Although standard macroeconomic policies are important for growth, other aspects of "policy"—broadly interpreted to encompass all government activities that matter for economic performance—are even more significant.

This paper focuses on human capital as a determinant of economic growth. Although human capital includes education, health, and aspects of "social capital," the focus of the present study is on education. The analysis stresses the distinction between the quantity of education—measured by years of attainment at various levels—and the quality, gauged by scores on internationally comparable examinations.

The recognition that the determination of long-term economic growth was the central macroeconomic problem was fortunately accompanied in the late 1980s by important advances in the theory of economic growth. This period featured the development of models in which purposeful research and application led over time to new and better products and

methods of production. Also central to the analysis was the manner in which technological advances in leading countries were imitated and adapted in less developed countries. The key feature of these frameworks was that the long-term rate of economic growth was explained within the model. For that reason, the line of research became known by the perhaps inelegant term endogenous growth theory. (In fact, the phrase received sufficient popular attention in the mid 1990s that it was inadvertently referred to as "indigenous growth theory" in the British press by the then Chancellor of the Exchequer, Kenneth Clarke.)

Shortly thereafter, in the early 1990s, there was a good deal of empirical estimation of growth models using cross-country and cross-regional data. This empirical work was, in some sense, inspired by the excitement of the new growth theories. However, the framework for the applied work owed more to an older type of growth theory, called the neoclassical growth model, which economists developed in the 1950s and 1960s. A central element of this analysis is the diminishing returns to the accumulation of physical capital. This property produces a convergence force whereby poor economies tend to catch up to rich ones. The main reason for convergence is the tendency for countries to experience diminishing returns as they get richer. However, this tendency is affected by various dimensions of government policy and by the accumulation of human capital. Therefore, the framework used in recent empirical studies has incorporated these additional factors.

The recent endogenous-growth models are useful for understanding why advanced economies—and the world as a whole—can continue to grow in the long run despite the tendency for diminishing returns in the accumulation of physical and human capital. In contrast, the older, neoclassical growth model does well for understanding relative growth rates across countries, for example, for assessing why South Korea grew much faster than the United States or Zaire over the last thirty years. Thus, overall, the new and old theories are more complementary than they are competing.

## EMPIRICAL FINDINGS ON GROWTH AND INVESTMENT ACROSS COUNTRIES

### *Empirical Framework*

My empirical findings on economic growth, described in an earlier form in Barro,[1] provide estimates for the effects of a number of government policies and other variables. The analysis applies to roughly one hundred countries observed from 1960 to 1995.

The framework includes countries at vastly different levels of economic development, and places are excluded only because of missing data. The attractive feature of this broad sample is that it encompasses great variation in the policies and other variables that are to be evaluated. In fact, my view is that it is impossible to use the experience of one or a few countries to accurately assess the long-term growth effects from legal and educational institutions, size of government, monetary and fiscal policies, and other variables.

One challenge in the broad cross-country study is to measure variables in a consistent and accurate way across countries and over time. Less developed countries tend, in particular, to have a lot of measurement error in national accounts and other data. Given this problem, the use of the broad panel relies on the idea that the strong signal from the diversity of the experience dominates the noise.

The empirical work considers average growth rates of per capita gross domestic product (GDP) over three ten-year periods, 1965–75, 1975–85, and 1985–95. In one respect, this long-term context is forced by the data, because many of the variables considered, including school attainment, are measured at best over five-year intervals. Data on internationally comparable test scores are available for even fewer years. The low-frequency context accords, in any event, with the underlying theories of growth, which attempt to explain long-term growth, not short-run business fluctuations.

The empirical results relate the rate of economic growth to the initial standard of living, measured by the level of GDP,

and to a set of other explanatory variables. The other variables include an array of policy measures: the ratio of government consumption outlays to GDP, a subjective indicator of the maintenance of the rule of law, a measure of international openness (the ratio of exports plus imports to GDP), and the inflation rate (based on consumer price indexes). Also included are the total fertility rate (a prime determinant of population growth), the ratio of investment to GDP, and the growth rate of the terms of trade (export prices relative to import prices).

### *Education Data*

The main education variable is one that I found previously had significant explanatory power for economic growth. This variable is the value at the start of each period of the average years of school attainment at the upper (secondary and tertiary) levels for males aged 25 and over. The analysis also considers several alternative measures of the quantity and quality of education: primary school attainment, attainment by females, and results on internationally comparable examinations.

The construction of the school-attainment data is discussed in Barro and Lee.[2a, 2b] The basic procedure was to begin with census figures on educational attainment. These data were compiled primarily by the United Nations, based on information from individual countries. Missing observations were filled in by using school-enrollment data. Effectively, enrollment is the investment flow that connects the stock of attainment to subsequent stocks. The resulting data set includes information for most countries on school attainment at various levels over five-year intervals from 1960 to 1990. The data set has recently been revised and updated; see Barro and Lee[3] for details. The new information includes actual figures for 1995 and projections to 2000.

### *Basic Empirical Results*

Before focusing on the results for education, it is worthwhile to provide a quick summary of the results for the other explanatory variables.

*The level of per-capita GDP.* As is now well known, the simple relation across countries between growth rates and initial levels of per capita GDP is virtually zero. However, this relation is misleading, because richer countries tend to have more favorable values of the other explanatory variables, such as rule of law and educational attainment. It is possible statistically to hold these other effects constant, that is, to assess the effect on economic growth from a change in the starting level of per capita GDP for given values of the other explanatory variables. When we do this, we isolate a strong, inverse relation between growth rate and level.

The estimates imply the relation between the growth rate and initial level of per capita GDP as shown in Figure 1.[4] This relation is negative overall but is not linear. For the poorest countries in the sample, the marginal effect of the starting level of per capita GDP on the growth rate is small and may even be positive. The estimates imply a positive effect for a level of per capita GDP less than $580 (in 1985 prices). This situation applies mainly to some countries in sub-Saharan Africa.

For the richest countries, the effect of the initial level of per capita GDP on the growth rate is strongly negative. The largest magnitude (corresponding to the highest value of per capita GDP in 1995) is for Luxembourg—the GDP value of $19,794 implies an effect of –0.059 on the growth rate. The United States has the next largest value of GDP in 1995 ($18,951), implying an estimated effect on the growth rate of –0.058. These values mean that an increase in per capita GDP of 10 percent implies a decrease in the growth rate on impact by 0.6 percent per year. However, an offsetting force, already noted, is that higher levels of per capita GDP tend to be associated with more favorable values of other explanatory variables, such as more schooling, lower fertility, and better maintenance of the rule of law. That is why richer countries perform reasonably well in terms of observed rates of economic growth.

Overall, the cross-country evidence shows no pattern of absolute convergence—whereby poor countries tend systematically to grow faster than rich ones—but does provide strong

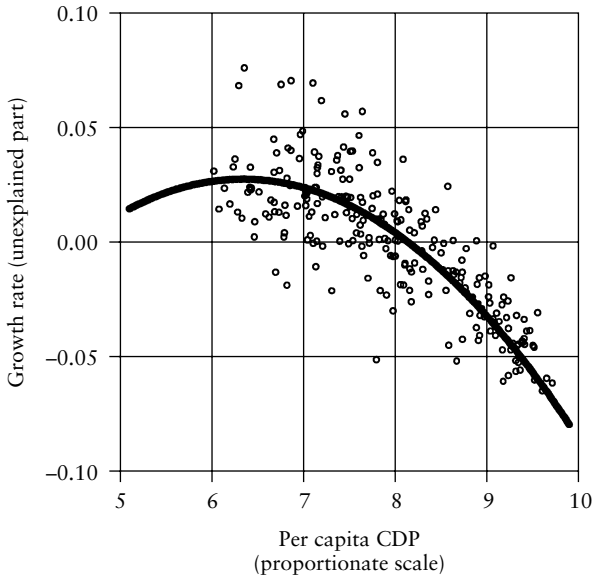


FIGURE 1. Growth Rate versus GDP.

evidence of conditional convergence. That is, except possibly at extremely low levels of per capita product, a poorer country tends to grow faster for given values of the policy and other explanatory variables. The pattern of absolute convergence does not appear because poor countries tend systematically to have less favorable values of the explanatory variables.

*Government consumption.* The ratio of government consumption to GDP is intended to measure a set of public outlays that do not directly enhance an economy's productivity. In interpreting the estimated effect on growth, it is important to note that measures of taxation are not being held constant. This omission reflects data problems in constructing accurate representations for various tax rates, such as marginal rates on labor and capital income, and so on. Since the tax side has not been held constant, the effect of a higher government consumption ratio on growth involves partly a

direct impact and partly an indirect effect involving the required increase in overall public revenues.

The results indicate that the effect of the government consumption ratio on economic growth is significantly negative. An increase in the ratio by 10 percentage points is estimated to reduce the growth rate on impact by 1.6 percent per year.

*The rule of law.* Many analysts believe that secure property rights and a strong legal system are central for investment and other aspects of economic activity.[5] The empirical challenge has been to measure these concepts in a reliable way across countries and over time. Probably the best indicators available come from international consulting firms that advise clients on the attractiveness of countries as places for investments. These investors are concerned about institutional matters such as the prevalence of law and order, the capacity of the legal system to enforce contracts, the efficiency of the bureaucracy, the likelihood of government expropriation, and the extent of official corruption. These kinds of factors have been assessed by a number of consulting companies, including Political Risk Services in its publication *International Country Risk Guide*.[6] This source is especially useful because it covers over one hundred countries since the early 1980s. Although the data are subjective, they have the virtue of being prepared contemporaneously by local experts.

Among the various indicators available, the index for overall maintenance of the rule of law (also referred to as "law and order tradition") turns out to have the most explanatory power for economic growth. This index was initially measured by Political Risk Services in seven categories on a zero-to-six scale, with six the most favorable. The index has been converted here to a zero-to-one scale, with zero indicating the poorest maintenance of the rule of law and one the best.

The results indicate that increased maintenance of the rule of law has a positive and statistically significant effect on the rate of economic growth. An improvement by one category

among the seven used by Political Risk Services (that is, an increase in the zero-to-one index by 0.17) is estimated to raise the growth rate on impact by 0.2 percent per year.

*International openness.* Openness to international trade is often thought to be conducive to economic growth. The basic measure of openness used here is the ratio of exports plus imports to GDP. The results show that the openness variable has a significantly positive effect on growth. However, there is some indication that the effect on growth diminishes as a country gets richer. The estimates imply that the influence of openness on growth would reach zero at a per capita GDP of $11,700 (1985 U.S. dollars). This value is below the per capita GDP of the richest countries, such as the United States. Hence, it may well be true that the NAFTA treaty promoted growth in Mexico but not in the United States and Canada.

*The inflation rate.* The results show a marginally significant, negative effect of inflation on the rate of economic growth. The estimates imply that an increase in the average rate of inflation by 10 percent per year would lower the growth rate on impact by 0.14 percent per year.

*The fertility rate.* The results indicate that economic growth is significantly negatively related to the total fertility rate. Thus, the choice to have more children per adult—and, hence, in the long run, to have a higher rate of population growth—comes at the expense of growth in output per person.

*The investment ratio.* The estimates indicate that the growth rate depends positively and marginally significantly on the investment ratio. This effect applies for given values of policy and other variables, as already discussed, which also turn out to affect the investment ratio. For example, an improvement in the rule of law raises investment and also raises growth for a given amount of investment.

*The terms of trade.* The results show that improvements in the terms of trade (a higher growth rate of the ratio of export prices to import prices) enhance economic growth.

### *Effects of Education*

Governments typically have strong direct involvement in the financing and provision of schooling at various levels. Hence, public policies in these areas have major effects on a country's accumulation of human capital. One measure of this schooling capital is the average years of attainment, as discussed before. These data are classified by sex and age (for persons aged 15 and over and 25 and over) and by levels of education (no school, partial and complete primary, partial and complete secondary, and partial and complete higher).

For a given level of initial per capita GDP, a higher initial stock of human capital signifies a higher ratio of human to physical capital. This higher ratio tends to generate higher economic growth through at least two channels. First, more human capital facilitates the absorption of superior technologies from leading countries. This channel is likely to be especially important for schooling at the secondary and higher levels. Second, human capital tends to be more difficult to adjust than physical capital. Therefore, a country that starts with a high ratio of human to physical capital—such as in the aftermath of a war that destroys primarily physical capital—tends to grow rapidly by adjusting upward the quantity of physical capital.

*Years of schooling.* The empirical results indicate that the average years of school attainment at the secondary and higher levels for males aged 25 and over has a positive and significant effect on the subsequent rate of economic growth.[7] Figure 2 depicts this relationship. The estimates imply that an additional year of schooling (roughly a one-standard-deviation change) raises the growth rate on impact by 0.44 percent per year. As already mentioned, a possible interpretation of this effect is that a work force educated at the secondary and higher

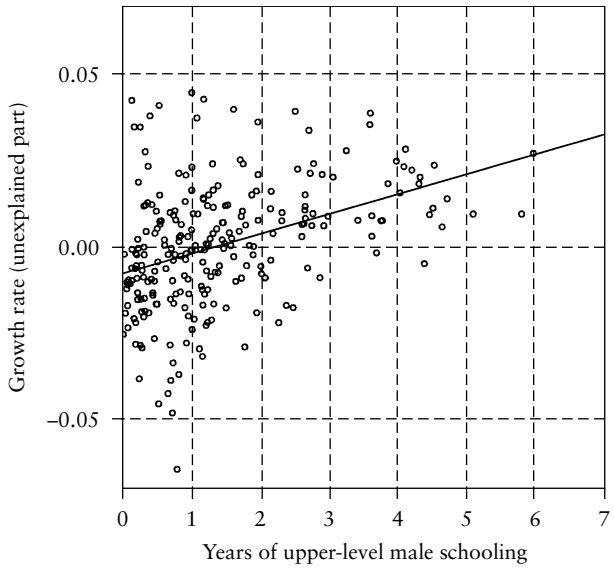


FIGURE 2. Growth Rate versus Schooling

levels facilitates the absorption of technologies from more advanced foreign countries.

The implied social rate of return on schooling—that is, the rate of return to the overall economy—is complicated. First, the system already holds fixed the level of per capita GDP and, therefore, does not pick up a contemporaneous effect of schooling on output. Rather, the effect from an additional year of average school attainment impacts on the growth rate of GDP and thereby affects the level of GDP gradually over time. Because of the convergence force—whereby higher levels of GDP feed back negatively into the growth rate—the ultimate effect of more schooling on the level of output (relative to a fixed trend) is finite.

Suppose that the convergence rate—the negative effect of higher per capita GDP on the growth rate—is 2.5 percent per year, which is the average value estimated across countries. In this case, the estimated effect of the schooling variable on growth turns out to imply that an additional year of attainment for the typical adult raises the level of output asymptot-

ically by 19 percent. This figure would give the implied social real rate of return to education (for males at the secondary and higher levels) if the cost of an individual's additional year of schooling equaled one year of foregone per capita GDP, if there were no depreciation in stocks of schooling capital (due, for example, to aging and mortality), and if the adjustment to the 19 percent higher level of output occurred with no lag. The finiteness of the convergence rate and the presence of depreciation imply lower rates of return. However, an opposing force is that the cost of an added year of schooling is probably less than one year's per capita GDP, because the cost of students' time spent at school would be less than the economy's average wage rate. We must, however, also consider the costs of teachers' time and other school inputs. In any event, if we neglect depreciation and assume that the cost of an additional year of schooling equals one year's foregone per capita GDP, then a convergence rate of 2.5 percent per year turns out to imply a social rate of return to schooling of 7 percent per year. This figure is within the range of typical microeconomic estimates of returns to education.

The empirical analysis has also considered additional dimensions of the years of schooling. Female attainment at the secondary and higher levels turns out not to have significant explanatory power for economic growth. One possible explanation for the weak role of female upper-level schooling as a determinant of growth is that many countries follow discriminatory practices that prevent the efficient exploitation of well-educated females in the formal labor market. Given these practices, it is not surprising that more resources devoted to upper-level female education would not show up as enhanced growth.

Male primary schooling turns out not to have significant explanatory power for growth, whereas female primary schooling has a positive, but statistically insignificant, effect. The particular importance of schooling at the secondary and higher levels (for males) supports the idea that education affects growth by facilitating the absorption of

new technologies—which are likely to be complementary with labor educated to these higher levels. Primary schooling is, however, critical as a prerequisite for secondary education.

Another role for primary schooling involves the well-known negative effect of female primary education on fertility rates. However, the female primary attainment variable would not be credited with this growth effect, because the fertility variable is included separately in the system that was estimated. If fertility is not included, then the estimated growth effect of female primary schooling becomes significantly positive.

*Quality of education.* Many researchers argue that the quality of schooling is more important than the quantity, measured, for example, by years of attainment. Barro and Lee[8] discuss the available cross-country aggregate measures of the quality of education. Hanushek and Kim[9] find that scores on international examinations—indicators of the quality of schooling—matter more than years of attainment for subsequent economic growth. My findings turn out to accord with their results.

Information on student test scores—for science, mathematics, and reading—is available for forty-three countries in the sample, that is, for about half of the countries. The available data were used to construct a single cross section of test scores on the science, reading, and mathematics examinations.[10] These variables were then entered into the systems for economic growth that I considered before.

The first result is that science scores have a significantly positive effect on economic growth. With science scores included, the estimated effect of male upper-level attainment is still positive but only weakly statistically significant. The estimated effect implies that a one-standard-deviation increase in science test scores—by 0.08—would raise the growth rate on impact by 1.0 percent per year. In contrast, the estimated effect of the school attainment variable now implies that a one-standard-deviation rise in attainment would increase the growth rate on impact by only 0.2 percent per year. Thus, the results suggest that the quality and quantity of schooling

both matter for growth but that quality is much more important.

Given the findings, it would be of considerable interest for a country to know how to improve the quality of education, as reflected in test scores. The results presented in Barro and Lee (1998) indicate that test scores are positively related to the average school attainment of adults (which would reflect parents' education) and negatively related to pupil-teacher ratios. Thus, the aggregate data indicate that smaller class sizes have beneficial effects. This relationship is controversial in micro studies. Another finding is that the length of the school term was unrelated to the test scores. In addition, pupils from Asian countries performed unusually well on the tests.

Many microeconomic studies have found that test scores may just proxy for other characteristics of students, such as family income and parents' education. Therefore, it is difficult to tell whether a positive relation between test scores and student outcomes, such as future earnings, reflects the quality of education or these other characteristics. In my cross-country analysis, the effects of test scores (and years of school attainment) apply after taking account of the other explanatory variables, including per capita GDP. Therefore, the estimated effects of schooling quality—as gauged by the test scores—would apply for a given value of per capita GDP and the other variables.

Mathematics scores turn out also to have a positive influence on growth. However, the results indicate that the science scores are somewhat more predictive of economic growth, and it is difficult from the available data to disentangle the effects of these two types of test scores.

There is also a weak indication that reading scores have a positive effect on economic growth. However, it is again difficult with the available data to separate this effect from those of science and mathematics scores.

Finally, as an attempt to increase the sample size, I constructed a single test-scores variable that was based on science scores, where available, and then filled in some missing observations by using the reading scores.[11] The results, now for

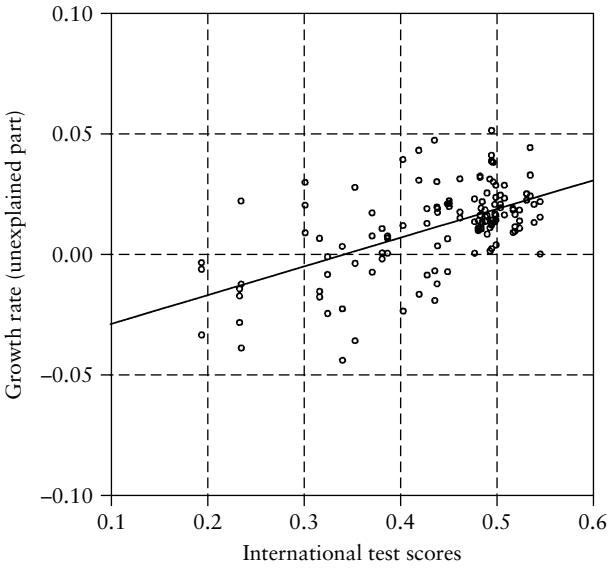


FIGURE 3. Growth Rate versus Test Scores

a somewhat larger sample, again indicate a significantly positive effect on growth. Figure 3 shows graphically the relation between economic growth and the overall test-scores variable. The Figure makes clear that test scores have strong explanatory power for economic growth.

## SUMMARY OF MAJOR RESULTS

The determinants of economic growth were analyzed for around one hundred countries observed from 1960 to 1995. The data reveal a pattern of conditional convergence in the sense that the growth rate of per capita GDP is inversely related to the starting level of per capita GDP. Other variables that influenced economic growth included measures of government policies and institutions, initial stocks of human capital, and the character of the national population.

With respect to education, growth is positively related to the starting level of average years of school attainment of adult males at the secondary and higher levels. Since workers

with this educational background would be complementary with new technologies, the results suggest an important role for the diffusion of technology in the development process. Growth is insignificantly related to years of school attainment of females at the secondary and higher levels. This result suggests that highly educated women are not well utilized in the labor markets of many countries. Growth is insignificantly related to male schooling at the primary level. However, this level of schooling is a prerequisite for secondary schooling and would therefore affect growth through this channel. Education of women at the primary level stimulates economic growth indirectly by inducing a lower fertility rate.

Data on students' scores on internationally comparable examinations in science, mathematics, and reading were used to measure the quality of schooling. Scores on science tests have a particularly strong positive relation with economic growth. Given the quality of education, as represented by the test scores, the quantity of schooling—measured by average years of attainment of adult males at the secondary and higher levels—is still positively related to subsequent growth. However, the effect of school quality is quantitatively much more important.

## NOTES

1. Robert J. Barro, *Determinants of Economic Growth: A Cross-Country Empirical Study* (Cambridge, Mass.: MIT Press, 1997).

2a. Robert J. Barro and Jong-Wha Lee, "International Comparisons of Educational Attainment," *Journal of Monetary Economics* 32 (1993): 363–94.

2b. Robert J. Barro and Jong-Wha Lee, "International Measures of Schooling Years and Schooling Quality," *American Economic Review* 86 (1996): 218–23.

3. Robert J. Barro and Jong-Wha Lee, "International Data on Educational Attainment Updates and Implications," unpublished, Harvard University, January 2000, forthcoming in *Oxford Economic Papers*.

4. The variable plotted on the vertical axis is the growth rate net of the estimated effect of all the explanatory variables aside from the initial value of per capita GDP. The construction in the two subsequent figures is analogous. The horizontal axis uses a proportionate scale.
5. In previous analyses, I also looked for effects of democracy, measured either by political rights or civil liberties. Results using subjective data from Freedom House indicated that these measures had little explanatory power for economic growth, once the rule-of-law indicator and the other explanatory variables were held constant. Raymond D. Gastil, *Freedom in the World* (Westport, Conn.: Greenwood Press, 1982–83 and other years). Recent editions are published by Freedom House.
6. These data were introduced to economists by Stephen Knack and Philip Keefer, "Institutions and Economic Performance: Cross-Country Tests Using Alternative Institutional Measures," *Economics and Politics* 7 (1995): 207–27. Two other consulting services that construct these type of data are Business Environmental Risk Intelligence (BERI) and Business International, now a part of the Economist Intelligence Unit.
7. The results are basically the same if the years of attainment apply to males aged 15 and over.
8. Robert J. Barro and Jong-Wha Lee, "Determinants of Schooling Quality," unpublished, Harvard University, July 1998, forthcoming in *Economica*.
9. Eric Hanushek and Dongwook Kim, "Schooling, Labor Force Quality, and the Growth of Nations" unpublished, University of Rochester (1999).
10. The data, measured as percent correct on each exam, apply to students, not to current participants in the labor force. More recently, the International Adult Literacy Survey provided test results for the working-age population. However, these data are at an early stage and cover only a few OECD countries—see OECD. *Human Capital Investment—An International Comparison*, OECD (Organization for Economic Cooperation and Development), Paris (1998) for a discussion.
11. The mathematics scores turned out not to provide any additional observations.