Education and 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-term 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 main 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 determinants of long-term economic growth were 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 "endogenous-growth" models, in which the long-term rate of growth was determined within the model. A key feature of these models is a theory of technological progress, viewed as a process whereby purposeful research and application lead over time

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to new and better products and methods of production and to the adoption of superior technologies that were developed in other countries or sectors. One major contributor in this area is Romer (1990).

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 endogenous-growth theories. However, the framework for the applied work owed more to the older, neoclassical model, which was developed in the 1950s and 1960s (see Solow 1956, Cass 1965, Koopmans 1965, the earlier model of Ramsey 1928, and the exposition in Barro and Sala-i-Martin 1995). The framework used in recent empirical studies combines basic features of the neoclassical model — especially the convergence force whereby poor economies tend to catch up to rich ones — with extensions that emphasize government policies and institutions and the accumulation of human capital. For an overview of this framework and the recent empirical work on growth, see Barro (1997).

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 workings of diminishing returns in the accumulation of physical and human capital. In contrast, the extended neoclassical framework does well as a vehicle 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 30 years. Thus, overall, the new and old theories are more complementary than they are competing.

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1. Framework for the Empirical Analysis of Growth

The empirical framework derived from the extended neoclassical growth model can be summarized by a simple equation:

$$(1) \qquad Dy = F(y, y^*)$$

where Dy is the growth rate of per capita output, y is the current level of per capita output, and y* is the long-run or target level of per capita output. In the neoclassical model, the diminishing returns to the accumulation of capital imply that an economy's growth rate, Dy, is inversely related to its level of development, as represented by y. In equation (1), this property applies in a conditional sense, that is, for a given value of y*. This conditioning is important because the variables y and y* tend to be strongly positively correlated across countries. That is, countries that are observed to be rich (high y) tend also to be those that have high long-run target levels of per capita output (high y*).

In a setting that includes human capital and technological change, the variable y would be generalized from the level of per capita product to encompass the levels of physical and human capital and other durable inputs to the production process. These inputs include the ideas that underlie an economy's technology. In some theories, the growth rate, Dy, falls with a higher starting level of overall capital per person but rises with the ratio of human to physical capital.

For a given value of y, the growth rate, Dy, rises with y*. The value y* depends, in turn, on government policies and institutions and on the character of the national population. For example, better enforcement of property rights and fewer market distortions tend to raise y* and, hence, increase Dy for given y. Similarly, if people are willing to work and save more and have fewer children, then y* increases, and Dy rises accordingly for given y. In practice, the determinants of y* tend to be highly persistent over time. For example, if a country maintains strong institutions and policies today, then it is likely also to maintain these tomorrow.

In this model, a permanent improvement in some government policy initially raises the growth rate, Dy, and then raises the level of per capita output, y, gradually over time. As output rises, the workings of diminishing returns eventually restore the growth rate, Dy, to a value consistent with the long-run rate of technological progress (which is determined outside of the model in the standard neoclassical framework). Hence, in the very long run, the impact of improved policy is on the level of per capita output, not its growth rate. But since the transitions to the long run tend empirically to be lengthy, the growth effects from shifts in government policies persist for a long time.

2. Empirical Findings on Growth and Investment across Countries

A. Empirical Framework

The findings on economic growth reported in Barro (1997) provide estimates for the effects of a number of government policies and other variables. That study applied to roughly 100 countries observed from 1960 to 1990. The sample has now been extended to 1995 and has been modified in other respects, as detailed below.

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 get an accurate empirical assessment of the long-term growth effects from legal and educational institutions, size of government, monetary and fiscal policies, and other variables.

There are a number of drawbacks from using the full sample with its great heterogeneity of experience. One problem involves the measurement of 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. In addition, it may be difficult to implement functional forms for models of economic growth that work satisfactorily over a wide range of economic development. Given these problems, the use of the broad panel relies on the idea that the strong signal from the diversity of the experience dominates the noise. To get some perspective on this issue, the empirical analysis includes a comparison of results from the broad country panel with those obtainable from sub-sets of rich or OECD countries.[2]

The other empirical issue, which is likely to be more important than measurement error, is the sorting out of directions of causation. The objective is to isolate the effects of alternative government policies on long-term growth. But, in practice, much of the government's behavior — including its monetary and fiscal policies and its political stability — is a reaction to economic events. For most of the empirical results, the

[2] Whereas researchers and policymakers in OECD countries are often skeptical about the value of including information on developing countries, researchers and policymakers from development institutions and poor countries are often doubtful about the use of incorporating data from the rich countries. The first position, which relies on issues about data quality and modeling consistency, seems more defensible than the second. If one is interested in recipes for development, then one surely ought to include in the sample the countries

labeling of directions of causation depends on timing evidence, whereby earlier values of the explanatory variables are thought to influence subsequent economic performance. However, this approach to determining causation is not always valid.

The empirical work considers average growth rates and average ratios of investment to GDP over three decades, 1965-75, 1975-85, and 1985-95.[3] In one respect, this long-term context is forced by the data, because many of the determining variables considered, such as school attainment and fertility, 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 do not attempt to explain short-run business fluctuations. In these theories, the exact timing of response — for example, of the rate of economic growth to a change in a public institution — is not as clearly specified as the long-run response. Therefore, the application of the theories to annual or other high-frequency observations would compound the measurement error in the data by emphasizing errors related to the timing of relationships.

Table 1 shows panel regression estimates for the determination of the growth rate of real per capita GDP.[4] Table 2 shows parallel estimates for the determination of the ratio of investment (private plus public) to GDP. Estimation is by three-stage least squares, using lags of the independent variables as instruments — see the notes to Tables

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that have managed to develop.

[3] For investment, the third period is 1985-92.

[4] The GDP figures in 1985 prices are the purchasing-power-parity adjusted, chain-weighted values from Summers and Heston, version 5.6. These data are available on the Internet from the National Bureau of Economic Research. See Summers and Heston (1991) for a general description of their approach. Real investment (private plus public) is also from this source.

1 and 2 for details. In each case, the observations are equally weighted, that is, larger countries do not receive a higher weight in the estimation.

In the baseline system shown in column 1 of Table 1, the effects of the starting level of real per capita GDP show up in the estimated coefficients on the level and square of log(GDP). The other regressors include an array of policy variables — the ratio of government consumption to GDP, a subjective index of the maintenance of the rule of law, a measure of international openness, and the rate of inflation (based on consumer price indexes). Also included are the total fertility rate, the ratio of investment to GDP, and the growth rate of the terms of trade (export prices relative to import prices).

B. Education Data

The education variable contained in the baseline regression system 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 subsequent analysis considers several alternative measures of the quantity and quality of education: primary school attainment, attainment of females, and results on internationally comparable examinations. The analysis also evaluates measures of health status, another dimension of human capital, as determinants of growth and investment.

The construction of the school-attainment data is discussed in Barro and Lee (1993, 1996). The basic procedure was to begin with census figures on educational attainment. These data were compiled primarily by the United Nations. 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 included 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 (2000) for details. The new data set includes actual figures for 1995 and projections to 2000. The fill-in part of the computational procedure has also been improved. One revision is to use gross enrollment figures (enrollment for students of all ages at a given level of schooling) adjusted to delete class repeaters, rather than either gross figures (which overstate schooling rates because of repeaters) or net figures (which consider only students of the customary age for each level of schooling). The problem with the net figures is that they create errors when students start school at ages either earlier or later than the customary ones. Another revision is that we now consider changes over time in a country's typical duration of each level of education.

Puzzling discrepancies exist between our data, based primarily on U.N. sources, and the figures provided by the OECD for some of the OECD countries (see OECD 1997, 1998a, 1998b). Table 3 compares our data (denoted Barro-Lee) with those provided by the OECD for OECD and some developing countries. The table shows the distribution of highest levels of school attainment among the adult population in recent years — 1995 for our data and 1997 or 1998 for the OECD (1996 for their data on the developing countries).

One difference is that our figures cover the standard UNESCO categories of no schooling, primary schooling, some secondary schooling, complete secondary schooling, and tertiary schooling.[5] We then compute average years of schooling at all levels by multiplying the percentages of the population at each level of schooling by the country's average duration of school at that level.

The OECD categories are below upper secondary, upper secondary, and tertiary. We believe that the first OECD category would correspond roughly to the sum of our first three categories. However, this approximation is satisfactory only if the OECD's concept of upper secondary attainment corresponds closely to the U.N. concept of complete secondary attainment. The OECD also reports figures on average years of schooling at all levels, but we are uncertain about how these numbers were calculated.

For many countries, the correspondence between the Barro-Lee and the OECD data is good. But, for several countries, the OECD data indicate much higher attainment at the upper secondary level and above — Austria, Canada, Czech Republic, France, Germany, Netherlands, Norway, Switzerland, and the United Kingdom. The source of the difference, in many cases, is likely to be the distinction between some and complete secondary schooling. The OECD classification probably counts as upper secondary many persons whom the U.N. ranks as less than complete secondary. The treatment of vocational education is particularly an issue here. Another source of discrepancy is that our figures refer to persons aged 25 and over, whereas the OECD data are for persons aged 25 to 64. Since secondary and tertiary attainment have been rising over time, this difference would tend to make the OECD figures on upper secondary and tertiary attainment higher than our corresponding numbers. Further research is warranted to pin

[5] Our data also distinguish partial from complete primary education, but that distinction is not made in Table 3. The primary schooling data in the table refer to the percent of the population for whom some level of primary schooling is the highest level attained.

down the exact relation between the Barro-Lee and OECD data. See de la Fuente and Domenech (2000) for additional discussion.

C. Basic Empirical Results

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

a. The Level of Per Capita GDP. As is now well known, the simple relation across a broad group of countries between growth rates and initial levels of per capita GDP is virtually nil. However, when the policy and other independent variables shown in column 1 of Table 1 are held constant, there is a strong relation between the growth rate and level of per capita GDP. The estimated coefficients are significantly positive for log(GDP) and significantly negative for the square of log(GDP).

These coefficients imply the partial relation between the growth rate and log(GDP) as shown in Figure 1.[6] This relation is negative overall but is not linear. For the poorest countries contained in the sample, the marginal effect of log(GDP) on the growth rate is small and may even be positive. The estimated regression coefficients for log(GDP) and its square imply a positive marginal effect for a level of per capita GDP below $580 (in 1985 prices). This situation applies mainly to some countries in Sub Saharan Africa.

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[6] The variable plotted on the vertical axis is the growth rate net of the estimated effect of all explanatory variables aside from log(GDP) and its square. The value plotted was also normalized to make its mean value zero.

For the richest countries, the partial effect of log(GDP) on the growth rate is strongly negative at the margin. The largest magnitude (corresponding to the highest value of per capita GDP in 1995) is for Luxembourg — the GDP value of $19,794 implies a marginal effect of -0.059 on the growth rate. The United States has the next largest value of GDP in 1995 ($18,951) and has an estimated marginal effect on the growth rate of -0.058. These values mean that an increase in per capita GDP of 10% implies a decrease in the growth rate on impact by 0.6% per year. However, an offsetting force 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.

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 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 determining variables other than log(GDP).

In the panel for the investment ratio in column 1 of Table 2, the pattern of estimated coefficients on log(GDP) is also positive on the linear term and negative on the square. These values imply a hump-shaped relation between the investment ratio and the starting level of GDP — the relation is positive for per capita GDP below $3,800 and then becomes negative.

b. 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.[7] 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.

Table 1, column 1 indicates that the effect of the government consumption ratio, G/Y, on growth is significantly negative. The coefficient estimate implies that an increase in G/Y of 10 percentage points would reduce the growth rate on impact by 1.6% per year.

Table 2, column 1 indicates that the government consumption ratio also has a significantly negative effect on the investment ratio. An increase in G/Y of 10 percentage points is estimated to lower the investment ratio by 2.4 percentage points. This result suggests that one way in which more nonproductive public spending lowers growth is by depressing investment. However, since the investment ratio is held constant in the growth-rate panel in Table 1, the estimated negative effect of G/Y on growth applies for a given quantity of investment. The depressing effect of G/Y on the investment ratio reinforces this influence.

[7] The system contains as an explanatory variable the average ratio of government consumption to GDP over the period in which growth is measured. However, the estimation uses a set of instrumental variables that contains prior ratios of government consumption to GDP but not the contemporaneous ratios. The standard international accounts include most public outlays for education and defense as government consumption, although these types of expenditures can reasonably be regarded as primarily investment. These two categories have been deleted from the measure of government consumption used here. If considered separately, the ratio of public spending on education to GDP has a positive, but statistically insignificant,

c. 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.[8] 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*.[9] This source is especially useful because it covers over 100 countries since the early 1980s. Although the data are subjective, they have the virtue of being prepared contemporaneously by local experts. Moreover, the willingness of customers to pay substantial fees for this information is perhaps some testament to their validity.

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 and investment. This index was initially

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effect on economic growth. The ratio of defense outlays to GDP has roughly a zero relation with economic growth.

[8] 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 (see Gastil 1982-1983) indicated that these measures had little explanatory power for economic growth or investment, once the rule-of-law indicator and the other variables shown in Table 1 were held constant.

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.

To understand the scale, note that the United States and most of the OECD countries (not counting Turkey and some of the recent members) had values of 1.0 for the rule-of-law index in recent years. However, Belgium, France, Portugal, and Spain were downgraded from 1.0 in 1996 to 0.83 for 1997-99, and Greece fell from 1.0 in 1996 to 0.83 in 1997, 0.67 in 1998, and 0.50 in 1999. Hungary has been rated at 1.0 in recent years, and the Czech Republic and Poland have been at 0.83. Mexico fell from 0.50 in 1997 to 0.33 in 1998-99, and Turkey fell from 0.67 in 1998 to 0.50 in 1999. Non-OECD countries rated at 1.0 in 1999 were Malta, Morocco, and Singapore. (Hong Kong was downgraded upon its return to China from 1.0 in 1996 to 0.83 in 1997-99.)

No country had a rating of 0.0 for the rule of law in 1999, but countries rated at 0.0 in some earlier years included Ethiopia, Guyana, Haiti, Sri Lanka, Yugoslavia, and Zaire. Countries rated at 0.5 in 1999 included Bangladesh, Bolivia, Ecuador, Malaysia, Myanmar, Pakistan, Peru, Sri Lanka, Suriname, Uruguay, several countries in Sub Saharan Africa, and much of Central America.

The results in column 1 of Table 1 indicate that, for given values of the other explanatory variables, increased maintenance of the rule of law has a positive and statistically significant effect on the rate of economic growth.[10] An improvement by one

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[9] These data were introduced to economists by Knack and Keefer (1995). Two other consulting services that construct this type of data are BERI (Business Environmental Risk Intelligence) and Business International (now a part of the Economist Intelligence Unit).

[10] The variable used is the earliest observation available for each country for the first two equations — in most cases 1982 and, in a few cases, 1985. For the third equation, the average value of the rule-of-law

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

The results from the investment panel in column 1 of Table 2 show that the rule-of-law index also has a positive, but only marginally significant, effect on the ratio of investment to GDP. An improvement by one category in the underlying rule-of-law indicator is estimated to raise the investment ratio by about 0.6 percentage points. The stimulus to investment is one way in which better maintenance of the rule of law would encourage growth. However, since the investment ratio is held constant in the growth panel in Table 1, the estimated positive effect of the rule-of-law indicator on growth applies for a given quantity of investment. The stimulative effect on the investment ratio reinforces this influence.

d. International Openness. Openness to international trade is often thought to be conducive to economic growth. Aside from classical comparative-advantage arguments, openness tends to promote competition and, hence, efficiency. Sachs and Warner (1995) have argued empirically that international openness is an important contributor to economic growth.

The basic measure of openness used is the ratio of exports plus imports to GDP. As is well known, however, this ratio tends to be larger the smaller the country. Basically, internal trade within a large country substitutes for much of the commerce that

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index for 1985-94 is used. Since the data on the rule-of-law index begin only in 1982 or 1985, later values of this variable are allowed to influence earlier values of economic growth and investment in the 1965-75 and 1975-85 periods. (For the third equation, the instrument list includes the rule-of-law value for 1985 but not for later years.) The idea here is that institutions that govern the rule of law tend to persist over time, so that the observations for 1982 or 1985 are likely to be good proxies for the values prevailing earlier. The a small country would typically carry out with other countries. Hence, only the international trade that differs from the value normally associated with country size would reflect policy influences, such as trade barriers.

I quantified the effect of country size by estimating a panel system in which the dependent variables were the openness ratios for countries at various dates. Country size was measured by the logs of land area and population. The other independent variables in this system were measures of trade policy — tariff and non-tariff barriers, the black-market premium on the foreign exchange rate, and IMF indicators of whether the country was restricting transactions on capital or current accounts. I then subtracted from the openness ratio the estimated effects from the logs of land area and population. This filtered variable proxies for the effects of various policy variables on international openness.

Column 1 of Table 1 shows that the filtered openness variable has a significantly positive effect on growth.[11] However, the negative effect of the interaction term with log(GDP) means that the effect on growth diminishes as a country gets richer. The coefficient estimates imply that the effect 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

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estimated effect of the rule-of-law index on economic growth is still positive, but less statistically significant, if the sample is limited to the growth observations that apply after the early 1980s.

[11] One concern is whether this relation could reflect a reverse effect from growth on the trade shares. I have also considered systems in which the openness ratios are deleted from the instrument lists and are replaced by measures of tariff and non-tariff barriers, lagged values of the black-market premium on the foreign exchange, and lagged values of IMF dummy variables for whether a country was restricting transactions on capital or current accounts. If I exclude from the system the interaction terms between the openness ratios and the logs of GDP, then the results with the instruments are similar to, but less statistically significant than, those found when the openness ratios are included in the instrument lists. However, if the interaction terms are included (and corresponding interaction terms are added to the instrument lists), then the estimated coefficients on the openness ratio and the interaction term are individually statistically insignificant. That is, the instruments are not good enough to distinguish empirically between these two openness variables.

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.

e. The Inflation Rate. Column 1 of Table 1 shows a marginally significant, negative effect of inflation on the rate of economic growth.[12] The estimated coefficient implies that an increase in the average rate of inflation of 10% per year would lower the growth rate on impact by 0.14% per year.

Column 1 of Table 2 shows that the inflation rate also has a significantly negative effect on the investment ratio. This depressing effect on investment would reinforce the direct negative effect on growth that has already been discussed.

f. Fertility Rate. Column 1 of Table 1 shows 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. It should be emphasized that this relation applies when variables such as per capita GDP and education are held constant. These variables are themselves substantially negatively related to the fertility rate. Thus, the estimated coefficient on the fertility variable likely isolates differing

[12]The system includes lagged, but not contemporaneous, inflation in the instrument lists. Because of the concern about reverse causation — lower growth causing higher inflation — the panel estimation in Table 1 was also carried out without lagged inflation in the set of instruments. Rather, the system included dummy variables for prior colonial history as instruments. These dummy variables have substantial predictive content for inflation. (An attempt to use central-bank independence as an instrument failed because this variable turned out to lack predictive content for inflation.) The estimated coefficient on the inflation rate in the specification with the colonial instruments is larger in magnitude and more statistically significant than that shown in column 1 of Table 1. However, the colonial instruments cannot be used in some more limited samples, such as the group of OECD countries.

underlying preferences across countries on family size, rather than effects related to the level of economic development.

Column 1 of Table 2 also reveals a significant negative relation between the investment ratio and the fertility rate. This relation can be interpreted as an indication that the number of children is a form of saving that is a substitute for other types of saving (which support physical investment). The negative effect of the fertility rate on the investment ratio reinforces the direct inverse effect of fertility on growth.

g. Investment Ratio. Column 1 of Table 1 shows 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 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. Thus, the estimated coefficient of the investment ratio in the growth panel — 0.033 (0.026) — is interpretable as an effect from a greater propensity to invest for given values of the policy and other variables.

Recall that the instrument lists for the estimation include earlier values of the investment ratio but not values that are contemporaneous with the growth rate. Hence, there is some reason to believe that the estimated relation reflects effects of greater investment on the growth rate, rather than a reverse effect from higher growth (and the accompanying better investment opportunities) on the investment ratio.

h. The Terms of Trade. Column 1 of Table 1 indicates that improvements in the terms of trade (a higher growth rate of the ratio of export prices to import prices) enhance economic growth. The measurement of growth rates in terms of changes in real GDP means that this relation is not a mechanical one. That is, if patterns of employment and production are unchanged, then an improvement in the terms of trade would raise real income and probably real consumption but would have a zero effect on real GDP. The positive impact of an improvement in the terms of trade on real GDP therefore reflects increases in factor employments or productivity. Column 1 of Table 2 shows that the investment ratio is not significantly related to changes in the terms of trade.

D. 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 constructed by Barro and Lee (1993, 1996). 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). As mentioned before, these data have been refined and updated in Barro and Lee (2000).

In growth-accounting exercises, the growth rate would be related to the change in human capital — say the change in years of schooling — over the sample period. My approach, however, is to think of changes in capital inputs, including human capital, as jointly determined with economic growth. These variables all depend on policy variables and national characteristics and on initial values of state variables, including stocks of human and physical capital.

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.

a. Years of Schooling. Column 1 of Table 1 shows 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.[13] Figure 2 depicts this partial relationship. The estimated coefficient implies than an additional year of schooling (roughly a one-standard-deviation change) raises the growth rate on impact by 0.44% per year. As already mentioned, a possible interpretation of this effect is that a workforce educated at the secondary and higher levels facilitates the absorption of technologies from more advanced foreign countries.

The implied social rate of return on schooling is somewhat involved. 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

[13] The results are basically the same if the years of attainment apply to males aged 15 and over.

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.

If the convergence rate (the coefficient on log[GDP] in a linear specification) is 2.5% per year (the average effect across countries), then the coefficient of 0.0044 on the schooling variable implies that an additional year of attainment for the typical adult raises the level of output asymptotically by 19%. 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% 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, the cost of an added year of schooling is likely to be 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% per year turns out to imply a real rate of return to schooling of 7% per year. This figure is within the range of typical microeconomic estimates of returns to education.

Table 4 considers additional dimensions of the years of schooling. Female attainment at the secondary and higher levels turns out not to have significant explanatory power for growth — see column 1. One possible explanation for the weak role of female upper-level schooling in the growth panel 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 is insignificant for growth, as shown in column 2 of Table 4. Female primary schooling is positive (column 3), but still statistically insignificant. 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 already held constant in the growth panels. If fertility is not held constant, then the estimated coefficient on female primary schooling becomes significantly positive: 0.0039 (0.0013).[14] Hence, this result suggests that female primary education promotes growth indirectly by encouraging lower fertility.

Column 1 of Table 2 indicates that years of schooling (for males at the secondary and higher levels) are insignificantly related to the investment ratio. Hence, the linkage between human capital and growth does not involve an expansion in the intensity of

[14] The estimated coefficient on male upper-level schooling in this system is somewhat higher than before: 0.0054 (0.0018). If the fertility variable is excluded and female upper-level schooling is entered instead of female primary schooling, then the estimated coefficient on the female variable is close to zero, similar to

physical capital. This result is inconsistent with some of the theoretical effects mentioned before involving the ratio of human to physical capital.

b. 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 (1998) discuss the available cross-country aggregate measures of the quality of education. Hanushek and Kimko (2000) find that scores on international examinations — indicators of the quality of schooling capital — matter more than years of attainment for subsequent economic growth. My findings turn out to accord with their results.

Information on test scores — for science, mathematics, and reading — are available for 43 of the countries in my sample for the growth panel.[15] One shortcoming of these data is that they apply to different years and are most plentiful in the 1990s. The available data were used to construct a single cross-section of test scores on the science, reading, and mathematics examinations. These variables were then entered into the panel systems for growth that I considered before. In these systems, the test scores vary cross-sectionally but do not vary over time within countries.

One difficulty in the estimation procedure is that later values of test scores — for example, from the 1990s — are allowed to influence earlier values of economic growth, such as for the 1965-75 and 1975-85 periods. The idea that the coefficients represent effects of schooling quality on growth therefore hinges on the persistence of test scores

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that shown in column 1 of Table 4.

[15] Information is available for 51 of the countries in the Summers-Heston data set for real GDP. However, some of these countries were missing data on other variables.

over time within countries. That is, later values of test scores may be reasonable proxies for earlier, unobserved values of these scores. Fortunately for this interpretation, the results turn out to be nearly the same if the instrument lists omit the test-score variables and include instead only prior values of variables that have predictive content for test scores. These variables are the total years of schooling of the adult population (a proxy for the education of parents) and pupil-teacher ratios at the primary and secondary levels. Results are also similar if prior values of school dropout rates — which are inversely related to test scores — are added as instruments.

The results for the growth effects of test scores are shown in Table 5. Note that sample sizes are less than half of those from Table 1 because of the limited availability of the data on examinations. The countries included are also primarily rich ones. For example, for the broadest sample of 43 countries in column 8, only 14 of the countries had a per capita GDP below $5,000 in 1985.

Science scores are significantly positive for growth, as shown in column 1 of Table 5. With this scores variable included, the estimated coefficient of male upper-level attainment is still positive but only marginally significant. (The coefficients for the other explanatory variables are not shown in the table.) The estimated coefficient on the science scores — 0.13 (0.02) — implies that a one-standard-deviation increase in scores — by 0.08 — would raise the growth rate on impact by 1.0 percent per year. In contrast, the estimated coefficient for the school attainment variable — 0.002 (0.001) — 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. However, this finding does not instruct a country on how to improve the quality of education, as reflected in test scores. For some tentative results along these lines, see Barro and Lee (1998).

Mathematics scores are also significantly positive in column 2 but less significant than the science scores. Column 4 includes the two scores together, and the results indicate that the science scores are somewhat more predictive of economic growth.

Reading scores are puzzlingly negative in column 3. However, the reading coefficient becomes positive when this variable is entered jointly with the science scores in column 5, the mathematics scores in column 6, or the science and mathematics scores in column 7. (Note, however, that, because of the limited number of countries that have results for reading and either science or mathematics, the sample of countries in columns 5-7 is substantially smaller than that in column 3.)

Finally, as an attempt to increase the sample size, I constructed a single cross-section for a test-scores variable that was based on science scores, where available, and then filled in some missing observations by using the reading scores.[16] This filling-in was accomplished by using the average relation between science and reading scores for countries in which results on both examinations were available. This procedure raises the sample of countries by six from that in column 1 of the table. The results, shown in column 8, are similar to those found in column 1. Figure 3 shows graphically the partial relation between economic growth and the overall test-scores variable.

[16] The mathematics scores turned out not to provide any additional observations.

E. Health Variables

Conceptually, a country's human capital would include health and dimensions of social capital, as well as education. Table 4 considers two basic, aggregate measures of health capital — life expectancy at birth and the infant mortality rate. These variables are each measured around the start of each sub-period: 1965, 1975, and 1985.

The estimated coefficient on the log of life expectancy — when this variable is added to the system from column 1 of Table 1 — is positive but not statistically significant, 0.016 (0.015). Similarly, the estimated coefficient on the infant mortality rate, -0.042 (0.049), is negative but not statistically significant. Hence, there is some indication that more health capital increases economic growth — holding fixed school attainment and other variables — but the results are not very reliable. It may be worthwhile to consider additional dimensions of health capital, such as morbidity measures and more details on life expectancy as a function of age.

F. Rich (or OECD) Countries versus Poor Countries

The results described thus far pertain to the full sample of countries for which data are available. However, since the test-scores data are available primarily for rich countries, the results shown in Table 5 apply mainly to this sample.

Columns 3-5 of Tables 1 and 2 show how the basic results change if the sample is restricted to OECD countries (defined to comprise only the 24 that were members prior to the 1990s), rich countries (defined as places in which per capita GDP in 1985 exceeded $5,000), and poor countries. Since the OECD countries dominate the rich sample, the results for these two cases — columns 3 and 4 of the tables — are similar in most respects.[17]

The results in columns 3-5 of Tables 1 and 2 omit the interaction terms with log(GDP) — that is, the squared term in log(GDP) and the interaction between the openness ratio and log(GDP). For comparison, column 2 of the tables shows the results for the full sample under this specification. Note that, for economic growth over the full sample, the estimated coefficient on log(GDP) — the convergence rate — is –0.0244 (0.0031) or about 2-1/2% per year. This number, described as the "iron law of convergence" in some previous studies, can be interpreted as the average rate of convergence for the broad set of countries. The corresponding coefficient for the openness ratio is 0.0172 (0.0047).

The separate results for economic growth for rich and poor countries are shown in columns 4 and 5 of Table 1. Column 6 shows p-values for Wald tests of equality of the coefficients of the variables for the rich and poor countries. Two differences are the higher rate of convergence in rich countries (-0.034 versus –0.019) and the larger effect of openness in poor countries (0.036 versus 0.011). These differences were taken into account by the interaction terms in column 1 of the table. Other notable differences are the larger negative effect of government consumption in poor countries (-0.17 versus -0.01) and the larger positive effect of the change in the terms of trade in poor countries (0.13 versus –0.01). No other estimated coefficients differ significantly at the 10 percent significance level. With respect to the upper-schooling variable, the estimated effect is

[17] Of the 24 countries that were members of the OECD before the 1990s, the one missing from the system is Luxembourg. The difficulty is missing data on education (from the Barro-Lee data set) and the terms of trade.

larger in poor countries — 0.0084 versus 0.0023 — but the p-value for the difference in the two estimated coefficients (0.12) exceeds 10 percent.

For the investment ratio in Table 2, the main difference in coefficients between rich and poor countries is in the openness ratio — 0.11 for poor versus 0.03 for rich. The estimated coefficients on the inflation rate (-0.045 for poor versus -0.014 for rich) also differ significantly at the 10 percent level (p-value = 0.09).

The conclusions from this exercise are not straightforward. If one is most interested in policy implications for OECD countries, then one might be tempted to rely on the results that use only OECD or rich countries — columns 3 and 4 in Tables 1 and 2. This procedure has the virtues of avoiding the low quality of data from poor countries and of not contaminating the rich-country results with those from places that are just too different because they are so much poorer. One shortcoming, however, from the limited range of experience of the OECD or rich samples is that it is hard to pin down the effects of most of the variables. For example, for the OECD group in column 3 of Table 1, the only variables that are at least marginally significant for explaining growth are initial GDP (the convergence effect), the openness ratio, the fertility rate, and the ratio of investment to GDP. For the investment ratio in column 3 of Table 2, the only significant variable for the OECD sample is the government consumption ratio.

My preference is to use the overall data in order to exploit the wide range of experience in policies and other variables from the broad world sample. Then, some modifications to the specification can be included to achieve more homogeneity between rich and poor countries. The interaction terms with the log of per capita GDP that were included in column 1 of Tables 1 and 2 are examples of this approach. With these modifications, my inclination would be to rely on the full-sample results even when considering applications to a sample of OECD or rich countries.

G. Other Policy Influences on Growth and Investment

Other research has considered additional influences on economic growth and investment. One area that is of particular concern to continental Europe involves governmental interventions into the operations of labor markets. The interventions that exist include mandated levels of wages and benefits, restrictions on labor turnover, and official encouragement of collective bargaining.

The assessment of the effects of these kinds of policies for a broad sample of countries has been hampered by lack of good data. To get a rough idea of whether these sorts of restrictions matter for growth, I used two crude proxy variables. One was based on labor-standards conventions adopted by the International Labor Organization (ILO). (The adoption of some selected standards was taken as a sign that the country was interfering more broadly with labor markets.) The other was survey information collected by Jeffrey Sachs and Andrew Warner for the competitiveness project of the World Economic Forum.

Regression results that used these data were suggestive of negative effects from labor-market restrictions on economic growth. However, probably because of the poor quality of the data, these findings were not statistically significant.

I have also examined data on public debt for a broad group of countries. The evidence is that a larger stock of debt in relation to GDP has no significant explanatory power for economic growth or the ratio of investment to GDP.

King and Levine (1993) analyzed the development of domestic capital markets. They used several measures of this development, including the extent of intermediation by commercial banks and other domestic financial institutions. The general finding is that the presence of a more advanced domestic financial sector predicts higher economic growth. The main outstanding issue here is to disentangle the effect of financial development on growth from the reverse channel. In particular, it is important for future research to isolate the effects of government policies — for example, on regulation of domestic capital markets — on the state of financial development and, hence, on the rate of economic growth.

Easterly and Rebelo (1993) examined aspects of public investment and also considered the nature of tax systems. One result is that public investment does not exhibit high rates of return overall. The main positive effects on economic growth emerged for investments in the area of transportation. With regard to tax systems, the findings were largely inconclusive because of the difficulties in measuring marginal tax rates on labor and capital incomes in a consistent and accurate way for a large sample of countries. Hence, an important priority for future research is better measurement of the nature of tax systems.

3. Summary of Major Results

The determinants of economic growth and investment were analyzed in a panel of around 100 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, holding fixed 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.

The results from a broad panel of countries were compared with findings for rich and poor countries considered separately. (The results for OECD countries were similar to those for the larger group of rich countries.) Some differences that emerge for the determination of economic growth are a higher convergence rate in rich countries, larger effects from international openness and terms-of-trade changes in poor countries, and more negative effects from government consumption in poor countries. Despite these differences and issues about data quality in poor countries, my conclusion is that the broad sample of countries should be used, even if one's interest is limited to rich countries. The reason is that the observed variations in policy and other variables among rich countries is too limited to make accurate inferences.

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Table 1

Panel Regressions for Growth Rate

Independent variable	Overall sample		OECD sample	Rich-country sample	Poor-country sample	Wald tests of coefficients
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Log(per capita GDP)	0.107 (0.025)	-0.0244 (0.0031)	-0.0340 (0.0036)	-0.0343 (0.0033)	-0.0190 (0.0042)	0.017
Log(per capita GDP) squared	-0.0084 (0.0016)	--	--	--	--	--
Male upper school	0.0044 (0.0018)	0.0025 (0.0019)	0.0000 (0.0010)	0.0023 (0.0012)	0.0084 (0.0040)	0.12
Govt. consumption/ GDP	-0.157 (0.022)	-0.155 (0.025)	0.015 (0.040)	-0.014 (0.042)	-0.167 (0.030)	0.044
Rule-of-law index	0.0138 (0.0056)	0.0074 (0.0062)	0.0115 (0.0113)	0.0116 (0.0058)	0.0196 (0.0089)	0.54
Openness ratio	0.133 (0.041)	0.0172 (0.0047)	0.0148 (0.0071)	0.0112 (0.0028)	0.0361 (0.0114)	0.017
(Openness ratio)* log(GDP)	-0.0142 (0.0048)	--	--	--	--	--
Inflation rate	-0.0137 (0.0090)	-0.0057 (0.0094)	-0.0228 (0.0210)	-0.0051 (0.0088)	0.0033 (0.0123)	0.44
Log(total fertility rate)	-0.0275 (0.0050)	-0.0257 (0.0056)	-0.0209 (0.0059)	-0.0174 (0.0051)	-0.0212 (0.0089)	0.76
Investment/GDP	0.033 (0.026)	0.067 (0.027)	0.045 (0.025)	0.029 (0.025)	0.053 (0.040)	0.47
Growth rate of terms of trade	0.110 (0.030)	0.103 (0.029)	-0.010 (0.056)	-0.008 (0.042)	0.134 (0.039)	0.040
Numbers of observations	81, 84, 81	81, 84, 81	23, 23, 23	32, 32, 31	49, 52, 50	--
R^2	0.62, 0.50, 0.47	0.47, 0.42 0.41	0.85, -0.65, 0.50	0.77, 0.62, 0.52	0.48, 0.39, 0.44	--

Notes to Table 1

Dependent variables: The dependent variable is the growth rate of real per capita GDP. The growth rate is the average for each of the three periods 1965-75, 1975-85, and 1985-95.

Independent variables: Individual constants (not shown) are included in each panel for each period. The log of real per capita GDP and the average years of school attainment for males aged 25 and over at the upper level (secondary and higher) are measured at the beginning of each period. Government consumption is measured exclusively of spending on education and defense. The openness ratio is the ratio of exports plus imports to GDP, filtered for the usual relation of this ratio to country size, as measured by the logs of land area and population. The government consumption ratio, the openness ratio, the ratio of investment (private plus public) to GDP, the inflation rate (for consumer prices), the total fertility rate, and the growth rate of the terms of trade (export over import prices) are period averages. (For the last period, the government and investment ratios are for 1985-92.) The variable openness ratio*log(GDP) is the openness ratio multiplied by the log of per capita GDP at the start of the period. The rule-of-law index is the earliest value available (for 1982 or 1985) in the first two equations and the period average for the third equation.

Estimation is by three-stage least squares. Instruments are the actual values of the schooling, openness, and terms-of-trade variables, and lagged values of the other variables. The earliest value available for the rule-of-law index (for 1982 or 1985) is included as an instrument for the first two equations, and the 1985 value is included for the third equation.

Standard errors are shown in parentheses. The R^2 values apply to each period separately. P-values from Wald tests, shown in column 6, are for tests of the hypothesis of equality for the respective coefficients shown in columns 4 and 5.

Table 2

Panel Regressions for Investment Ratio

Independent variable	Overall sample		OECD sample	Rich-country sample	Poor-country sample	Wald tests of coefficients
	(1)	(2)	(3)	(4)	(5)	(6)
Log(per capita GDP)	0.244 (0.025)	0.0143 (0.0099)	0.0180 (0.0224)	0.0027 (0.0150)	0.0115 (0.0112)	0.33
Log(per capita GDP) squared	-0.0148 (0.0053)	--	--	--	--	--
Male upper school	0.0009 (0.0058)	-0.0034 (0.0058)	0.0037 (0.0043)	0.0023 (0.0047)	-0.0017 (0.0095)	0.75
Govt. consumption/ GDP	-0.236 (0.075)	-0.240 (0.078)	-0.338 (0.187)	-0.025 (0.112)	-0.281 (0.075)	0.20
Rule-of-law index	0.036 (0.020)	0.034 (0.021)	0.053 (0.068)	0.009 (0.029)	0.045 (0.025)	0.84
Openness ratio	0.431 (0.115)	0.031 (0.013)	-0.046 (0.032)	0.028 (0.013)	0.111 (0.022)	0.006
(Openness ratio)* log(GDP)	-0.047 (0.013)	--	--	--	--	--
Inflation rate	-0.093 (0.024)	-0.097 (0.025)	0.066 (0.064)	-0.014 (0.023)	-0.045 (0.024)	0.089
Log(total fertility rate)	-0.050 (0.015)	-0.046 (0.016)	0.019 (0.027)	-0.016 (0.022)	-0.069 (0.020)	0.80
Growth rate of terms of trade	0.007 (0.075)	0.017 (0.075)	0.057 (0.181)	-0.025 (0.112)	0.057 (0.078)	0.72
Numbers of observations	81, 84, 81	81, 84, 81	23, 23, 23	32, 32, 31	49, 52, 50	--
R^2	0.58, 0.61, 0.63	0.48, 0.53 0.58	-0.04,-0.03, 0.28	0.65, 0.20, 0.20	0.32, 0.51, 0.64	--

Notes to Table 2

The dependent variable is the ratio of real investment (private plus public) to real GDP. The measure is the average of the annual observations on the ratio for each of the periods 1965-75, 1975-85, and 1985-92. (The data presently available from Summers and Heston [1991] end in 1992.) See the notes to Table 1 for additional information.

Table 3

Barro-Lee and OECD Data on Educational Attainment

	Barro-Lee Data						OECD Data			
Country	**No School**	**Primary**	**Partial Secondary**	**Complete Secondary**	**Tertiary**	**Years of School**	**Below Upper Secondary**	**Upper Secondary**	**Tertiary**	**Years of School**
Australia	2	25	28	21	24	10.3	47	29	24	11.9
Austria	1	32	25	31	12	8.4	31	62	8	11.9
Belgium	5	49	21	10	16	8.6	47	29	25	11.7
Canada	2	14	31	24	30	10.7	25	28	47	13.2
Czech Republic	1	35	33	22	9	9.3	17	73	11	12.4
Denmark	0	34	8	39	19	9.9	38	42	20	12.4
Finland	0	31	15	35	19	9.8	35	45	21	11.6
France	1	48	24	13	15	7.7	32	50	19	11.2
Germany	5	51	16	13	15	7.7	16	61	23	13.4
Greece	6	52	8	24	11	8.1	57	25	17	10.9
Iceland	2	48	22	16	13	8.4	--	--	--	--
Ireland	3	35	25	20	16	8.8	53	27	20	10.8
Italy	14	43	20	12	12	6.6	65	27	8	10.0
Japan	0	31	30	17	22	9.4	--	--	--	--
Korea	9	18	16	36	21	10.1	40	42	18	--
Luxembourg	--	--	--	--	--	--	71	18	11	--
Netherlands	3	32	32	14	19	9.0	39	39	22	12.7
New Zealand	0	34	18	9	39	11.3	41	34	25	11.4
Norway	1	12	23	44	21	11.8	19	53	29	12.4

Table 3, continued

	Barro-Lee Data						OECD Data			
Country	**No School**	**Primary**	**Partial Secondary**	**Complete Secondary**	**Tertiary**	**Years of School**	**Below Upper Secondary**	**Upper Secondary**	**Tertiary**	**Years of School**
Portugal	14	61	9	6	10	4.6	80	9	11	10.0
Spain	27	33	16	13	12	5.8	72	12	16	11.2
Sweden	2	18	15	44	21	11.2	25	46	28	12.1
Switzerland	5	26	24	31	15	10.2	18	61	21	12.6
Turkey	31	47	9	7	7	4.6	77	15	8	--
UK	3	41	27	13	16	9.0	24	54	21	12.1
USA	1	8	21	24	47	12.2	14	53	33	13.5
Argentina	6	53	15	10	16	8.1	73	18	9	--
Brazil	22	59	6	5	8	4.3	75	16	9	--
India	52	28	9	6	5	4.2	92	3	6	--
Indonesia	44	33	9	10	4	4.0	81	15	4	--
Malaysia	17	34	19	24	7	7.7	67	26	7	--
Paraguay	10	64	9	10	8	5.7	67	19	14	--
Thailand	20	62	5	4	9	5.7	87	3	11	--
Uruguay	3	54	23	9	10	6.9	73	12	14	--

Notes to Table 3

The table shows the percentages of the population for whom the indicated level of schooling is the highest one attained. The Barro-Lee data, from Barro and Lee (1993, 1996, 2000), refer to the overall population aged 25 and over in 1995. The OECD figures, from OECD (1997, 1998a, 1998b), are for persons aged 25-64 in 1997 or 1998 (and for 1996 for the developing countries). In the Barro-Lee data, the average years of schooling come from multiplying the percentages at the various levels by the country's typical duration of school at that level and then summing over the categories. (This computation also considers the breakdown between partial and complete primary schooling.) The OECD procedure for this calculation is presently unclear (to us).

Table 4

Panel Regressions for Growth Rate — Additional Measures of Human Capital in Overall Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Female upper school	-0.0011 (0.0040)	--	--	--	--	--	--
Male primary school	--	0.0011 (0.0013)	--	--	--	--	--
Female primary school	--	--	0.0019 (0.0013)	--	--	--	--
Male upper school squared	--	--	--	-0.0003 (0.0007)	--	--	--
Male upper school *log(GDP)	--	--	--	--	-0.0002 (0.0019)	--	--
Log(life expectancy)	--	--	--	--	--	0.0158 (0.0147)	--
Infant mortality rate	--	--	--	--	--	--	-0.042 (0.049)

Notes to Table 4

The variables shown are entered, one at a time, into the system described in column 1 of Table 1. Estimated coefficients of the other variables contained in Table 1 are not shown. The various years of school attainment are for persons aged 25 and over. Life expectancy applies at birth. The infant mortality rate is for persons aged less than one year. The life expectancy and infant mortality variables are measured at the start of each period and are included in the instrument lists. See the notes to Table 1 for additional information.

Table 5

Panel Regressions for Growth Rate — Effects of Test Scores in Overall Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Science score	0.129 (0.022)	--	--	0.064 (0.037)	0.060 (0.021)	--	0.034 (0.027)	--
Mathematics score	--	0.076 (0.022)	--	0.036 (0.029)	--	-0.001 (0.027)	-0.017 (0.029)	--
Reading score	--	--	-0.025 (0.040)	--	0.034 (0.026)	0.074 (0.028)	0.067 (0.028)	--
Overall test score	--	--	--	--	--	--	--	0.125 (0.029)
Male upper school	0.0019 (0.0011)	0.0019 (0.0013)	0.0013 (0.0018)	0.0020 (0.0012)	0.0000 (0.0009)	0.0010 (0.0009)	0.0009 (0.0009)	0.0017 (0.0015)
Numbers of observations	37, 37, 36	34, 34, 33	32, 32, 32	34, 34, 33	26, 26, 26	23, 23, 23	23, 23, 23	43, 43, 42
R^2	0.72, 0.45, 0.28	0.68, 0.52 0.55	0.72, .39, 0.53	0.69, 0.52, 0.51	0.82, 0.29, 0.53	0.74, 0.36 0.55	0.76, 0.33 0.54	0.65, 0.59 0.37

Notes to Table 5

Test scores from science, mathematics, and reading examinations are measured as percent correct. The data used are a cross-section, consisting of only one average score in each field per country (for countries for which the data are available). The overall test score, used in column 8, equals the science score where available. The overall score uses the reading score, adjusted for differences in average levels from the science scores, to fill in some additional observations. (The mathematics scores turn out not to generate any additional useable observations, once the science scores are considered.) The test-score variables were entered into the system for the overall sample described in column 1 of Table 1. The test-scores variables are included in the instrument lists for each equation. For the other explanatory variables in the system, the estimated coefficient of the male upper school variable is shown, but the other estimated coefficients are not shown. See the notes to Table 1 for additional information.

Figure 1

Growth Rate versus log(GDP)

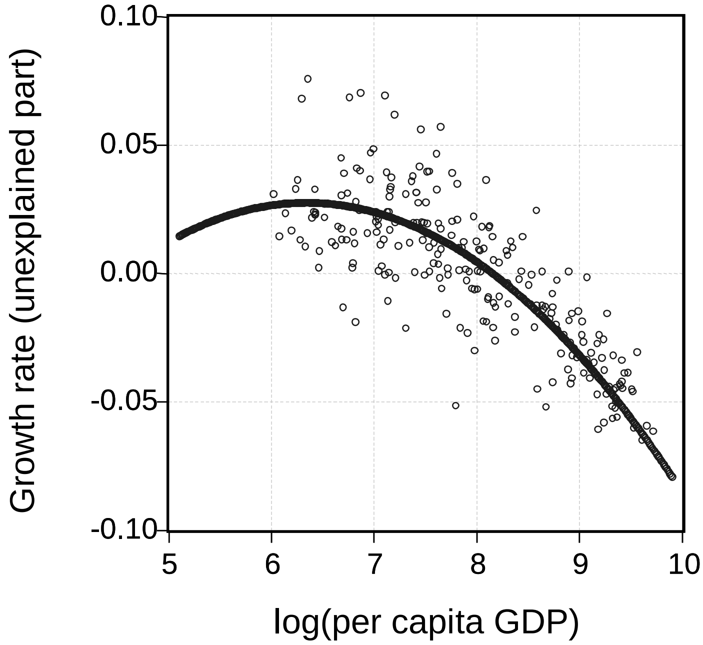

Figure 2
Growth Rate versus Schooling

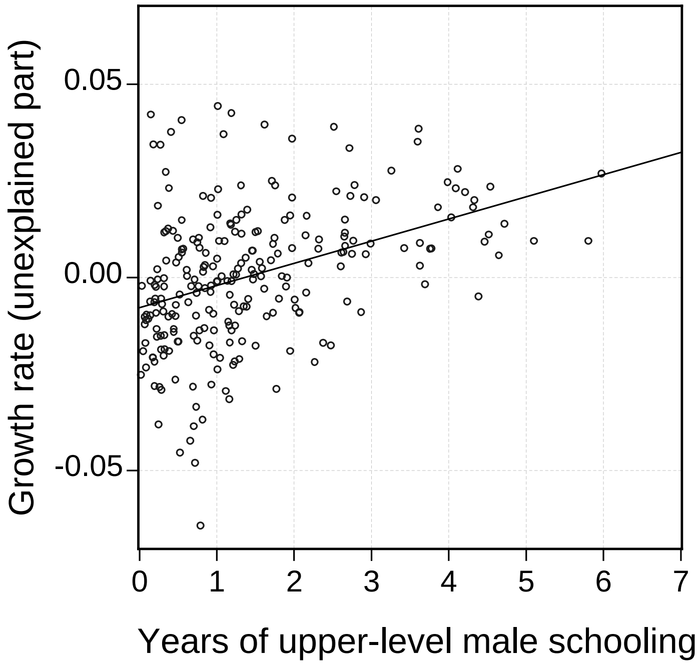

Figure 3

Growth Rate versus Test Scores