ECONOMIC GROWTH
AND CONVERGENCE

Robert J. Barro

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PREFACE

We are pleased to publish *Economic Growth and Convergence* as the forty-sixth in our series of Occasional Papers, which present perspectives on development issues by noted scholars and policy makers.

In this paper, Robert Barro examines the futures and limitations of the theory of economic convergence. The theory holds that less developed countries or regions develop at a greater rate in per capita terms than their richer or more developed counterparts, causing a tendency toward ''convergence'' in their per capita incomes. The theory is borne out mainly in regions with similar economic and political structures.

After presenting the empirical data supporting convergence theory, Dr. Barro descusses the possibility of isolating the variables that impact on a country's growth rate—such as openness to international trade, political stability, and the educational attainment of the labor force. When these variables are held constant, the estimated rate of convergence for real per capita GDP in the less developed nations turns out to be highly significant statistically and a magnitude only slightly below that found among the U.S. states and the regions of Europe and Japan. There is, essentially, an inverse relationship between a country's starting point and its rate of economic growth.

Dr. Barro points out that absolute convergence—that is, poor countries literally catching up to the richer countries of the world— depends on whether the tendency toward convergence applies to government policy and other determinants of long-run target positions. Counterproductive economic and social policies hinder growth by creating disincentives to technological innovation and by limiting trade.

Less developed countries that are unable to reform harmful policies limit their opportunities for convergence.

We at the International Center for Economic Growth hope that Dr. Barro's contribution will help developing and postsocialist countries to avoid past mistakes and meet the challenges of the new world economic environment. He has gained considerable recognition for his theoretical and empirical contributions to the understanding of economic growth and its causes. His essay represents a significant contribution to our mission to promote adoption of appropriate policies advancing human welfare and helping support emerging democracies throughout the world.

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General Director
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Economic Growth and Convergence

A key issue in economic development is whether economies that start out behind tend to grow faster in per capita terms and thereby converge toward those that began ahead. This convergence property seems to apply empirically for economies that have similar underlying structures—such as the regions of the major developed countries or among the OECD countries—but not for a heterogeneous collection of countries that includes the poor nations of Africa, South Asia, and Latin America. One reason for the failure of convergence in this broad context is that countries are effectively heading toward different long-run targets for per capita income. These targets depend on government policies in areas such as taxation, protection of property rights, and provision of infrastructure services and education. The targets can also vary due to factors that governments cannot readily influence, such as the underlying attitudes about saving, work effort, and fertility, and the availability of natural resources.

For a given long-run target—determined by government policies and other factors—the convergence tendency depends on the speed with which an economy approaches this target. This speed turns out empirically to be similar across economies, such as a broad cross section of countries, that differ greatly in other respects. Conceptually,

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the speed of convergence depends on issues like diminishing returns to capital, the behavior of saving, the mobility of capital and labor, and the diffusion of technology from leaders to followers.

I begin with a discussion of some empirical evidence on economic growth, especially as it pertains to the convergence question. Then I relate these facts to theories of economic growth and make inferences for the role of government policies.

Some Empirical Evidence on Convergence

Regional data. Figures 1–4 relate to regional economies: the U.S. states and the regions of some major countries in western Europe. Figure 1, which applies to 47 continental U.S. states or territories,[1] plots the average annual growth rate of per capita personal income

FIGURE 1.   Convergence of Personal Income across U.S. States: 1880 Income and Income Growth from 1880 to 1988

Log of 1880 per capita personal income
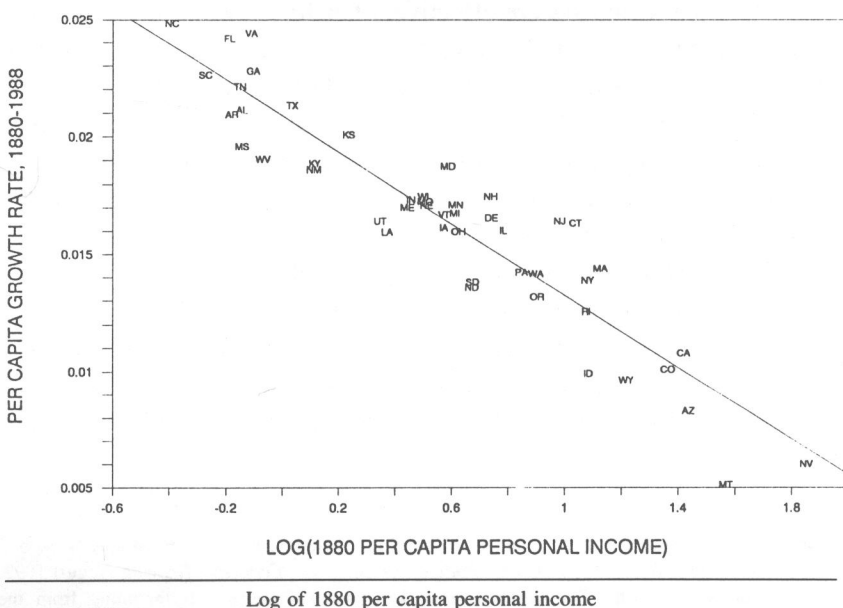
(exclusive of transfer payments) from 1880 to 1988 against the logarithm of per capita personal income in 1880. The figure shows a striking inverse relationship, that is, the places that were poorer in 1880 grew significantly faster in per capita terms over the subsequent 108 years. Thus, the behavior of growth rates across the U.S. states is consistent with convergence, in the sense of the poor places growing faster than the rich ones.

Part of the story that underlies Figure 1 is the catching-up of the southern states to the initially richer eastern and western states. But the convergence pattern applies equally well within regions as across regions; for example, the initially poor eastern states, such as Maine and Vermont, tended to grow faster than the initially rich eastern states, such as Massachusetts and New York.

The data shown in Figure 1 turn out to imply that the rate of convergence is roughly 2 percent per year. (See Barro and Sala-i-Martin (1992a) for the details.) In other words, about 2 percent of the gap between a rich and a poor economy tends to be eliminated in one year. This rate of convergence implies a half life of about 35 years, that is, it takes 35 years on average for half of an initial spread to vanish. Furthermore, it takes 70 and 115 years, respectively, to eliminate 75 percent and 90 percent of the gap. These numbers accord with the period of roughly a century after 1880 that it took for the per capita income of the typical southern state to come close to that in the typical northern state.

Figure 2 shows a measure of the dispersion of per capita income (the standard deviation of the logarithm of per capita personal income) across the U.S. states from 1880 to 1988. (Personal income is measured exclusive of transfer payments until 1929 and is shown with and without transfers thereafter.) The dispersion declined steadily from 1880 until 1920, then rose in the 1920s because of the sharp fall in real incomes originating in agriculture. The effect of the agricultural shock was pronounced because the agricultural states had lower than average levels of per capita income prior to the shock. The dispersion declined from the 1930s until the late 1970s but increased during the 1980s back to the levels of the early 1960s. (Recent data show that dispersion declined again after 1988.)

In the early 1980s, the rise in dispersion reflected the oil shock of

FIGURE 2.   Dispersion of Personal Income across U.S. States, 1880–1988
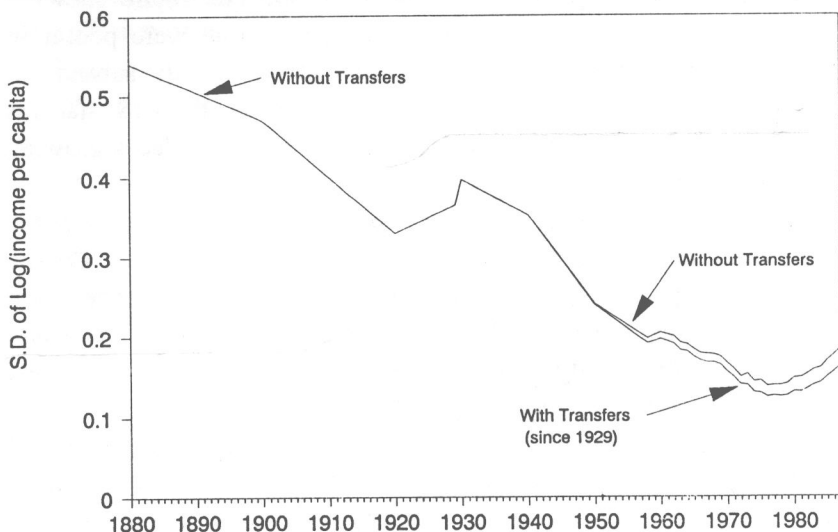
a. Income dispersion is measured by the unweighted cross-sectional standard deviation of the log of per capita personal income.
b. Data on the dispersion of per capita personal income inclusive of government transfer payments are included since 1929, although the effect of including transfer payments is negligible before 1950.

1979–80, an effect that was pronounced because the oil states already had above average levels of per capita income. The behavior of oil prices does not seem, however, to account for the continuing rise in dispersion in the late 1980s. This recent behavior resembles the pattern for measures of inequality for the incomes of individuals and families. The rise in dispersion at the state level may therefore reflect elements that have been cited in studies of the increased income inequality for families: the changing technological mix and the increased returns to education.

Figures 3 and 4 describe the behavior of per capita gross domestic product (GDP) from 1950 to 1985 for 73 regions of 7 European countries (11 in Germany, 11 in the United Kingdom, 20 in Italy, 21 in France, 4 in the Netherlands, 3 in Belgium, and 3 in Denmark). Figure 3 plots the regional growth rate of per capita GDP from 1950 to 1985 (expressed relative to the mean growth rate for the respective country)

FIGURE 3. Growth Rate versus Initial Level of Per Capita GDP for 73 European Regions


Log (1950 per capital GDP), deviation from country mean
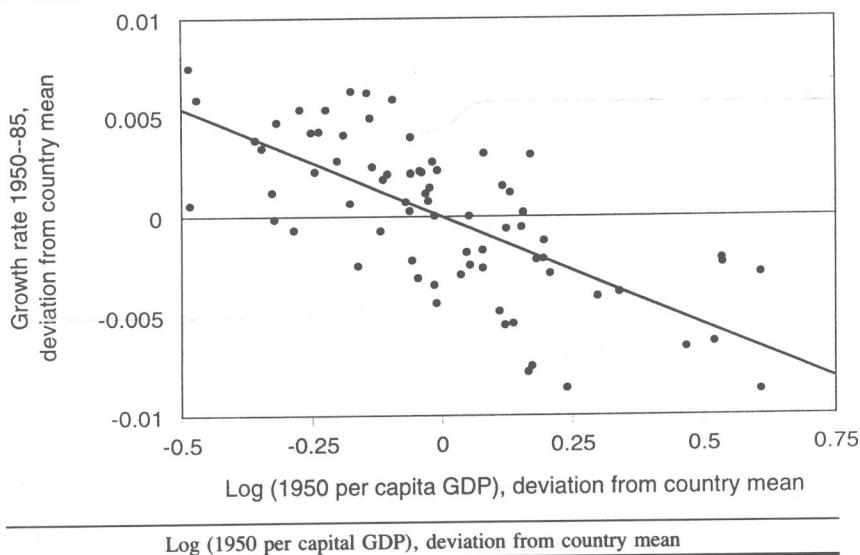
versus the logarithm of per capita GDP in 1950 (again measured relative to the mean for each country).[2] Although the relation is less striking than that shown in Figure 1, the inverse association between the initial position and the subsequent growth rate is statistically highly significant. The results turn out quantitatively to imply a speed of convergence that is again about 2 percent per year (see Barro and Sala-i-Martin 1991). Similar behavior also shows up for the provinces of Japan (Barro and Sala-i-Martin 1992c), although in this case, the estimated rate of convergence is about 3 percent per year.

Figure 4 shows the dispersion across the 63 European regions from the 4 larger countries—Germany, the United Kingdom, Italy, and France. The dispersion of per capita GDP declined from 1950 to 1970, but then changed little on net from 1970 to 1985.

Evidence from a broad sample of countries. Figures 5 and 6 provide information about convergence for 114 countries, roughly all of the significant countries that exist except for the formerly centrally

FIGURE 4.   Dispersion of Per Capita GDP across 63 Regions of 4 Major
   European Countries
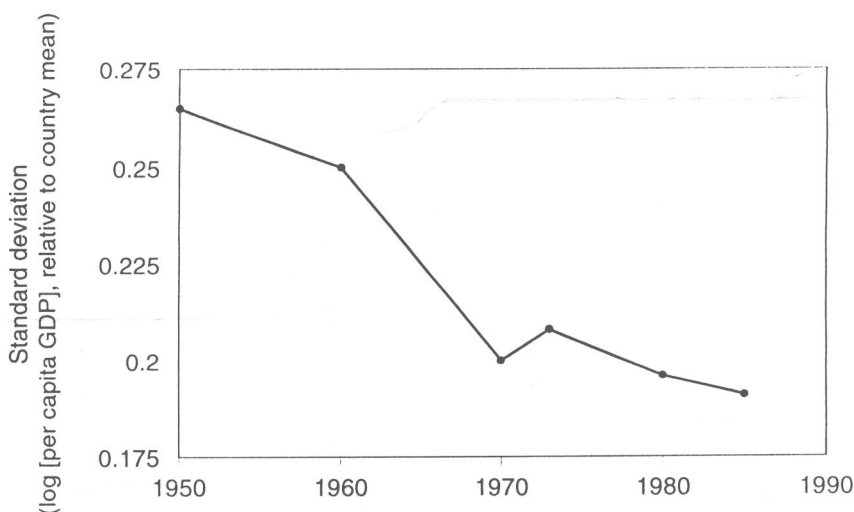
planned economies. Figure 5 plots the average growth rate of real per
capita GDP from 1960 to 1985 against the logarithm of real per capita
GDP in 1960.[3] In contrast to the clear inverse relationships that
showed up in Figures 1 and 3, the growth rate and initial level are
essentially uncorrelated in Figure 5; the association is actually slightly
positive. The cross-country data therefore do not reveal convergence:
the poor countries did not tend to grow faster per capita than the rich,
and, hence, the typical poor country did not tend to catch up to the
typical rich country (see Romer 1990a for a discussion of this evi-
dence).

The convergence behavior found for regions in Figures 1 and 3
shows up across countries if the sample is restricted to a relatively
homogeneous group of well-off places (see Baumol 1986, DeLong
1988, and Dowrick and Nguyen 1989). If one looks, for example, at
the twenty countries that were members of the OECD in 1960, then the
initially poorer countries tended to grow faster per capita. The esti-
mated rate of convergence in this sample turns out, however, to be
only about 1 percent per year.

FIGURE 5.   Growth versus Initial Level of Real Per Capita GDP for 114 Countries
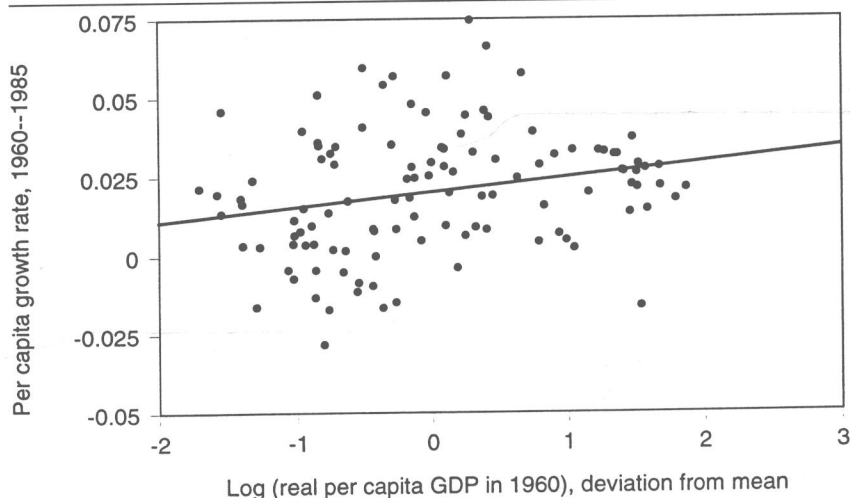
Figure 6 shows the time path from 1960 to 1985 for the dispersion of per capita real GDP for the 114 countries. (The data are plotted at five-year intervals.) The dispersion rose moderately but steadily over the sample. Figure 7 shows that this pattern also applied since 1950 for the sixty countries that have the earlier data.

Theoretical Perspectives on the Empirical Evidence

One framework for studying convergence is the neoclassical growth model developed for a closed economy by Ramsey (1928), Solow (1956), Swan (1956), Cass (1965), and Koopmans (1965). In this model, the force toward convergence involves the accumulation of capital through domestic savings in a context of diminishing returns. As an economy accumulates capital and thereby develops, the falling rate of return on capital tends to reduce the rate of growth. Thus, poor

FIGURE 6. Dispersion of Logarithm of Real Per Capita GDP for
114 Countries
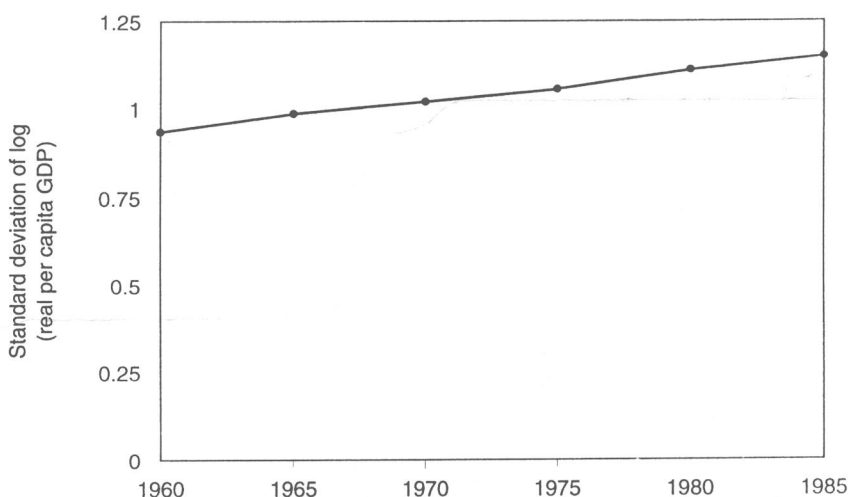
countries tend to grow faster because they have a higher rate of return on capital.

If different economies—say, countries or regions of countries—have the same underlying technology, preferences, and government policies, then the standard growth model predicts an *absolute* form of convergence. Economies with lower starting levels of income and product per person tend to grow faster in per capita terms because the smaller level of per capita product translates into a higher productivity of capital. This prediction accords with the regional data considered in Figures 1 and 3.

Quantitatively, the empirical estimate that regional convergence occurs at about 2 percent per year turns out to accord with the underlying growth model only if the diminishing returns to capital—the source of convergence in that model—set in slowly (see Barro and Sala-i-Martin 1992a). We have to take a broad view of capital to include human capital—educational attainment, work experience, and health—so that the rate of return on capital does not fall rapidly as

FIGURE 7. Dispersion of Logarithm of Real Per Capita GDP for 60 Countries
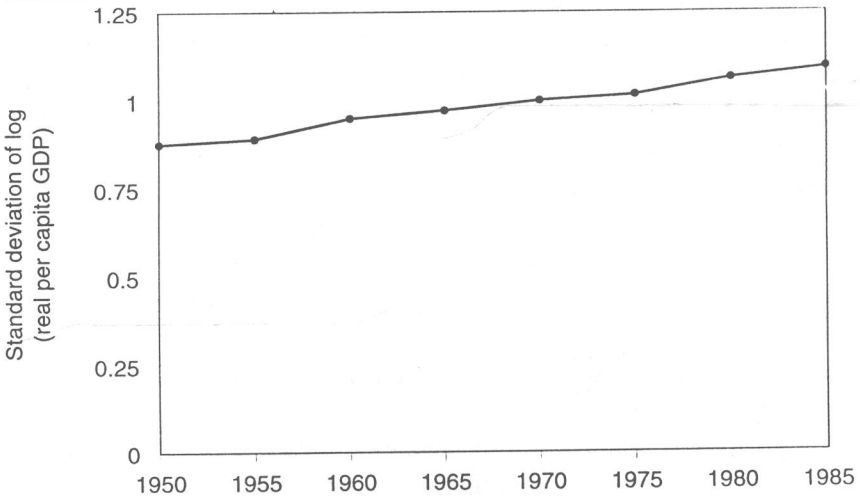
capital is accumulated. To fit the empirical estimate of the convergence rate, the share of capital income in total income has to be roughly three-quarters. This high capital share is reasonable, however, if we include human capital as part of the total capital stock.

If we try to apply the theory to the heterogeneous group of over one hundred countries, then we have to allow for differences in underlying conditions. These elements include not only the level of technology and attitudes about saving, work, and fertility, but also government policies in regard to taxation, maintenance of property rights, and provision of infrastructure services. Economies may differ substantially in some of these respects and may accordingly be converging to different long-run paths of per capita income.

Let y_i be the current level of per capita income for economy i and y_i^* be the long-run target that the economy is approaching. If economies have different long-run values, y_i^*, then the standard growth model predicts a *conditional* form of convergence. An economy grows faster if its starting level of per capita income, y_i, is further away from its

own long-run value, y_i^*. This conclusion follows because the private return from investment—net of taxation and risk of expropriation—depends inversely on the gap between y_i and y_i^*.

The results for the broad sample of countries shown in Figure 5 can fit with the standard growth model if the countries vary substantially in their target values, y_i^*. These variations could plausibly be large because of differences in government policies that affect the incentives to invest and operate efficiently; the countries differ in their openness to international trade and domestic competition, in effective tax rates on market activity, and in political stability and other factors that influence property rights. Since the sample comprises considerable heterogeneity with regard to cultural histories, the countries may also vary significantly in respect to their underlying preferences about saving, fertility, and work effort.

The interpretation offered by the standard growth theory is therefore that the variations across the 114 countries in per capita GDP, y_i, reflect mainly the variations in the long-run targets, y_i^*, and are accordingly essentially uncorrelated with the gaps from the targets, $y_i - y_i^*$. Since the underlying theory predicts an inverse relation between the growth rate and this gap, this interpretation is consistent with the absence of a significant relation between the growth rate and the initial level, y_i. In contrast, for the U.S. states and the regions of European countries and Japan, the interpretation was that the y_i^* were roughly equal, and, hence, that the variations in y_i reflected mainly differences in the gaps, $y_i - y_i^*$. The growth rate was therefore inversely related to the initial level in these samples.

The role of human capital. Extensions of the neoclassical growth model have distinguished the sector that produces goods—consumables and physical capital—from an education sector that produces new human capital (see, for example, Uzawa 1964, Lucas 1988, and Mulligan and Sala-i-Martin 1992). The assumption in these models is that the education sector is relatively intensive in human capital: it takes human capital embodied in teachers to produce human capital in students.

One finding stressed by Mulligan and Sala-i-Martin (1992) concerns imbalances between human and physical capital, that is,

departures of the ratio of human to physical capital from the ratio that prevails in the long run. The key result is that a higher ratio of human to physical capital, and, hence, a higher ratio of human capital to output, raises the growth rate. A country with an abundance of human capital tends also to focus its investment on physical capital; that is, a high ratio of human to physical capital results in a high ratio of physical investment to GDP.

The conclusions about imbalances between human and physical capital are reinforced if the accumulation of human capital involves adjustment costs that are much higher than those applicable to physical capital. (Machines and buildings can be assembled quickly, but people cannot be educated rapidly without encountering a sharp drop-off in the rate of return to investment.) An economy with a high ratio of human to physical capital is then like an economy that is described by the transitional dynamics of the usual neoclassical growth model. The economy effectively starts with a quantity of physical capital per worker that is substantially below its steady-state position, that is, far below the amount that matches the large quantity of human capital. The usual convergence effect implies that the growth rate of output exceeds its steady-state value in this situation.

A high ratio of human to physical capital applies, as an example, after a war that destroys large amounts of physical capital, but that leaves human capital relatively intact. Japan and Germany after World War II are illustrative cases. The theory accords with the empirical observation that countries in this situation tend to recover rapidly.[4]

In the standard neoclassical growth model, a higher rate of population growth reduces the steady-state value of capital per worker and thereby lowers the steady-state value of per capita income, y_i^*. The decrease in y_i^* implies that the economy grows in the transition (for a given value of y_i) at a slower rate. The rate of population growth is exogenous in this model, and the effect on the steady-state level of capital per worker involves the flow of new capital that has to be provided to accompany the flow of new workers.

Richer theories, such as the one by Becker, Murphy, and Tamura (1990), include the resources expended on children and allow fertility to be a choice variable of families. A key result is that a larger stock of human capital per person raises the wage rate and therefore the time

cost of raising children. (The assumption is that the productivity in the sector that raises children does not rise as fast as that in the sectors that produce goods and new human capital.) A higher stock of human capital motivates families to choose a lower fertility rate and to raise the investment in human capital for each child (that is, to substitute quality for quantity in children). These responses of population growth and human capital investment tend to raise the growth rate of output. This model therefore provides another channel through which a larger stock of human capital results in a higher subsequent rate of economic growth.

Empirical Analysis

In a recent study (Barro 1991) and in ongoing research (Barro and Lee 1993), I have attempted to isolate observable variables that serve as proxies for the long-run targets, y_i^*. If these targets can satisfactorily be held constant, then the theory predicts that an inverse relation between a country's growth rate and its starting position, y_i, would emerge. This result does, in fact, obtain if one holds constant variables like the share of government consumption in GDP, measures of openness to international trade (such as tariff rates and the black-market premium on foreign exchange), indicators of political stability (such as the frequency of revolutions and coups), and measures of initial human capital (such as the values at the start of the sample of educational attainment and life expectancy). If these kinds of variables are held constant, then the estimated rate of convergence for real per capita GDP turns out to be statistically highly significant and of a magnitude, about 1.5 percent per year, that is only slightly below that found for the U.S. states and the regions of Europe and Japan. These results are therefore consistent with the conditional convergence predicted by the standard growth model. In particular, the typical country is converging to its own long-run target at nearly the same rate at which the typical U.S. state or region of Europe and Japan is converging to its target.

Tables 1 and 2 contain a sample of this empirical research. Table 1 shows regression equations for the growth rate of real per capita GDP. (The data on GDP are the values adjusted for differences in