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What Determines Economic Growth?

Since 1973, per capita income growth in the United States and other advanced countries has slowed to 2.2 percent a year, or almost half the 3.9-percent annual rate of the preceding quarter century. If the United States had maintained the level of growth experienced in the 1950s and 1960s, real per capita income today would be about 11 percent ($2,200 in 1987 dollars) greater than it actually is. In contrast, it has been estimated that eliminating the variability in U.S. consumption since World War II would be equivalent to boosting current real consumption by only about 4.8 percent ($420 in 1987 dollars).[1] If the choice is between long-term growth policies and further short-term stabilization policies, long-term growth policies clearly have the potential for vastly higher benefits.

Perhaps the reason why economists have neglected long-run economic growth is that, for a long time, the profession relied on a theory that offered little scope for policy to influence important sources of growth. According to traditional growth theory, the main determinants of long-run economic growth are not influenced by economic incentives. Recently, however, the study of economic growth has been reinvigorated by new developments in theory and empirical findings that suggest growth is in the sphere of policy. This new literature, referred to as endogenous growth theory, helps to explain movements in long-term growth and why some countries grow faster than others.

Because long-term economic growth is the fundamental determinant of whether our grandchildren will have better lives than ours or whether the poor nations will catch up with or fall further behind the rich nations, this article attempts to summarize what economists have learned about economic growth and applies recent empirical findings to the above issues.

The first section examines the long-term growth record, focusing on the extent of growth variations across countries and across decades. The second section presents the traditional growth model and recently developed endogenous growth models. The next section discusses whether poor countries are catching up with richer nations or whether the rich are getting relatively richer. The fourth section examines factors that have been found to influence long-run economic growth, and the last section presents lessons for the future.

A historical perspective on economic growth

Despite the recent slowdown in economic growth, long-run growth not only has persisted since the early nineteenth century but has accelerated. Maddison (1991) has documented the persistence and acceleration of economic growth for 14 advanced capitalist countries (*Table 1*). The annual growth rate of the 14 countries averaged only 0.9 percent from 1820 to 1870 but rose to 1.6 percent between 1870 and 1989. For the forty years from 1950 through 1989, growth in these

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[1] *Lucas (1987, 27). Lucas estimates that eliminating the variability in U.S. consumption would be equivalent to increasing average real consumption about 0.1 percent per year. However, if current income volatility has effects on future productivity, as allowed for by Ramey and Ramey (1991), the long-run costs of volatility may be higher.*

Table 1
Growth Rates of Per Capita Real GDP, by Country

(Annual Averages)

	1820–1870	1870–1989	1950–1973	1973–1989
Australia	1.9	1.2	2.4	1.7
Austria	.6	1.8	4.9	2.4
Belgium	1.4	1.5	3.5	2.0
Denmark	.9	1.8	3.1	1.6
Finland	.8	2.3	4.3	2.7
France	.8	1.8	4.0	1.8
Germany	.7	2.0	4.9	2.1
Italy	.4	2.0	5.0	2.6
Japan	.1	2.7	8.0	3.1
Netherlands	.9	1.5	3.4	1.4
Norway	.7	2.2	3.2	3.6
Sweden	.7	2.1	3.3	1.8
United Kingdom	1.2	1.4	2.5	1.8
United States	1.5	1.9	2.2	1.6
Average	.9	1.6	3.9	2.2

SOURCE: Maddison (1991).

countries was at an even higher rate (3.2 percent), despite the slowdown since 1973.

Maddison (1991) and Romer (1986) have shown that the leading technological country, defined in terms of productivity per worker hour, has experienced increasing rates of growth since 1700. Intuitively, this pattern may be a consequence of the creation of new technology in the leading country. According to Maddison, there have been only three technological leaders in the past four centuries: the Netherlands, the United Kingdom, and the United States. Maddison's research shows that the growth rate of the leading country in three successive periods increased relative to that of the leader in the preceding period (*Table 2*).

Using annual data spanning up to 130 years across 16 countries, Ben-David and Papell (1993) find evidence of increasing per capita growth rates of gross domestic product (GDP). They find that in the more recent periods, trend GDP per capita growth rates were, on average, 2.5 times higher than the growth rates in the earlier periods.

Just by examining the GDP growth record in the United States, we can see that growth over the long run has tended to accelerate. Table 3 shows the per capita growth of the United States in five successive periods. The annual growth rate has risen from 0.58 percent for 1800–1840 to 1.82 percent for 1960–91. Romer (1986) also found a similar upward drift in the growth rates of per capita GDP for all countries in the Maddison (1991) sample for which data were available.

Table 2
GDP Growth Rates of Leading Technological Countries

Period	Leading country at beginning of period	Average annual compound growth rate (Percent)
1700–1820	Netherlands	–.05
1820–1890	United Kingdom	1.2
1890–1989	United States	2.2

SOURCE: Maddison (1991).

How reliable are the Maddison–Romer conclusions? Two factors—changes in household production and upward biases in measures of the rate of inflation—would seem to strengthen their conclusion that growth has been persistent and accelerating.

First, GDP does not cover household production and leisure. Because hours of work have steadily decreased, it would seem that nonmarket output should have increased relative to measured GDP. Hours of work seemed to be roughly constant at about 3,000 worker hours per year until about 1870, when they began to drop (Maddison 1991, 270–71, 276). Today, annual worker hours are about 1,600 in most of the advanced industrial countries, which suggests a substantial increase in leisure time. Leisure time, however, has probably not increased as much as worker hours have fallen because labor force participation rates have increased. Nonetheless, had the measures of GDP included estimates of the value of household production and leisure time, it is likely that the growth rates would have been higher in the period since 1870.

Another factor understating the pickup in living standards in this century is the overestimation of inflation. The rate of growth in real GDP is the rate of growth in nominal GDP less the rate of inflation as measured by some price index. But price indexes tend to overstate changes in the cost of living (Gordon 1992). They are biased upward partly because they do not incorporate new products in a timely fashion; for example, the consumer price index (CPI) did not include automobiles until 1940, several decades after production of the Model T. Price indexes also do not completely incorporate quality changes in existing products, account for the substitution of cheaper goods for more expensive goods over time, or take into consideration the availability of discount outlets. If the CPI is off, say, 0.5 percent per year, then official measures can understate the real rate of GDP growth by the same magnitude. The substitution

Table 3
Per Capita Real GDP Growth in United States

Period	Average annual compound growth rate (Percent)
1800–1840	.58
1840–1880	1.44
1880–1920	1.78
1920–1960	1.68
1960–1991	1.82

SOURCES:
Economic Report of the President (1992).
Romer (1986).

bias has been estimated to be about 0.18 percent per year in the United States, and quality changes in U.S. consumer durables have biased the rate of price increase in these products by about 1.5 percent per year (Gordon 1992). Thus, a bias of 0.5 percent or even 1 percent per year would not be too farfetched.

What can explain accelerating growth over nearly two centuries? Is the recent slowdown in per capita growth a new trend or a temporary setback? The following section addresses these questions in discussing the two main theories of economic growth.

Theories of economic growth

Growth is a complicated process, but the main theories of economic growth are conceptually simple. There are basically two categories of economic growth theories—those based on the traditional Solow (1956) growth model and those based on the concept of endogenous growth. The Solow model emphasizes capital accumulation and exogenous rates of change in population and technological progress. This model predicts that all market-based economies will eventually reach the same constant growth rate if they have the same rate of technological progress and population growth. Moreover, the model assumes that the long-run rate of growth is out of the reach of policymakers.

The recent proliferation of endogenous growth models began with the work of Paul Romer. Romer (1986) observed that traditional theory failed to reconcile its predictions with the empirical observations that, over the long run, countries appear to have accelerating growth rates and, among countries, growth rates differ substantially.

Endogenous growth theories are based on the idea that long-run growth is determined by economic incentives. The most popular models of this type maintain that inventions are intentional and generate technological spillovers that lower the cost of future innovations. Naturally, in these models an educated work force plays a special role in determining the rate of technological innovation and long-run growth. The following subsections discuss the structure of the two models.

The Solow growth model. The traditional growth model advanced by Robert Solow (1956), a Nobel Prize winner, is perhaps the most famous one.[2] The key idea of this framework is that growth is caused by capital accumulation and autonomous technological change. Solow views the world as one in which output, Y, is generated by the production function

(1) $$Y = F(K, L),$$

where K is the capital stock and L is the labor force. Solow postulated that the production function displays constant returns to scale, so that doubling all inputs would double output. However, holding one input constant—say, labor—and doubling capital will yield less than double the amount of output. Referred to as the law of diminishing marginal returns, this is one of the distinguishing elements of the Solow model.

The Solow model is driven by savings and variations in the ratio of capital to labor. Suppose that $k = K/L$ is the capital–labor ratio. It is convenient to begin with the observation that the percentage change in k equals the percentage change in K less the percentage change in L; that is,

(2) $$k/k = \quad K/K - \quad L/L.$$

The change in the capital stock equals investment, and investment equals the output that is saved rather than consumed. Thus,

(3) $$K = sY,$$

where s is the savings rate. Solow assumed that both the savings rate, s, and the growth rate of population, $\quad L/L$, are constant. Substituting (3) into (2) and multiplying by k yields

(4) $$k = sY/L - k(\quad L/L).$$

Equation 4 has a simple interpretation. The term sY/L is the amount of investment per unit of the labor force. The term $k(\quad L/L)$ is the amount of investment per worker that is necessary to maintain the capital–labor ratio, $k = K/L$. For example,

[2] *For a recent exposition, see Wynne (1992).*

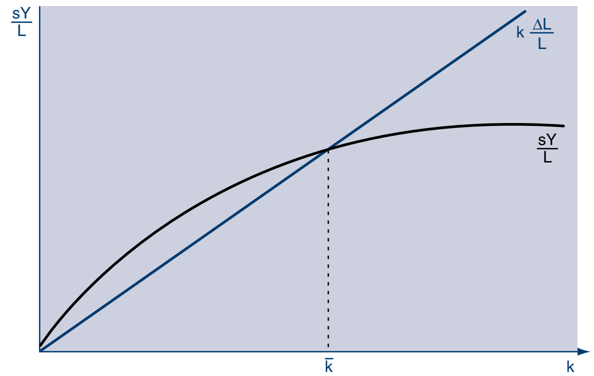
suppose K equals \$5 million and L equals 100, so k equals \$50,000. Then, a growth rate of 0.02 percent for the population requires \$1,000 of new investment per worker (\$100,000) to keep k equal to \$50,000.

The Solow model is depicted in Figure 1, which measures investment per worker on the vertical axis and the population capital–labor ratio on the horizontal axis. The amount of investment per worker, sY/L, increases at a decreasing rate because the law of diminishing returns implies that per capita output, Y/L, declines as k rises. On the other hand, investment per worker required to keep capital intact, $k(\Delta L/L)$, rises steadily because it is just proportional to k. Therefore, the two curves are likely to intersect at some equilibrium capital–labor ratio, $\bar{k}$. When the capital–labor ratio is less than $\bar{k}$, actual investment per worker exceeds that required to keep k constant, so k rises. When the capital–labor ratio is more than $\bar{k}$, investment per worker falls short of that required to keep k constant, so k falls. Thus, the economy gravitates toward $\bar{k}$. This is called a *steady state* because the economy can persist forever at this point. The capital stock and the level of output are rising at the same rate as the growth in the population, so per capita income, Y/L, does not change.

In the Solow growth model, where technological progress is exogenous, income will rise with the level of physical or human capital (accumulated human knowledge), but the rise will not generate ever-increasing growth rates. Skilled workers increase the level of income, just like any other productive factor, but they do not increase growth in the long run because technological progress does not depend on the presence of a skilled work force.

The basic conclusion of the model is that the rate of growth of the economy in the long run simply equals the rate of growth in the labor force plus the rate of exogenously determined technological progress. It is important to note that the rate of savings affects only the level of GDP, not the long-run rate of growth. A larger rate of savings will cause the rate of growth to increase temporarily because greater capital accumulation increases the productivity of labor and the level of GDP. But in the long run, the rate of growth will settle down to the rate of change in the labor force plus the rate of technological progress.

Figure 1
The Solow Growth Model



The Solow model implies that if rates of growth differ among countries, it is only because the countries are at different stages of movement toward the steady state. Rich countries should grow at a slower pace than poor ones; accordingly, over time, the per capita incomes of the rich and poor countries should converge.

Endogenous growth models with innovation. The Solow model suffers from its assumption that technological progress is not explained by economic forces. However, while the Solow model is silent on the mechanism of technological progress, some recently developed endogenous growth models have attempted to articulate the economic process behind technological development. Joseph Schumpeter (1950) and Jacob Schmookler (1966) have argued forcefully that technological progress takes place because innovators find it profitable to discover new ways of doing things. Technological progress does not just happen as a result of disinterested scientists operating outside the profit sector. Schmookler reviewed the record of important inventions in petroleum refining, papermaking, railroading, and farming and found "not a single, unambiguous instance in which either discoveries or inventions" were solely the result of pure intellectual inquiry (p. 199). Rather, the incentive was to make a profit.

The implication is that productivity growth might be related to the structure and policies followed by the economy, rather than to the exogenous forces of nature and luck. If growth is endogenous, we would expect to find a wide variation in the rates of growth of different nations, with no apparent correlation with their levels of per capita income.

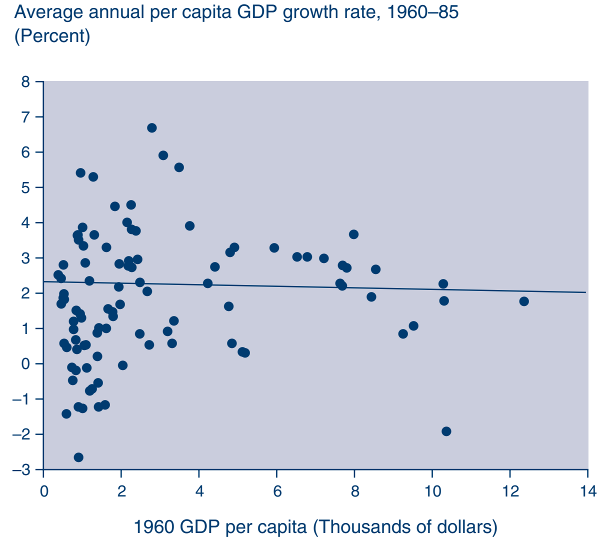
Research and development are carried out to make a profit on a new product. But every new product adds to the stock of human knowledge, so the cost of innovation falls as knowledge accumulates. To use an old metaphor, we stand on the shoulders of those who precede us. Obviously, the car required the prior invention of the wheel and the gasoline engine. Panati (1987) gives some interesting examples. The potato chip followed french fried potatoes; detergents followed soap (by 3,000 years); the hair dryer was suggested by the vacuum cleaner; and athletic shoes required vulcanized rubber. These examples suggest that the rate of growth of the economy will vary directly with the rate of introduction of new products: think of the automobile, the airplane, the personal computer, or the television set.

Some recently developed endogenous growth models have tried to capture the process behind the introduction of new products.[3] In these models, technological progress is faster, the larger is the level of accumulated human knowledge. The explanation is that the cost of innovation falls as the level of human knowledge increases.[4] As opposed to the Solow model, there are no diminishing returns to capital when other factors are held constant; so, raising the level of capital can lead to ever-increasing growth rates. Therefore, income growth will tend always to be faster among countries that have a relatively large stock of capital, a large educated population, or an economic environment that is favorable to the accumulation of human knowledge.

The convergence hypothesis

A stark prediction of the Solow model is that countries with similar preferences and access to the same pool of technology should eventually reach the same per capita income level. Consequently, poor nations will tend to grow faster than richer nations until their income levels catch up with, or converge to, the income levels of rich countries.

Figure 2
Real GDP Growth Per Capita
and 1960 Real GDP Per Capita



SOURCE OF PRIMARY DATA: Summers and Heston (1991).

In contrast to the Solow model, the endogenous growth model makes no such predictions. The model allows for the possibility that countries that start off richer and have more resources, such as human or physical capital, may always be ahead of less developed countries.

What is happening? Are the poor countries catching up with the richer nations, or are the rich getting relatively richer? Comparing their incomes is difficult because nations use different currencies and may have large variations in costs of living. If one uses market exchange rates to convert official GDP statistics into a common currency, the poorest 60 percent of the world's nations received only about 5 percent of the world's income in 1988, down from about 10 percent in 1960. It appears the poor countries are losing out. But the cost of living in poor countries is lower than in rich countries. To correct for this difference, it is necessary to use a measure of purchasing power parity—

[3] *See, for example, Lucas (1988), Romer (1990), and Grossman and Helpman (1991).*

[4] *See the Appendix for a formal presentation of this model.*

that is, the exchange rate that would make the costs of living of countries comparable. Robert Summers and Alan Heston (1991), therefore, recalculated the incomes of nations, using estimates of purchasing power parities. On this basis, the Solow model apparently has the correct predictions because income convergence appears to be taking place. From 1960 to 1988, the share of the poorest 60 percent of the world's population rose from about 17 percent of world income to almost 21 percent, while the share of the richest tier of countries fell from 68 percent of world income to about 60 percent.

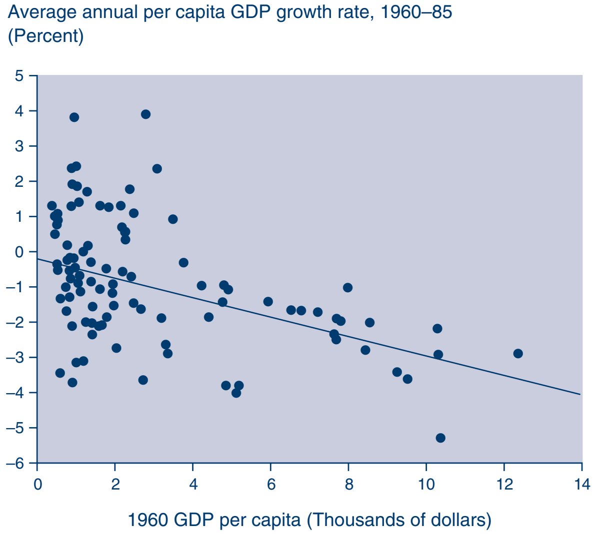
This analysis may be misleading, however, because changes in income shares are highly sensitive to how one defines income classes. If one compares the richest 10 percent of countries with the poorest 10 percent of countries, convergence does not appear to be taking place. Generally, the middle-income countries, which are sometimes grouped with the very poor countries, are experiencing convergence with the rich nations.

Another way of determining the degree to which incomes are converging across countries is to observe the relationship between growth rates and levels of income. If income levels of countries tend to converge, poor countries should grow faster than richer countries as they catch up to reach the higher level of income. Figure 2 shows the relationship between income in 1960 and growth rates between 1960 and 1985 for 98 countries of the Summers–Heston data set. There does not appear to be any strong negative relationship between growth rates and the level of income, which may indicate that convergence is not taking place. If it was, the diagram should show a negative, or downward-sloping, relationship between the level of income and growth rates, rather than the relationship pictured.

Some have argued that a problem with Figure 2 is that it does not hold constant other factors that determine growth. If we examine the relationship of income levels in 1960 and economic growth between 1960 and 1985, holding constant human capital, we find that the poor countries appear to be catching up with the rich countries (*Figure 3*).

Although income convergence conditional on human capital and other variables has been used as evidence against endogenous growth theory (Mankiw, Romer, and Weil 1992), it is not necessarily inconsistent.[5] We pointed out earlier that endogenous growth theory suggests that countries with higher levels of education (human capital) might provide greater incentives for invention and, therefore, much higher rates of growth. But holding human capital constant, endogenous growth theory may also predict convergence. Endogenous growth theory merely says that countries may diverge if they have different levels of human capital, all other factors constant. There is evidence suggesting divergence because countries do have different levels of human capital, and human capital tends to be positively correlated with economic growth.

Figure 3
Real GDP Growth Per Capita and 1960 Real GDP Per Capita: Human Capital Held Constant



SOURCES OF PRIMARY DATA: Summers and Heston (1991). United Nations (1971).

The determinants of economic growth

The Solow and endogenous growth models have different implications for what is, or is not,

[5] *Furthermore, the methodology of regressing average growth rates against initial income levels does not necessarily provide statistical evidence of convergence. For a description of this problem, see Danny Quah (1990).*

Figure 4
Solow Model:
Increase in Income Due to Educational Subsidy

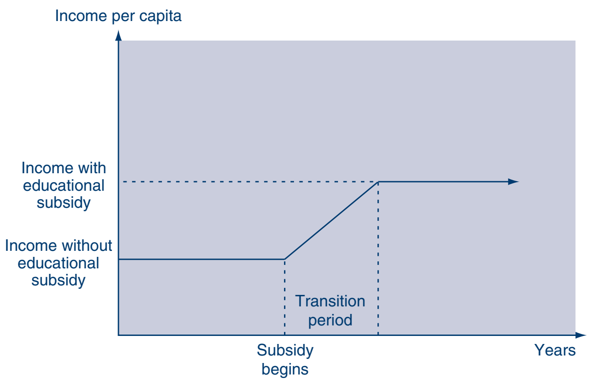
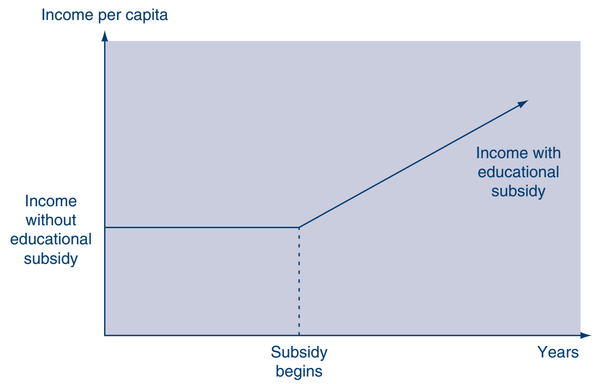


Figure 5
Endogenous Growth Model:
Increase in Growth Due to Educational Subsidy



important in determining the rate of growth. Using these models as guides, economists have tried to estimate the role of various factors suspected of determining the rate of economic growth.

Does the real world behave like the endogenous growth model, in which technological progress and long-term growth are influenced by economic factors, or like the Solow growth model, in which the determinants of technological progress and growth are exogenous? The question is important because the answer can tell us how countries may influence their growth rates. It is a difficult question to answer because technological progress is a long-run phenomenon and may take centuries to observe. Furthermore, over the relatively short period for which data are available, factors that apparently influence growth rates may, in reality, be changing only income levels. Hence, an observed increase in growth may be just a short-run transition to a higher income level and not a permanent increase.

For example, suppose Indonesia decides to subsidize college education by providing free tuition. If the Solow model accurately reflects reality, Indonesia will experience faster growth in the transition to a higher level of income (because of more investment in the accumulation of human knowledge), but income *growth* in Indonesia will not permanently increase (*Figure 4*). If the endogenous growth model is a better reflection of reality, the greater accumulation of human knowledge will result in not only higher income but also a permanently higher growth rate (*Figure 5*). The problem is distinguishing between models in the short run. Both models make the same short-run prediction that free college tuition increases Indonesia's growth. It is only in the long run, when growth either speeds up or does not change, that distinguishing between these two models becomes possible.

Plosser (1992) points out that the Solow growth model, even in the transition to a higher income level, cannot satisfactorily describe the changes in growth rates across countries. Imagine, for example, that Indonesia increases its rate of investment by 50 percent. As discussed above, the model predicts that the growth rate would immediately increase but would gradually decline over time until the new higher income and level of capital were reached. Assuming that the share of total capital in output is one-third, the Solow model predicts that income per capita would only rise about 22 percent.[6] If the country completed the transition to the new higher level of income in thirty years, then the increase in the average annual

[6] *One-third is typically found to be capital's share of output across countries. This assumes a Cobb–Douglas production technology of the form* $Y = K^{\alpha}L^{1-\alpha}$*, where* α *is capital's share of output.*

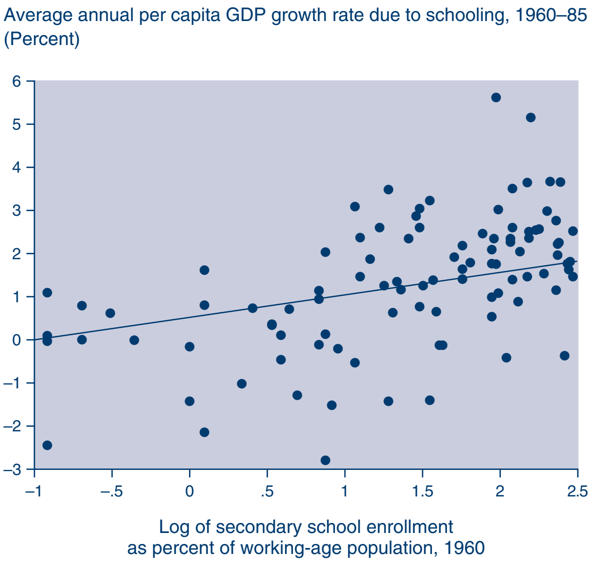
growth rate would be about 0.7 percent per year.[7] Consequently, large increases in investment rates have little ability in the standard Solow growth model to explain the observed large differences in growth rates across countries.

Studies have stressed different reasons why economic growth varies across countries. Because of the current popularity of endogenous growth models, most recent studies have focused on the role of human capital accumulation. However, human capital as an input to production is also important in the Solow model. In addition to human capital, a country's economic environment can play an important role in influencing economic growth. For example, internal competitive structure, a country's openness to trade, its political stability, and the efficiency of its government can influence innovative activity and economic growth, as discussed below.

Human knowledge. Does educating a work force increase a country's growth? Barro (1991), Mankiw, Romer, and Weil (1992), Levine and Renelt (1992), and Gould and Ruffin (1993), among others, have found evidence suggesting an educated populace is a key to economic growth. A larger educated work force may increase growth either because of faster technological progress, as individuals build on the ideas of others, or by simply adding to the productive capacity of a country. For example, in 1960, only 7 percent of Guatemala's children of secondary school age actually attended secondary school. Barro (1991) estimates that had the Guatemalans invested in education to increase attendance to a relatively modest 50 percent in 1960, the country's growth rate per capita from 1960 to 1985 might have increased an amazing 1.3 percent per year.

Figure 6 depicts the empirical relationship between GDP growth rates and secondary school enrollment as a proportion of the working-age population for 98 countries between 1960 and 1985.[8] On the vertical axis are average annual per capita growth rates for 1960–85, and on the horizontal axis is the log of secondary school enrollment rates as a proportion of the working-age population in 1960. Held constant are income levels in 1960, as well as capital savings rates. The slope of the fitted line in Figure 6 implies that increasing the secondary school enrollment rate a modest 2 percent, from 8 percent to 10 percent, raises the average growth rate an estimated 0.5 percent per year, holding other factors constant. The figure suggests that one important way for poor coun-

Figure 6
Partial Association Between Real GDP Growth Per Capita and School Enrollment Rate

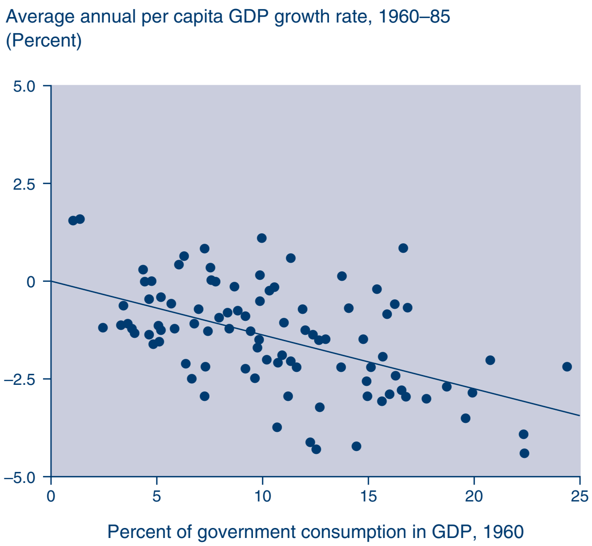


SOURCE OF PRIMARY DATA: Mankiw, Romer, and Weil (1992).

[7] *Plosser (1992) notes that there is considerable controversy over how fast an economy moves to its new level of income. Barro and Sala-i-Martin (1992) and Mankiw, Romer, and Weil (1992) estimate that it takes between 25 years and 110 years for one-half of the transition to be completed, depending on the sample and other characteristics considered. King, Plosser, and Rebelo (1988) compute the half-life of the transition as ranging from 5 years to 10 years under their parameter assumptions.*

[8] *School enrollment rates are often used as a proxy for accumulated knowledge because of the lack of data on the size of the educated population. A problem with using school enrollment rates, however, is that they measure the increase in the size of the educated population rather than the actual stock of educated people. Using literacy rates across countries may be more attractive because they are a measure of the stock of educated people. They, too, present problems, however, as literacy rates are sometimes measured differently across countries.*

Figure 7
Partial Association Between Real GDP Growth Per Capita and Government Consumption in GDP



SOURCE: Barro (1991, 431).

tries to advance is through greater investment in education.

Political and governmental factors. How much does the political environment help or hinder economic growth? One can imagine that an extremely unstable government (one that is susceptible to rapid policy reversals) would create insecurity about the future and decrease the incentives to invest in future development. For example, oil exploration would disappear if private investors believe that the government will expropriate oil wells. Likewise, people will not invest in developing new products if they cannot reap the rewards of their ideas. This is why copyright and patent protection can be an important factor in economic growth. Although it is difficult to measure property rights in a country, a safe assumption is that they suffer when a country experiences a large number of revolutions and political assassinations.

Holding constant the levels of education, income, and government consumption, Barro (1991) estimates that political instability, as measured by the number of revolutions and political assassinations in a country, decreases GDP growth per capita. For example, with greater political stability, South Korea's growth rate would have been 6.25 percent per year, rather than 5.25 percent, from 1960 to 1985. More dramatically, El Salvador may have lost almost 7 percent per year in per capita growth because of its extreme political instability.[9]

If political instability has a negative influence on growth, how does the size of government affect economic growth? Barro (1989, 1990, 1991) finds that the larger the share of government spending (excluding defense and education) in total GDP, the lower are growth and investment. Barro also finds that government investment has no statistically significant effect on economic growth. A government may attempt to increase private productivity through government spending, but the evidence suggests it has no such effect and may even decrease growth. Growth appears to fall with higher government spending because of lower private savings and because of the distortionary effects from taxation and government expenditure programs. Figure 7 shows the negative relationship between per capita growth and the share of government consumption in GDP. Held constant are income levels in 1960, as well as the level of education and indicators of the political stability. As Figure 7 shows, increasing the share of government consumption in GDP from 10 percent to 15 percent would decrease economic growth about 0.6 percent per year.

International trade. Do countries that are open to international trade grow faster than closed economies? Evidence suggests that the answer is yes. From 1960 to 1985, economies that have pursued outward-oriented pro-trade policies—such as the four so-called Asian Tigers (Singapore, Hong Kong, South Korea, and Taiwan)—experienced growth rates between 8 percent and 10 percent a year. In contrast, the relatively closed economies of Africa and Latin America experienced growth rates rarely exceeding 5 percent a year. Ben-David (1991) finds that when countries in Europe joined the European Community and dropped their trade

[9] As measured by assassinations and revolutions, political instability can also be associated with the direct destruction of a country's capital stock. This, by itself, can certainly reduce a country's growth rate.

barriers, incomes increased and approached those of the wealthier nations.

A country open to international trade may experience faster technological progress and increased economic growth because the cost of developing new technology falls as more high-tech goods are available. In other words, trade increases growth because it makes a greater variety of products and technologies available. De Long and Summers (1991) find that relatively closed countries with high effective rates of protection have productivity growth rates that, on average, are 1.1 percentage points below those of other countries. Roubini and Sala-i-Martin (1991) find that a country that moves from being a strongly outward-oriented trade regime to a strongly inward-oriented trade regime would experience a 2.5-percentage-point decrease in its annual growth rate. Gould and Ruffin (1993) attempt to distinguish between human capital as an input to production and human capital as the source of long-term growth in open and closed trading regimes. They find that when human capital, as measured by literacy rates, is relatively high, open economies experience growth rates 1 to 2 percentage points higher than the growth rates of closed economies.

Equipment investment. De Long and Summers (1991) have argued that equipment investment has potentially large effects on economic growth. They explain that new technologies have tended to be embodied in new types of machines. For example, at the end of the eighteenth century, steam engines were necessary for steam power, and automatic textile manufacture required power looms and spinning machines. In the early twentieth century, assembly-line production was unthinkable without heavy investments in the new generations of high-precision metal-shaping machines that made parts interchangeable and assembly lines possible.

In examining a cross-sectional distribution of growth rates in the post–World War II period, De Long and Summers find evidence suggesting that investments in machinery and equipment are a strategic factor in growth and possibly carry large positive benefits in generating further technological progress. Holding constant such factors as relative labor productivity, labor force growth, school enrollment rates, and investment other than in machinery and equipment, De Long and Summers find that each extra percentage point of total output devoted to investment in machinery and equipment is associated with an increase of 0.26 percentage point per year in economic growth. Other investment also has a positive impact on growth, but the effect is only one-fourth as large as that for machinery investment.[10]

Overview of factors behind growth. Table 4 summarizes factors that have been shown to influence growth rates. As the table indicates, factors that are associated with increasing human or physical capital investment tend to enhance technological progress and economic growth. On the other hand, factors that reduce incentives to invest, or interfere with well-functioning markets, tend to reduce growth.

Conclusion

For centuries, economists have been trying to answer questions about what determines economic growth and to make predictions about the future. Malthus, an economist who wrote in the late eighteenth century, predicted that expanding population growth combined with limited resources and declining productivity would result in only a subsistence income. Certainly, in the slowly growing agrarian era in which Malthus lived, it would have seemed impossible for the land to provide for everyone with unbounded plenitude. However, with the technological advances in the latest century, it is difficult to be pessimistic. New products appear to beget other products, so technology seems to be advancing at ever-increasing rates.

Endogenous growth literature arose out of the desire to explain why, over long periods, economic growth appears to be accelerating and why some countries grow faster than others. The traditional Solow model left unanswered too many questions about growth differentials across countries and the mechanism of technological progress.

[10] *Whether equipment investment generates positive externalities that influence technological progress is subject to some debate. Auerbach, Hassett, and Oliner (1992) argue that economic growth due to equipment investment is completely consistent with the basic Solow model.*

Table 4
Determinants of Economic Growth

Growth enhancing	Growth reducing
Schooling, education investment[1,2]	Government consumption spending[1]
Capital savings, investment[2]	Political, social instability[1]
Equipment investment[3]	Trade barriers[3,4,5,6]
Level of human capital[1,6]	Socialism[1]

[1] Barro (1991).
[2] Mankiw, Romer, and Weil (1992).
[3] De Long and Summers (1991).
[4] Ben-David (1991).
[5] Roubini and Sala-i-Martin (1991).
[6] Gould and Ruffin (1993).

Technological progress, however, is what ultimately determines growth, and growth determines whether our grandchildren will have better lives than ours.

We are just beginning to understand theoretically and empirically the mechanisms of economic growth, and much work has yet to be done. But so far, there appears to be a strong relationship between investment, particularly human capital investment, and growth. Other factors also are positively related to investment and growth, such as political stability, well-defined property rights, equipment investment, low trade barriers, and low government consumption expenditures. These findings are consistent with the long-run growth predictions of endogenous growth models but are also consistent, in the short run, with Solow models. It may be several decades before we have enough detailed long-run data to distinguish clearly between these theories. In the meantime, maintaining policies consistent with long-run growth can have significant benefits.

Appendix

Endogenous Growth Model with Innovation

This Appendix explains the basic endogenous growth model found in Grossman and Helpman (1991). Suppose there are n products. To simplify, each product sells for the same price and has the same cost of production. Each product is the property of a single firm. We assume that each unit requires only one unit of labor so that the marginal cost of production is simply the wage rate, w. Every firm sets a price, p, that is the same markup over costs,

$$\text{(A.1)} \qquad p = w(1/\alpha),$$

where $1/\alpha$ is the markup. The parameter α is between 0 and 1. In effect, α is the cost of production per dollar's worth of the product. Accordingly, the profit on \$1 worth of sales will be $(1 - \alpha)$. If the economy sells \$$E$ worth of products, then the total profit of all n firms is

$$\text{(A.2)} \qquad \Pi = E(1 - \alpha).$$

Research and development take place in the form of new products. Firms invent new products in an effort to capture some fraction of the profits given in (A.2). It takes a units of labor to invent a new product. Accordingly, firms will enter the market as long as the present value of future profits, called v, exceeds innovation costs, wa (that is, $v \quad wa$). Firms will enter the market until w rises or v falls up to the point that

$$\text{(A.3)} \qquad wa = v.$$

The rate of growth of new products is $g = \Delta n/n$. Each firm's profit is $E(1 - \alpha)/n$; accordingly, the profit of any existing firm falls as new firms develop new products. The stock market valuation of any set of n firms must be reduced by the growth rate, g. If g is zero, the aggregate value of all n firms would be $vn = E(1 - \alpha)/r$, where r is the rate of interest. But if g is greater than zero, then the aggregate value of the stock market is

$$\text{(A.4)} \qquad vn = E(1 - \alpha)/(r + g).$$

Combining (A.2), (A.3), and (A.4), we have

$$\text{(A.5)} \qquad p = v/a\alpha = E(1 - \alpha)/a\alpha n(r + g).$$

To determine the rate of growth of new products, we need to know how much labor is devoted to their production and how much is devoted to research and development. The amount of labor devoted to production is the total output of products (because one unit of

(Continued on the next page)

Appendix

Endogenous Growth Model with Innovation—*Continued*

output requires one unit of labor). In turn, the total output of products is the physical sales volume, E/p. The amount of labor devoted to research and development is the number of new products, ng, multiplied by the labor required per new product, a, or ang. Thus, the growth rate, g, is determined by the equation

$$ang + E/p = L, \tag{A.6}$$

where L is the total amount of labor available. Substituting (A.5) into (A.6) yields

$$ang + a\alpha n(r + g)/(1 - \alpha) = L. \tag{A.7}$$

Multiplying by $(1 - \alpha)$, we get

$$g(1 - \alpha) + \alpha(r + g) = L(1 - \alpha)/an, \tag{A.8}$$

which equals

$$g = L(1 - \alpha)/an - \alpha r. \tag{A.9}$$

The key assumption in the theory of endogenous growth is that there are technological spillovers. A simple way of capturing this idea is to let the cost of invention fall as human knowledge accumulates. In this model, human knowledge can be regarded as the number of products, n. Accordingly, it is assumed that $a = c/n$, where c is a positive constant. Substituting this into (A.9) yields the final growth equation:

$$g = L[(1 - \alpha)/c] - \alpha r. \tag{A.10}$$

An important implication is that the larger the stock of people capable of carrying out research and development, L, the larger the rate of growth. Because human capital is growing, the endogenous growth model implies accelerating growth rates.

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