CHAPTER 6

HUMAN CAPITAL

Give a man a fish, and you feed him for a day. Teach a man to fish, and you feed him for a lifetime.

— *Chinese proverb*

So far, we have treated labor, the human input into production, as constant across countries and over time. But in fact, the quality of labor that a person supplies can vary enormously. A worker can be weak or strong, ill or healthy, ignorant or educated. In day-to-day experience, we see that people who have better labor to supply—those who are particularly smart or who can work tirelessly—are able to earn higher wages. The same has been true for stronger people for much of history, although it is rarely true in developed countries today. (But physical attributes do still matter: A study of workers in the United States and Canada found that those judged to have above-average looks earned 12% more than similarly qualified workers who were judged to have below-average looks.[1])

In this chapter we explore the idea that differences in the quality of workers are one explanation for differences in income among countries. We would not expect differences in labor quality to explain *all* of the differences in income that we see around us (as we have already laid out some other reasons why incomes differ, and we know more are to follow); but we want to look into how large a contribution to these differences labor quality makes.

The qualities of labor on which we focus go by the collective name **human capital** because they share several important qualities with physical capital. First, as with physical capital, we focus on qualities of people that are *productive*—that is, characteristics that enable them to produce more output. Second, we concentrate on the qualities that are *produced*, just as we said that a key aspect of physical capital is that it is itself produced. We will see that investment in human capital

[1]Hamermesh and Biddle (1994).

production is a major expense for an economy. Third, just like physical capital, human capital earns a return. The manner in which a return is earned differs between the two, however. Human capital earns a return by giving the worker who owns it a higher wage, and only does so while he or she is working, whereas physical capital can earn its return while its owner is relaxing at the beach. Finally, just like physical capital, human capital depreciates.

6.1 | Human Capital in the Form of Health

As a country develops economically, the health of its population improves. This improvement in health is direct evidence that people are leading better lives. In other words, health is something that people value for itself. But health also has a productive side: Healthier people can work harder and longer; they can also think more clearly. Healthier students can learn better. Thus, better health in a country will raise its level of income. It is this productive aspect of health—that is, health as a form of human capital—that we now explore.

The Effect of Health Differences on Income

As countries develop, their people get bigger. The average height of men in Great Britain rose by 9.1 centimeters (3.6 inches) between 1775 and 1975. Similarly, in 1855 two-thirds of young Dutch men were shorter than 168 centimeters (5 feet, 6 inches), but today the figure has fallen to 2%. These changes are purely attributable to changes in environment because the genetic makeup of these populations has changed very little.[2]

As with many of the changes that we examine in this book, the change in physical stature in many developing countries has paralleled the shift in the developed countries, except that it started later and has proceeded more rapidly. For example, the average height of South Korean men in their 20s rose 5 centimeters (2 inches) between 1962 and 1995.

The principal explanation for these improvements in height is better nutrition. In Great Britain daily calorie intake per adult male rose from 2,944 in 1780 to 3,701 in 1980. Similarly, in South Korea daily calorie consumption per adult male rose from 2,214 to 3,183 between 1962 and 1995.[3] Height serves as a good indicator of malnutrition, particularly malnutrition experienced in utero and during the first years of life. Shortness is a biological adaptation to a low food supply, because short people require fewer calories to get by.

[2]Fogel (1997).
[3]Data on height and calorie consumption in Korea are from Sohn (2000).

People stunted by malnutrition are also less healthy. More significantly, the same malnutrition that causes shortness is also reflected in lower abilities as a worker. (Shortness does not always indicate malnutrition or poor health—it also reflects a person's genetic predisposition. In the United States, where most adults were well nourished as children, there is little relationship between a man's height and his wages; specifically, a 1% difference in height is associated with a 1% difference in wages. In Brazil, where malnutrition is extensive, a 1% difference in height is associated with a 7.7% difference in wages.[4])

Economic historian Robert Fogel has attempted to quantify the contribution of improved nutrition to economic growth in the United Kingdom in the two centuries between 1780 and 1980. Improved nutrition raised output by two means: first, by bringing people into the labor force who would otherwise have been too weak to work at all, and second, by allowing the people who were working to work harder. Fogel calculated that in 1780 the poorest 20% of adults in the United Kingdom were so badly nourished that they did not have the energy for even one hour of manual labor per day. By 1980, this sort of malnutrition had been completely eliminated, and all adults were nourished well enough to work. This change by itself would have increased the amount of output per adult by a factor of 1.25. Among adults who were working, Fogel calculated that the increase in caloric intake allowed a 56% increase in the amount of labor input that could be provided. Putting these two effects together, better nutrition raised output by a factor of $1.25 \times 1.56 = 1.95$. Spread over 200 years, this was an increase of 0.33% per year. Given that the actual growth of income per capita in the United Kingdom over this period was 1.15% per year, improved nutrition can be seen as having produced slightly less than one-third of the overall growth in income.

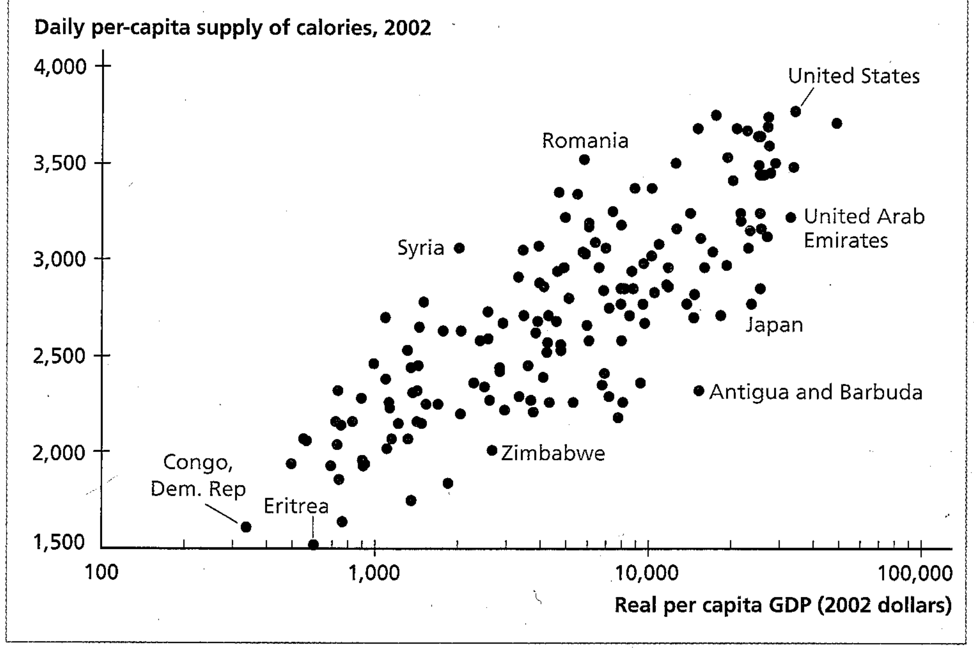
In developed countries today, most people are well nourished. But in much of the developing world, malnutrition is still pervasive. Figure 6.1 shows the relationship between GDP per capita and the number of calories available for consumption per day. The richest countries have calorie supplies of between 3,000 and 3,500 per day; in the poorest countries, daily calorie supplies average less than 2,000. The levels of nutrition shown in this figure understate the true extent of malnutrition in a number of countries because they are national averages and don't take account of inequalities in food distribution within countries. For example, in Latin America the richest 20% of the population has per-capita food consumption that is 50% larger than that of the poorest 20% of the population. Thus, even in countries with enough food on average, the poorest part of the population is malnourished. Worldwide, some 774 million people suffered from malnutrition in 1999.[5]

These differences in nutrition are paralleled by differences in health. One way of measuring the average level of health in a country is by looking at life expectancy

[4]Strauss and Thomas (1998).
[5]Rosen and Shapouri (2001).

FIGURE 6.1

Nutrition versus GDP per Capita



Sources: FAOSTAT database, Heston, Summers, and Aten (2006).

at birth. Figure 6.2 shows a strong relationship between life expectancy and GDP per capita. Most of the poorest countries in the world have a life expectancy below 60 years, while among the richest countries, life expectancy ranges between 75 and 82 years. Other measures of health paint a similar picture. For example, the fraction of nonpregnant women who are anemic averages 48% for the poorest quarter of countries but only 18% for the richest quarter of countries.[6]

These data establish that there are large variations in health between rich and poor countries and that these differences can contribute to differences in income between the two groups. We now turn to the question of where these health differences originate.

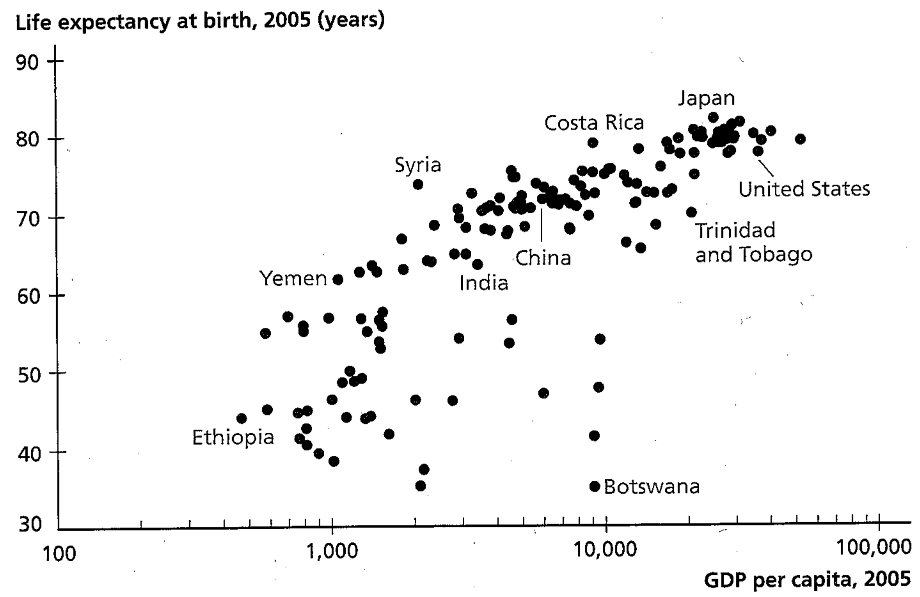
Modeling the Interaction of Health and Income

In the previous section we saw that improvements in nutrition, by allowing workers to function more effectively, have contributed significantly to increases in income per capita. But this is only part of the story. Better nutrition is not only a contributor to,

[6]Shastry and Weil (2003).

FIGURE 6.2

Life Expectancy Versus GDP per Capita



Sources: Heston, Summers, and Aten (2006), World Bank (2007a).

but also a *result of*, higher income, because people in wealthier countries can afford more and better food.

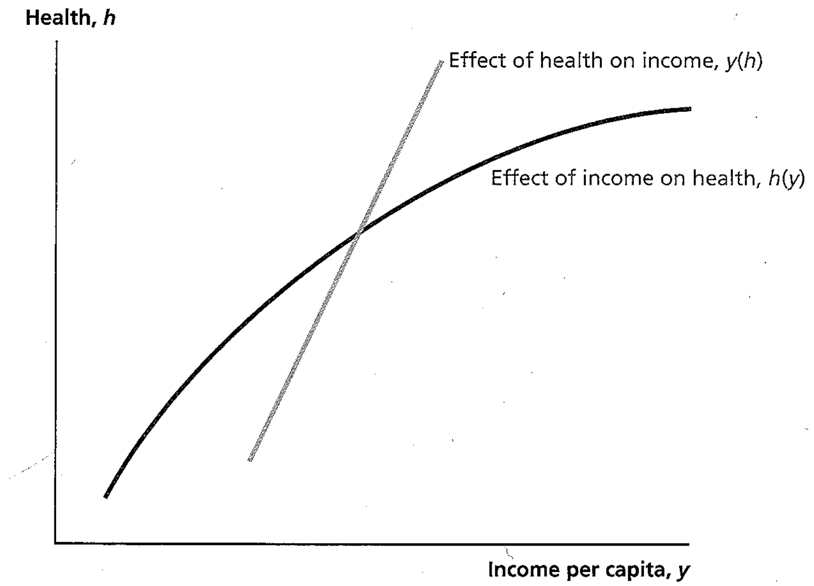
What is true for nutrition is true for health more generally. People who are richer can afford better inputs into health, such as vaccines, clean water, and safe working conditions. Among the rich countries of the Organization for Economic Cooperation and Development (OECD), there are an average of 2.2 doctors per thousand people; in the developing world, the average is 0.8; and in sub-Saharan Africa, the average is only 0.3.[7] And healthier people are better workers. Thus, for understanding the relationship between health and income, it is important to realize that both are endogenous variables. (Recall from Chapter 3 that we defined an endogenous variable as one determined within an economic model, in contrast to an exogenous variable, which is taken as given when we analyze a model.)

Figure 6.3 illustrates the interaction of health and income. The horizontal axis measures income per capita, y, and the vertical axis measures the health of workers, which we denote as h. The curve labeled $y(h)$ shows the impact of health on the level of income per capita. For higher values of h, workers are able to produce more

[7]United Nations Development Program (2000).

FIGURE 6.3

How Health Interacts with Income



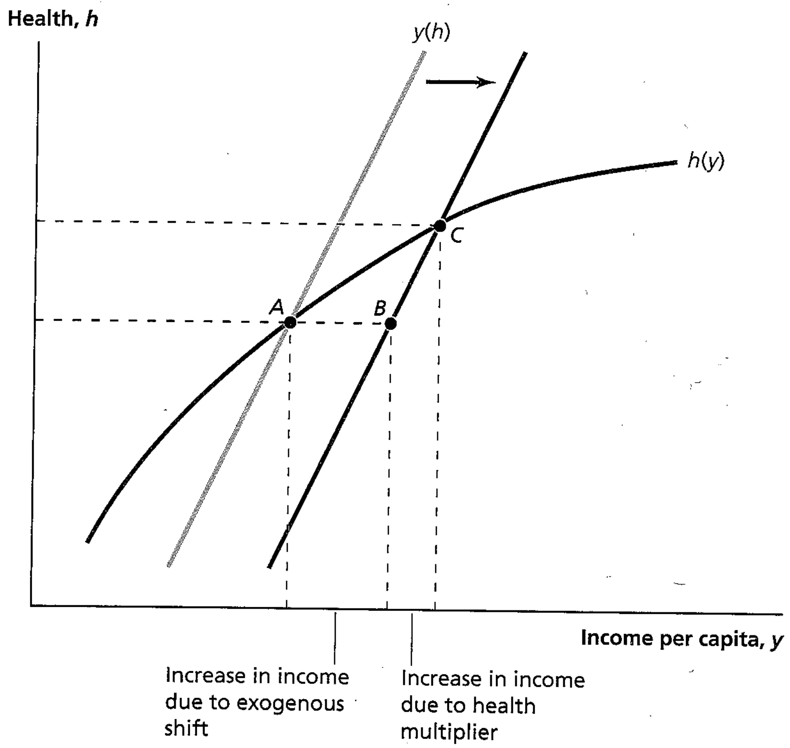
output, so the curve is upward sloping. The second curve, $h(y)$, shows the impact of income per capita on health. This curve also is upward sloping, showing that higher income improves health. But notice that this curve flattens out at high levels of income. This flattening captures the idea that the beneficial effects of income on health are more pronounced at lower levels of income.

The intersection of the two curves in Figure 6.3 will determine the equilibrium levels of income and health. To see the implications of the model, consider a change in income that is unrelated to health. That is, suppose that for some exogenous reason—for example, an improvement in productive technology—workers of any given health level can now produce more output. As shown in Figure 6.4, such a change will shift the $y(h)$ curve to the right. If there were no change in workers' health, the increase in output would match the increase in productivity. This effect is shown as the movement from point A to point B in Figure 6.4. However, as the figure makes clear, this is not the end of the story. The rise in output will improve workers' health, and this improved health will feed back to produce an additional increase in output. Thus, there will be a "multiplier" effect by which an initial increase in productivity will produce a larger increase in output. This is shown as the movement from point B to point C in Figure 6.4.

We can similarly use this model to think about the effects of exogenous health improvements such as those resulting from the introduction of a new

FIGURE 6.4

Effect of an Exogenous Shift in Income



vaccine or medicine. Such an improvement will shift the $h(y)$ curve upward—in other words, at any given level of income, workers will be healthier. Just like an improvement in productivity, this sort of exogenous improvement in health will produce a multiplier effect: Healthier workers will produce more output, and the higher level of output will allow for better nutrition, further improving health.

These exogenous improvements in health became especially significant in the 20th century. Many of the advances that have reduced mortality have also led to better health in general. For example, in the American South before World War I, the hookworm parasite, which causes anemia, exhaustion, and stunted physical and mental growth, played a significant role in holding back economic development. Called the "germ of laziness" by one contemporary journalist, hookworm infected as much as 42% of the southern population in 1910, and it was estimated that sufferers from the disease earned only half as much as healthy workers. Following intensive public health efforts, the prevalence of the disease decreased

markedly by the 1930s.[8] In many parts of the world, the control of malaria, which was greatly aided by the invention of the pesticide DDT during World War II, had a similarly dramatic effect on productivity.

6.2 | Human Capital in the Form of Education

People work with their minds as well as their bodies. Indeed, in developed economies, intellectual ability is far more important than physical ability in determining a person's wage. For this reason, investment that improves a person's intellect—in other words, education—has become the most important form of investment in human capital.

Changes in the Level of Education

Education levels differ markedly among countries. Table 6.1 shows how the education level of the adult population has changed between 1960 and 2000 for three groups of countries: developing (73 countries), advanced (23 countries), and the United States (which is also included in the set of advanced countries). In 2000, 34% of the adult population in the developing world had no education at all. Among the advanced countries, the comparable figure was 3.7%; in the United States, it was only 0.8%. At the other end of the spectrum, only 3.0% of

TABLE 6.1

Changes in the Level of Education, 1960–2000

			Percentage of the Adult Population with			
		Average Years of Schooling	No Schooling	Complete Primary Education	Complete Secondary Education	Complete Higher Education
Developing Countries	1960	2.05	64.1	17.1	2.5	0.4
	2000	5.13	34.4	43.0	14.8	3.0
Advanced Countries	1960	7.06	6.1	72.9	20.2	3.0
	2000	9.76	3.7	84.6	44.7	13.0
United States	1960	8.49	2.0	78.4	31.0	7.0
	2000	12.05	0.8	94.9	68.1	24.5

Source: Barro and Lee (2000). Data are for population aged 15 and over.

[8] Ettling (1981).

HEALTH AND INCOME PER CAPITA: TWO VIEWS

Poor countries have populations that are unhealthy in comparison to those of rich countries. There is also little doubt that raising income in a given country will improve its level of health and that improving health in a country will raise its level of income. The question that is left open in this analysis is, What is the primary source of differences in both income and health between rich and poor countries? Specifically, do the forces driving these differences come primarily from the side of health or from the side of income?

We can lay out this issue more formally using a diagram like the ones we have just examined. Consider two countries, A and B. Country A is both healthier and richer than Country B. In each of the two panels of Figure 6.5, points *A* and *B* represent these "data" about the two countries. What we cannot observe directly are the $h(y)$ and $y(h)$ functions that determine these points. Different combinations of these two functions could explain the data that we observe.

Panel (a), "The Health View," assumes that all differences between the countries have their roots in the countries' health environments—that is, in things other than income that also affect health (for example, the presence or absence of tropical diseases). The health environment is summarized in the $h(y)$ function. We have assumed that this function in Country A, labeled $h_A(y)$, is higher than the corresponding function in Country B, $h_B(y)$. So at any given level of income, Country A has better health than Country B. By contrast, the two countries are assumed to have the same $y(h)$ function, so that for a given level of health, the two countries have the same level of income. In equilibrium, the two countries have different levels of income, however, because of their different health environments.

Panel (b), "The Income View," assumes the opposite: that all differences between the countries have their roots in aspects of production that are unrelated to health—for example, in physical capital accumulation or technology. At any given level of health, Country A produces more output than Country B. Thus the function $y_A(h)$ lies to the right of $y_B(h)$. In this case, we assume that the two countries have the same $h(y)$ function, so that for a given level of income, the two countries have the same level of health. As in the first panel, in equilibrium, the countries differ in both health and income.

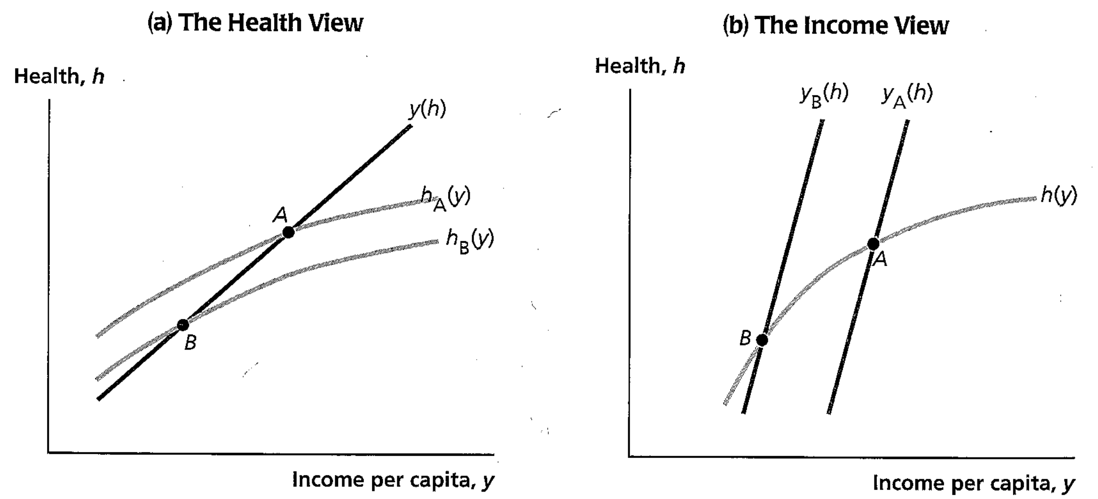
As the two panels make clear, differences in either $h(y)$ or $y(h)$ are sufficient to explain the observed differences in both health and income between the countries. Either story is logically consistent in the sense that it could fit the data on how income and health differ among countries. To sort out which story is correct, we would have to look for additional data.

The two possibilities portrayed in Figure 6.5 are obviously extreme. Almost all economists would agree that in the real world, differences in income among countries are explained by differences in *both* the $y(h)$ and $h(y)$ curves. The issue that is hotly debated is which channel is relatively more important. One school of thought holds that almost all of the relative ill health in poor countries is a result of their being poor. In other words, if these countries were to raise their level of income per capita to the level of rich countries, they would also have the same level of health as rich countries. The other school of thought holds that there are large differences in the health environment between rich and poor countries that would persist even if the two groups of countries had the same levels of income per capita. Under this view, the poor health environment in poor countries is a *cause* of their low levels of income.*

In Chapter 15, we return to the subject of differences in health among countries as we explore the role of geography in affecting the health environment.

*Acemoglu, Johnson, and Robinson (2001); McArthur and Sachs (2001).

FIGURE 6.5
Health and Income per Capita: Two Views



the adult population of the developing world had completed higher education (that is, college), compared with 13.0% for the advanced countries and 24.5% for the United States.

Table 6.1 also points to a large increase in the number of years of schooling over the period for which these data are available. In the developing countries, education of the adult population increased by 3.1 years, while in the advanced countries, it increased by 2.7 years. Given the initially low levels of education in the developing world in 1960, the *percentage* increases in education were especially large. The average number of years of schooling and the fraction of adults that had finished primary school more than doubled. Even more remarkably, the fraction that had completed secondary school rose sixfold, and the fraction that had completed higher education increased by a factor of seven.

Education is an investment in building human capital. And like investments in physical capital, it can be costly. In 2003 the U.S. government spent $525 billion on

THE ECONOMIC EFFECTS OF MALARIA

Malaria is one of the great scourges of the world, causing some 650 million episodes of illness and between 1 million and 3 million deaths every year, with this burden concentrated in poor, tropical countries. In April 2000, heads of state and other leading figures from 44 African nations convened in Abuja, Nigeria, to initiate a major effort to halve malaria mortality in Africa by the year 2010. The declaration that emerged from the Abuja conference was quite explicit in discussing malaria's economic effects: "Malaria has slowed economic growth in African countries by 1.3% per year. As a result of the compounded effect over 35 years, the GDP level for African countries is now up to 32% lower than it would have been in the absence of malaria."

The humanitarian benefits of controlling malaria are enormous. But are the economic benefits really so large? Economists are far from agreement on this issue. Comparing the performance of countries with high vs. low rates of malaria, or those that saw large reductions in the rate of disease to those that did not, many economists, most prominently Jeffrey Sachs of Columbia University's Earth Institute, have concluded that the economic effects of malaria are indeed large. (It was research by Sachs that was the source of the 1.3% growth effect cited in the Abuja declaration.) However, comparisons like this are subject to the sort of omitted variable bias discussed in Chapter 2. Countries with high rates of malaria may have other characteristics (for example, a climate that lowers agricultural productivity) that lead to low income. Similarly, the fact that a country was able to eradicate malaria may be evidence of some other good characteristic (for example, effective institutions) that leads to high growth, rather than growth being due to eradication *per se*. For these reasons, many economists are skeptical of Sachs's findings. One recent cross-country analysis that tried to isolate the effects of mortality reductions (due to malaria eradication as well as other health advances) by looking at the spread of medical technology in the decades after World War II found that increases in life expectancy had *no* effect on GDP per capita.*

Medical evidence suggests that the most important effects of malaria on worker productivity are associated with exposure in infancy and early childhood, as well as *in utero*. Young children account for the vast majority of severe malaria cases as well as deaths from the disease. By the time they are adolescents, most residents of high-malaria regions have developed some immunity. But malaria in childhood can damage an adult's human capital through several channels. The malaria parasite interferes with fetal nutrition and also causes pre-term deliveries, both of which lower birth weight, which in turn affects cognitive development. Severe cases of the disease can also lead directly to brain damage. Among older children, lethargy resulting from anemia, as well as school absences due to malaria episodes, interfere with accumulation of human capital.

Historical studies have recently confirmed the medical evidence on the long-run effects of childhood malaria. Between 1940 and 1960, a massive international campaign using the newly discovered weapon of DDT largely eliminated malaria from an area that was home to one-fifth of the world's population. In Colombia, for example, the case rate for malaria was reduced by two-thirds between 1957 and 1961. In the Indian state of Uttar Pradesh, annual malaria deaths fell from 140,000 in 1952 to below 20,000 in 1963. Comparing children born just before and just after this disease reduction provides a "natural experiment" for examining malaria's long-run effects.

The findings from these studies show that childhood malaria has a large impact. For example, in India, malaria eradication raised literacy and primary school completion by 12 percentage points. In the worst-affected regions of Sri Lanka, malaria eradication raised the average amount of schooling per child by 2.4 years. In Brazil, Colombia, and Mexico, adults who suffered malaria in their early lives had productivity equal to half that of those who did not.†

While suggesting that malaria may indeed have important economic effects, these studies also raise a caveat about the timing of the economic benefits of controlling the disease. If the main channel through which malaria affects the economy is indeed the human capital of children who are exposed to the disease, then controlling malaria will not result in a more productive labor force (and thus higher output) until the current adult population is replaced with people born after disease controls are introduced—a process that will not start at all for two decades and will not be completed for another four decades.

*Acemoglu and Johnson (2007); Gallup and Sachs (2001).
†Bleakley (2007); Lucas (2007); Cutler et al. (2007).

education, and private individuals spent another $153 billion.[9] Total educational spending came to 6.2% of GDP. But measuring spending this way greatly understates the true cost of educational investment. The reason is that in addition to the obvious costs of education—teachers' salaries, buildings, and textbooks—there is a more subtle expense: the opportunity cost that students pay in the form of wages they forgo while getting educated. One estimate is that the opportunity cost of forgone wages is roughly equal to all other educational spending in the United States—put another way, half of the cost of education is opportunity cost.[10]

[9]U.S. National Income and Product Accounts, Tables 2.4 and 3.17.
[10]Kendrick (1976).

Doubling the figure for government and private spending to account for opportunity cost, we find that the total cost of investment in education was 12.4% of U.S. GDP in 2003. By contrast, investment in physical capital in that year was 19.0% of GDP. Thus, investments in the two types of capital, physical and human, were of similar magnitude.

The increase in education around the world shown in Table 6.1 represents a large rise in the resources invested in producing human capital. In the United States, for example, government spending on education as a percentage of GDP rose by a factor of five over the course of the 20th century. In many developing countries, rapid population growth has caused a large fraction of the population to be of school age, so the burden of education spending is particularly large.

Education and Wages

Human capital in the form of education has many similarities to physical capital: Both require investment to create, and once created, both have economic value. We previously observed that physical capital earns a return—that is, firms or workers are willing to pay to use a piece of physical capital because doing so allows them to produce more output. If we want to see how productive a piece of physical capital is, we can simply measure how much of a return it commands in the market. In the case of human capital from education, however, calculating returns is more complicated because human capital is always attached to its owner. We cannot separate part of a person's education from the rest of his body and see how much it rents for. This fact makes measuring the return to human capital harder than is the case for physical capital.

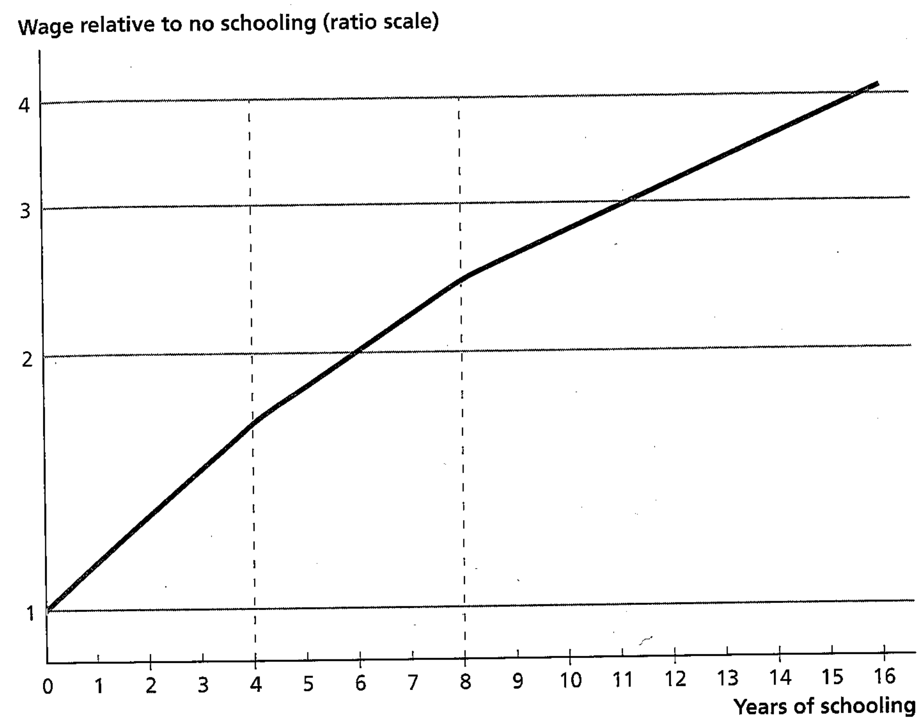
To get around this problem, economists infer the returns to human capital from data on people's wages. The fact that people who have higher levels of education earn higher wages can be taken as evidence that the market values their human capital. We define the **return to education** as the increase in wages that a worker would receive if he or she had one more year of schooling. To be specific, suppose that we found the return to a particular year of schooling—say, seventh grade—to be 10%. This finding implies that if we compared two otherwise identical workers, one of whom had a sixth-grade education and one of whom had a seventh-grade education, we would expect the more educated worker to earn 1.10 times as much as the less educated worker.

Figure 6.6 shows an example of the relationship between wages and schooling, based on data drawn from both developing and developed countries. The returns to education on which the chart is based are 13.4% per year for the first four years of schooling (grades 1–4), 10.1% per year for the next four years (grades 5–8), and 6.8% per year for education beyond eight years.[11] (The fact that earlier years of schooling have higher returns is not surprising, because these are the years in which the most important skills, notably reading and writing, are taught.) To understand the figure, start with the case of a worker with one year of schooling. Because the rate of return to first grade is 13.4%, such a worker will earn 1.134 times as much as a worker with no schooling. Similarly, a worker with two years of schooling will earn 1.134 times as much as a worker with one year of schooling, or 1.134^2 times as much as a worker with no schooling. Extending this logic, a worker with four years of schooling will earn 1.134^4 times as much as a worker with no schooling. Now consider the case of a worker with five years of schooling. Such a worker would earn 1.101 times as much as a worker with four years of schooling, because the rate of return to the fifth year of schooling is 10.1%. This implies that the worker with five years of schooling will earn $1.101 \times 1.134^4 = 1.82$ times as

[11] Hall and Jones (1999).

FIGURE 6.6

Effect of Education on Wages



much as a worker with no schooling. Carrying on in this fashion, we can calculate, for a worker with any number of years of schooling, her wage relative to that of a worker with no schooling. These are the numbers that are graphed in the figure.

Human Capital's Share of Wages

When we examined physical capital in Chapter 3, we measured physical capital's share of national income, which is the fraction of GDP that is paid to owners of physical capital in return for its use. The number that we calculated for physical capital's share of GDP was 1/3. The part of GDP that is not paid to owners of physical capital—that is, the other 2/3 of output—is paid to labor.

Now that we have introduced the idea of human capital, we can investigate how much of the payment to labor represents payment to the human capital that workers possess and how much represents a payment for "raw labor," that is, what workers would have earned if they did not possess any human capital.

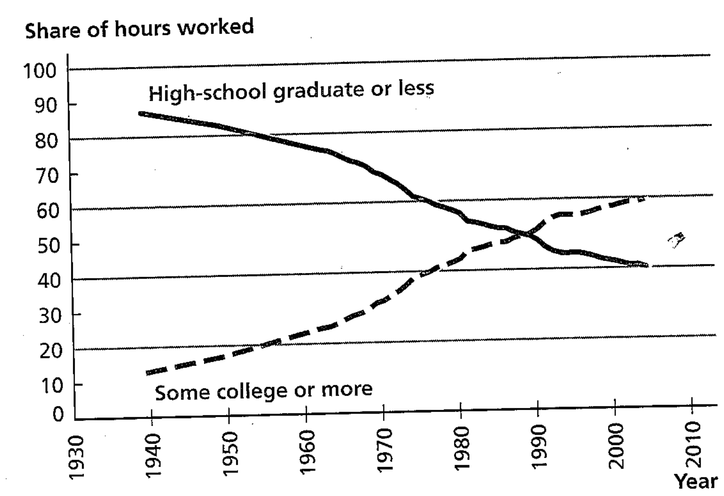
THE COLLEGE PREMIUM IN THE UNITED STATES

The rates of return to schooling depicted in Figure 6.6 are averages for a large number of countries. In fact, the rate of return to schooling varies significantly from country to country and within a given country over time. For example, the return to education is generally higher in poor countries than in rich countries, reflecting the fact that skilled workers are scarcer in poor countries and thus earn higher relative wages.

What happens when we apply this same logic to a single country over time? Figure 6.7 shows the educational composition of the labor force in the United States from 1940 to 2005. Clearly there has been a significant rise in the fraction of labor input supplied by educated workers. College-educated workers have become far less scarce over this period. Our logic would imply that there should have been a resulting decline in the return to a college education over this period.

One way to measure the return to a college education is the **college premium,** which is the ratio of the wages of workers with college education to those with a high-school degree. Figure 6.8 depicts the college premium from 1940 to 2005. As the figure shows, the return to a college education fell in the 1970s. In his book *The Overeducated American* (1976), economist Richard Freeman argued that this decline in the relative wage of college-educated workers was a result of their growing supply and that the college premium would only continue to decline as college degrees became more common. But then, starting around 1980, the college premium began shooting up. By 2005, the college premium was half again as large as it had been in 1940, even though the fraction of hours worked by people with some education beyond high school had risen from 12.9% to 59.7%.

FIGURE 6.7
Share of Hours Worked by Education Level, 1940–2005



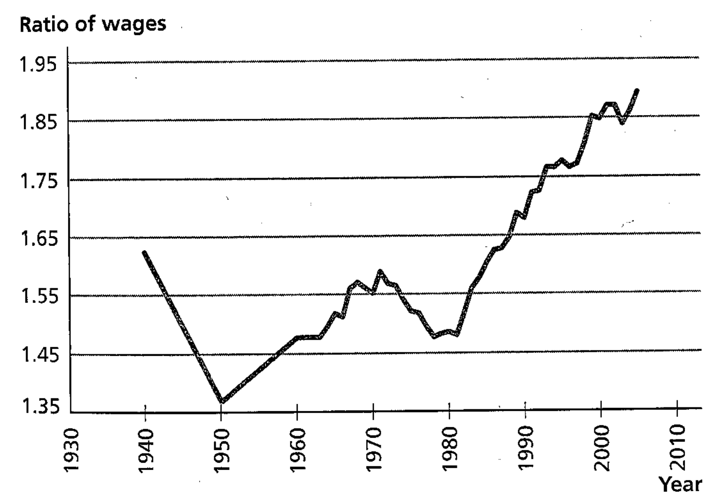
Sources: Autor, Katz, and Krueger (1998); Autor, Katz, and Kearney (2008).

The explanation for this phenomenon is that some factor other than the increase in the number of college-educated workers affected the wage premium received by more educated workers. That is, compensating for the increase in the supply of college-educated workers, there was also an increase in demand for them.

The source of this increase in demand for educated workers (which was seen not only in the United States but throughout the developed world) remains a mystery. There are two prominent theories. The first is that the shift resulted from the opening up of economies to international trade. According to this view, because the world as a whole has a far lower percentage of educated workers than the United States, the opening of trade effectively made educated U.S. workers scarcer.

The second theory used to explain the increase in the wage premium for college-educated workers is that technological change over the last several decades has been "skill-biased." In other words, technology has made educated workers relatively more productive than their less-educated peers. Specifically, it is argued, the introduction of computers into the workplace allowed highly educated workers to increase their production greatly. The new technology had little effect on the output of less-educated workers and in some cases replaced them entirely.

FIGURE 6.8
Ratio of College Wages to High-School Wages



Sources: Autor, Katz, and Krueger (1998); Autor, Katz, and Kearney (2008).

Unfortunately, when one receives a paycheck, the two items are not listed separately! Our analysis of the relationship between education and wages provides the tools to accomplish this task. (Because we lack similar data on the relationship between health and wages, we focus only on human capital from education.)

Let's start with the case of an individual worker. Suppose that this worker has five years of education. In the discussion of Figure 6.6, we calculated that the wage of such a worker would be $1.134^4 \times 1.101 = 1.82$ times as large as the wage of an otherwise similar worker who had no education. The extra wage earned as a result of having received five years of schooling is the return to the human capital created by that education. For example, if the worker with no education earned $1.00 and the worker with five years of education earned $1.82, then we could think of $0.82 as being the part of the wage due to human capital and the remaining $1.00 as being the part due to raw labor. The fraction of the wages attributed to human capital would be 0.82/1.82 = 45%, while the other 55% of the wage would be the part attributable to raw labor. For a worker with fewer than five years of education, the fraction of her wage due to human capital from education would be smaller than 45%. For a worker with more than five years of eduation, the fraction would be greater than 45%. Given data on the educational attainment of the entire labor force, we can conduct a similar calculation for each worker and then sum up to find the fraction of wages in the economy as a whole that represents returns to human capital from education.[12]

Table 6.2 shows the data required to perform such calculations for two groups of countries, developing and advanced. The population is divided into seven educational groups, ranging from no schooling through complete higher education. The second column of the table shows the number of years of education associated with each level of schooling. People who have some primary education but have not completed their primary schooling are assumed to have 4 years of schooling, those with incomplete secondary schooling are assumed to have 10 years of education, and those with incomplete higher education are assumed to have 14 years of education. The third column shows the wage of people in each educational category relative to the wage of workers with no schooling. These wages are calculated using the same methodology as in Figure 6.6. The final two columns of the table show the breakdown of the adult population by educational categories for the two groups of countries, developing and advanced.

Figures 6.9 (for developing countries) and 6.10 (for advanced countries) illustrate graphically how the numbers in Table 6.2 are combined to form an estimate of the

TABLE 6.2

Breakdown of the Population by Schooling and Wages

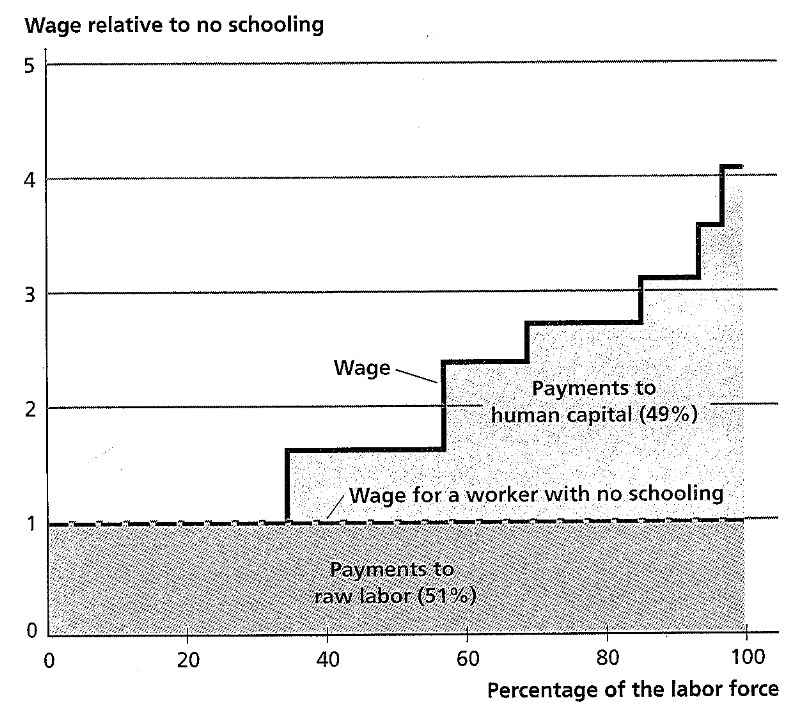
Highest Level of Education	Years of schooling	Wage Relative to No Schooling	Percentage of the Population: Developing Countries	Percentage of the Population: Advanced Countries
No Schooling	0	1.00	34.4	3.7
Incomplete Primary	4	1.65	22.6	11.7
Complete Primary	8	2.43	11.9	13.4
Incomplete Secondary	10	2.77	16.3	26.5
Complete Secondary	12	3.16	8.3	16.6
Incomplete Higher	14	3.61	3.5	15.1
Complete Higher	16	4.11	3.0	13.0

Source: Barro and Lee (2000).

[12]Pritchett (2001).

FIGURE 6.9

Share of Human Capital in Wages in Developing Countries

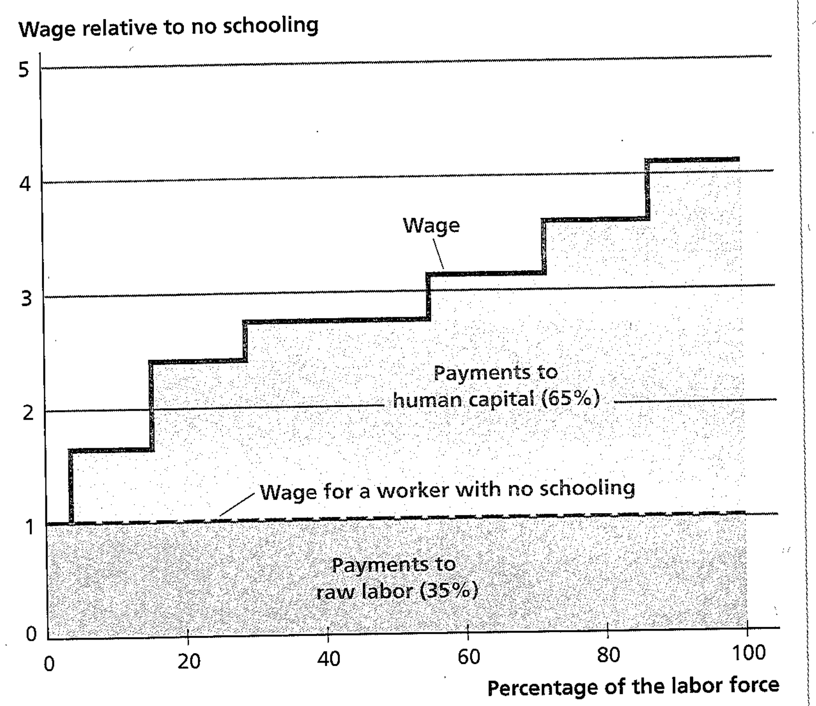


fraction of wages that represents a return to human capital. The solid line in each figure shows the wages of workers with different levels of education. These wages are all measured relative to the wage of workers with no education. The dashed horizontal lines show the wage of workers with no education. For any given level of education, then, the distance between the solid line and the dashed line is the part of the wage that is due to human capital. The entire area between the solid line and the dashed line then represents the total wages paid to human capital. Similarly, the area underneath the dashed line is the wages paid to raw labor. And the sum of these two areas—that is, the entire area under the solid line—represents the total amount of wages paid in the economy.

Dividing the part of wages due to human capital by the total amount of wages paid gives the share of wages paid to human capital. In the developing countries, this share is 49%, and in the advanced countries, it is 65%. Once we know human capital's share of wages, it is simple to calculate human capital's share of national income. Specifically, because wages are 2/3 of national income, we multiply human capital's share of wages by 2/3. For the developing countries, this calculation yields human capital's share of national income as 33%, and for advanced countries, it yields 43%.

FIGURE 6.10

Share of Human Capital in Wages in Advanced Countries



These numbers say that in the developing world, the share of national income that flows to human capital is now equal to the share earned by physical capital, while among the more advanced countries, the share going to human capital is larger than the share going to physical capital. In other words, throughout the world, workers are in effect "capitalists" in the sense that they are earning a return to their own earlier investments in human capital. As the level of education increases around the world, this mixing of "worker" and "capitalist" will continue. Some economists have argued this rising importance of human capital is what actually drove the decline of class politics in much of the world: When workers and capitalists are one and the same, the idea of class struggle makes less sense.[13]

These data on the share of national income that is earned by human capital can also shed light on some of our earlier analysis using the Solow model. The ability of

[13] Galor and Moav (2000).

the Solow model to explain cross-country differences in income depends on the value of the exponent on capital in the Cobb-Douglas production function, α. In Chapter 3, we examined data on the share of national income that was earned by physical capital and found that 1/3 seemed to be a good average, which implied that α should also be 1/3. But in Chapter 4 we found that using a value of $\alpha = 2/3$ made the model fit the data better, in the sense of explaining differences in income between low- and high-population-growth countries, than using a value of $\alpha = 1/3$. Similarly, homework problem 4 in Chapter 3 showed that a larger value of α means that differences in investment rates among countries will have a larger effect on steady-state output per worker.

We can now explain why it is appropriate to use a value of α larger than physical capital's share of national income. The key idea is that we should take a broader view of what is meant by *capital*. If we include both human and physical capital in our definition, then the share of national income earned by capital is indeed 2/3 in the developing world and is even higher in the advanced countries. Thus, if we were to analyze the Solow model as we did in Chapters 3–5, in which the only factors of production were capital and labor, it would indeed be reasonable to assume that capital's share of national income was 2/3 and similarly to assume that the exponent on capital in the Cobb-Douglas production function, α, was 2/3.

6.3 How Much of the Variation in Income Across Countries Does Education Explain?

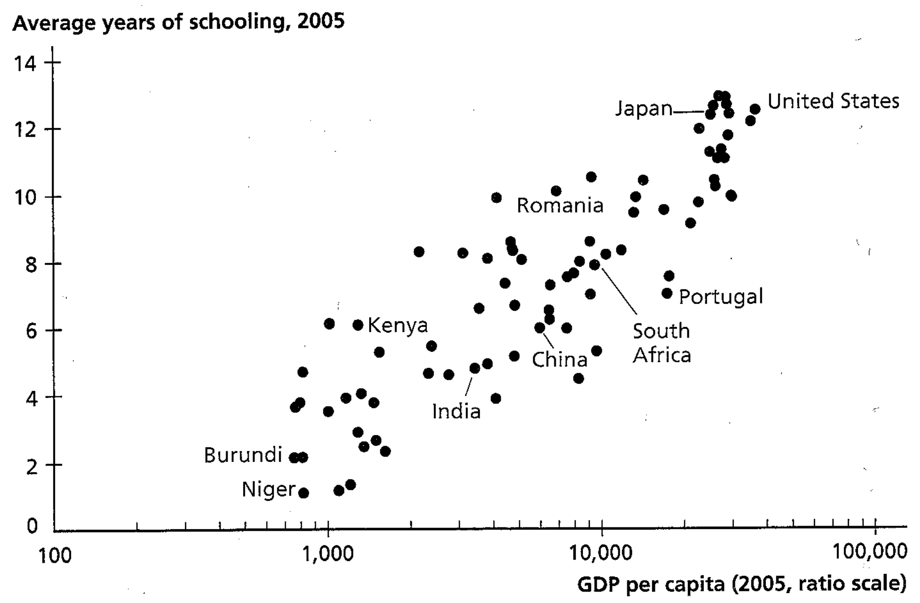
Having found big differences in countries' levels of human capital, we now consider the extent to which such differences can explain differences in income per capita among countries. We focus on the effect of human capital due to schooling (rather than improved health), because this is the most important measure of human capital and also the only one for which we can get consistent data.

A Quantitative Analysis of the Impact of Schooling Differences Among Countries

As shown by the scatter plot in Figure 6.11, the relationship between average years of schooling in a country and the level of income per capita is very strong. But this observation alone does not tell us how much of the difference in income is *caused* by the difference in education. After all, it is also true that countries that are richer can afford to spend more on education. Even if education had no effect whatsoever on income, we would expect to see a positive relationship like the one depicted in the figure.

To get a quantitative measure of the effect of education differences on income differences, we conduct an exercise similar to Chapter 3's assessment of the effect

FIGURE 6.11
Average Years of Schooling Versus GDP per Capita



Sources: Cohen and Soto (2007); Heston, Summers, and Aten (2006); World Bank (2007a).

of differences in investment rates and Chapters 4 and 5's assessment of the effect of population growth. In this case, we ask how much two countries that differ in their schooling but not in any other aspect of their factor accumulation (such as investment rate or population growth) will differ in their levels of income per capita.

We start with the same Cobb-Douglas production function as we used in Chapters 3–5. However, rather than supposing that each worker supplies one unit of labor, as in previous chapters, we now assume that countries differ in the amount of labor input that each worker supplies. We use the symbol h to denote the amount of labor input per worker, and we will show how h is related to schooling. We assume that all workers in a country are the same, so that if L is the number of workers, total labor input in the country is hL. Incorporating this notion, the production function becomes

$$Y = AK^{\alpha}(hL)^{1-\alpha},$$

where A is a measure of productivity and K is capital.

It is useful to rewrite the production function by moving the measure of labor input per worker outside of the parentheses:

$$Y = h^{1-\alpha}AK^{\alpha}L^{1-\alpha}.$$

Notice that this is the same as the production function that we used in Chapters 3–5, except that the term A has been replaced by the term $h^{1-\alpha}A$. In Chapter 4 we derived the equation for the steady-state level of output per worker for a country that has an investment rate of γ, a population growth rate of n, and a depreciation rate of δ:

$$y^{ss} = A^{1/(1-\alpha)}\left(\frac{\gamma}{n+\delta}\right)^{\alpha/(1-\alpha)}.$$

Allowing for variation in the amount of labor input per worker, then, we can replace the term A in this equation with the term $h^{1-\alpha}A$. Thus, the steady-state level of output per worker is[14]

$$y^{ss} = (h^{1-\alpha}A)^{1/(1-\alpha)}\left(\frac{\gamma}{n+\delta}\right)^{\alpha/(1-\alpha)}$$

$$= h \times \left[A^{1/(1-\alpha)}\left(\frac{\gamma}{n+\delta}\right)^{\alpha/(1-\alpha)}\right].$$

This equation makes clear that the steady-state level of output is directly proportional to h, the measure of labor input per worker.

To determine how large a difference in output can be produced by variations in labor input per worker, we consider the case of two countries with the same values for A, γ, and n but different values for h. Calling the countries i and j, we can write the ratio of their steady-state levels of output as

$$\frac{y_i^{ss}}{y_j^{ss}} = \frac{h_i \times \left[A^{1/(1-\alpha)}\left(\frac{\gamma}{n+\delta}\right)^{\alpha/(1-\alpha)}\right]}{h_j \times \left[A^{1/(1-\alpha)}\left(\frac{\gamma}{n+\delta}\right)^{\alpha/(1-\alpha)}\right]} = \frac{h_i}{h_j}. \qquad (6.1)$$

This equation says that if there are no other differences between the countries, the ratio of output per worker in steady state will just be equal to the ratio of labor input per worker. If the value of h is twice as big in Country i as in Country j, then steady-state output per worker will also be twice as big in Country i.

To determine the degree to which schooling differences explain differences in income per capita, we need only to investigate the relationship between our measure of labor input per worker, h, and the amount of schooling in a country. To do so, we can go back to our analysis of the relationship between a person's wages and his level of schooling. We saw above that the return to education is 13.4% for the first

[14] Students with more patience can start with the production function and follow the steps of Chapter 4 to get the same result.

four years, 10.1% for the next four years, and 6.8% for schooling beyond eighth grade (these are the numbers depicted in Figure 6.6). In other words, a person with one year of schooling earns 1.134 times as much as a person with no schooling, and so on. One way to interpret this finding is that a person with one year of schooling supplies 1.134 times as many units of labor as a person with no schooling, and that each of these units of labor is then paid a fixed amount. Under this interpretation, the wage that a worker earns is simply proportional to his amount of labor input, h.

We can now use the data on average years of schooling to make quantitative predictions about the importance of educational differences for differences in income per capita among countries. Specifically, for each country we use its average level of schooling to construct a measure of h relative to a country with no schooling. According to Equation 6.1, if two countries differed only in their schooling, then their steady-state levels of income per worker would be proportional to their levels of h.

To be more concrete, let's consider a comparison of two countries. Let Country j have average schooling of 2 years and Country i have average schooling of 12 years. Call h_0 the level of labor input per worker in a country with *no* schooling. The level of labor input in Country j is

$$h_j = 1.134^2 \times h_0 = 1.29 \times h_0 .$$

The level of labor input in Country i is

$$h_i = 1.134^4 \times 1.101^4 \times 1.068^4 \times h_0 = 3.16 \times h_0.$$

Using Equation 6.1 gives us a ratio of steady-state income in the two countries:

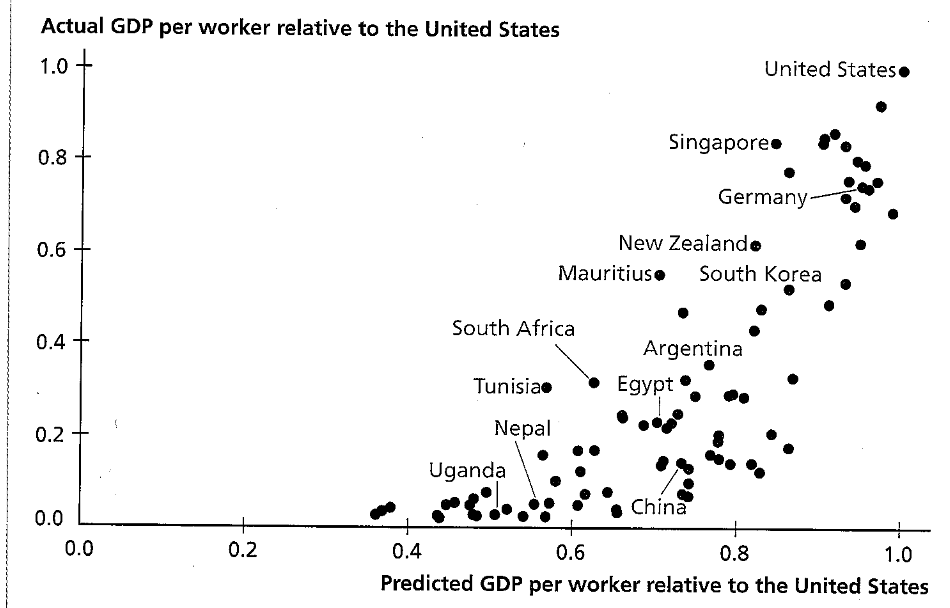
$$\frac{y_i^{ss}}{y_j^{ss}} = \frac{h_i}{h_j} = \frac{3.16 \times h_0}{1.29 \times h_0} = 2.47.$$

Figure 6.12 shows the result of applying this analysis to a large group of countries. We calculate the predicted ratio of income per worker in each country to income per worker in the United States, based on the data on average schooling. These predicted values are plotted on the horizontal axis. On the vertical axis is plotted the *actual* ratio of income per worker in each country to income per worker in the United States. If differences in schooling explained all of the differences in income among countries, the data points in Figure 6.12 would lie along a straight line with a slope of 45 degrees; the actual ratio of every country's income per worker to income per worker in the United States would be the same as the ratio predicted by the model. If schooling differences had no ability to explain why income differs among countries, by contrast, no pattern would be visible when we compared the predicted and actual ratios of income.

According to the data plotted in Figure 6.12, variation in education explains some, but not all, of the variation in income per worker among countries. The

FIGURE 6.12

Predicted versus Actual GDP per Worker



poorer a country is predicted to be on the basis of its average schooling, the poorer it generally is. There are a few interesting exceptions, however. For example, based on the schooling data, Singapore should be the 24th richest country in the sample; in fact it is the 5th richest. Conversely, China, South Korea, and New Zealand are all predicted to be much richer in comparison to the rest of the world than they really are. The other interesting aspect of the figure is that differences in income that are predicted on the basis of schooling data tend to be smaller than actual differences in income among countries. For example, based on schooling differences, the poorest country in the sample should be Niger, with income per capita equal to 36% of the United States. In fact, Niger has income per capita of only 3% of the United States.

It is interesting to compare Figure 6.12 with Figure 3.7, which conducted a similar exercise to look at the effects of differences in investment in physical capital among countries (see p. 67). Most important, in both figures the single factor that is being considered explains some, but not all, of the differences in income among countries. For example, using data on investment in physical capital, Uganda is predicted to have 44% of the income per worker of the United States. Using data on schooling, it is predicted to have 52% of the income per worker of the United States. Combining these two factors, Uganda would have income per worker equal to $0.44 \times 0.52 = 23\%$ of the income of the United States. Thus, using information about both human and physical capital takes us closer to fitting the actual data on income per worker, although this exercise still does not get us all the way, because Uganda's income per worker actually equals only 4% of U.S. income per worker. Similarly, the errors made in predicting where countries will fall in the world income distribution in the two exercises tend to offset each other. For example, in Figure 6.12, South Africa is predicted to be 30% richer than Tunisia, while in Figure 3.7, Tunisia is predicted to be 39% richer than South Africa. In fact, the two countries have roughly equal levels of income. These observations suggest that combining data on human and physical capital will allow us to do a better job of predicting which countries will be rich and which will be poor than looking at only one factor at a time. We pursue this project in Chapter 7.

Before we conclude our examination of the ability of human capital to explain differences in income among countries, it is worth considering some of the ways in which our exercise might be missing important aspects of the data. Here we examine two possibilities.

The Quality of Schooling. Our analysis of the impact of educational differences among countries has been based on data on the average number of years of schooling in each country. Implicitly, we have assumed that the quality of schooling does not vary among countries. Is such an assumption warranted?

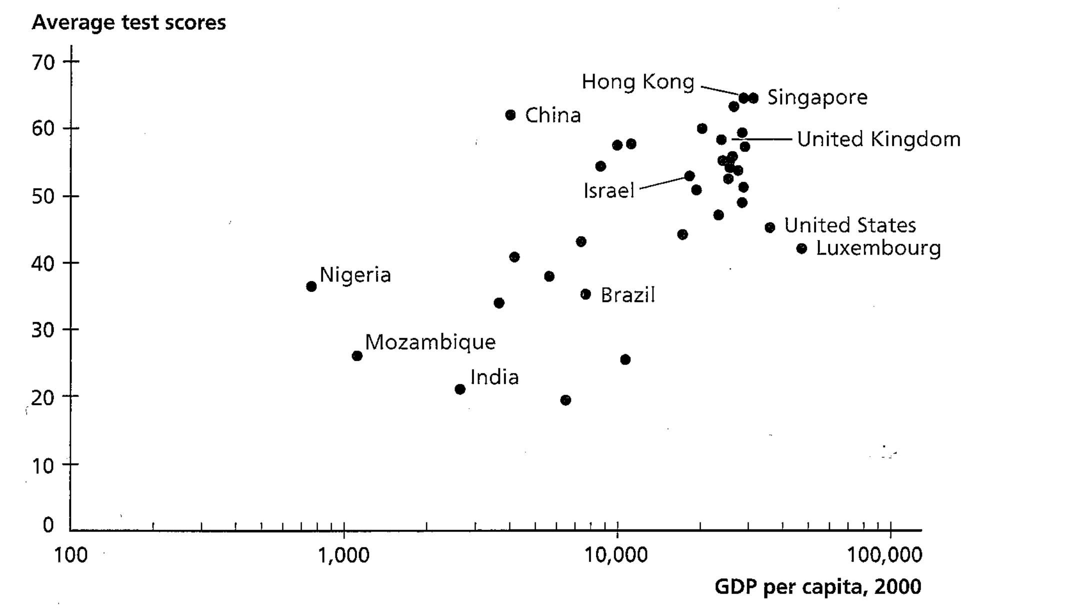
We can measure the quality of schooling by looking at the inputs into education, such as teachers and textbooks, and the output from education—that is, what students know. In the case of inputs to education, there is clear evidence that richer countries are able to supply more. In 2005, the student/teacher ratio in primary schools in high-income countries was 16; among low-income countries it was 42, and in sub-Saharan Africa it was 48. In addition, teachers in developing countries are not as well trained as in the developed world. In Mozambique, for example, 70% of the teachers in grades 1–5 themselves have only seven years of schooling. And in many developing countries, textbooks are so scarce that students have to share them. Finally, as we saw earlier in this chapter, widespread health problems in poor countries mean that students are able to learn less in a year of school than are students in rich countries.[15]

With respect to the output of education—what students learn—one measure is how well students perform on tests. Figure 6.13 shows the relationship between income per capita and student performance on a series of standardized math and science tests. Not surprisingly, students in rich countries tend to do better, although there are two interesting exceptions to the general trend: the United States, which has very low test scores for a rich country, and China, which has very high scores for a poor country.[16]

[15]UNESCO (1999, 2000); World Bank (2007a).
[16]Hanushek and Kimko (2000).

FIGURE 6.13

Student Test Scores Versus GDP per Capita



Source: Hanushek and Kimko (2000).

Overall, the evidence suggests that richer countries have not only *more* schooling than poor countries but also *better* schooling. Because of this difference in quality, the measure of human capital that we used—the differences in the number of years of education—will understate the true difference in the level of human capital of workers in those countries.

Externalities. An important way in which human capital differs from physical capital is in the area of externalities. An **externality** is an incidental effect of some economic activity for which no compensation is provided. In the case of education, many economists believe that there are big externalities: that is, giving one person more education raises not only her own output but the output of those around her as well. For example, educated farmers are generally the first in an area to adopt new technologies (high-yielding seed varieties, new fertilizers, and so on), but these innovations are then copied by less-educated friends and neighbors. Thus one person's education can raise the production of many. A study in Ethiopia found that the direct benefit received by a person who got an education was smaller than the total externality benefit of education, that is, the sum of benefits received by everyone else in the village. Put another way, more than half of the benefit of an individual's going to school for another year accrued to people other than the person attending school.[17] In developed countries, where education is more widespread, we would not expect externalities of this sort to be so significant. But there are other ways in which education can have positive externalities. For example, a more-educated population is more likely to have an honest and efficient government.

Positive externalities from human capital are one explanation for why governments often get involved in producing human capital (in the form of public education or mandatory schooling). Left on their own, people do not take into account the full social benefit of an education when they decide how much education to obtain for themselves or their children, so the amount they choose will be lower than what would be socially optimal.

The existence of externalities from education affects our calculation of the importance of human capital for explaining income differences among countries. In assessing the relationship between schooling and human capital, we looked only at the *private* return to education. That is, our starting point was the amount that a year of education raises an individual's wages. But if much of the contribution of an individual's human capital toward national income is not reflected in that person's own wages, then this private return to education will understate the true increase in human capital due to an extra year of schooling. If we were to redo our calculations, assuming a higher return to education, we would find that human capital played a larger role in explaining differences in income among countries.

6.4 | Conclusion

In this chapter we have explored the improvements in the quality of labor that economists group together under the name *human capital*. In many ways, the accumulation of human capital and the impact of human capital on production are closely analogous to the situation with physical capital. Spending on education, which produces human capital, is similar to the investment spending that produces physical capital. Both human and physical capital are inputs into production—indeed, their shares of national income are roughly equal. Finally, differences in the accumulation of human capital among countries seem to be part of the explanation for why some countries are rich and some poor, just as was the case with the accumulation of physical capital.

While human and physical capital have many similarities, there are also important differences between the two. The only reason for investing in physical capital is economic: Were it not for the returns that physical capital earns, no one would want to own any. By contrast, people value human capital in the form of health primarily

[17] Weir and Knight (2000).

HUMAN PERFECTABILITY AND THE GROWTH SLOWDOWN

As this chapter has stressed, an important difference between human capital and physical capital is that the former is "installed" in its owner whereas the latter exists independently of its owner. As a consequence, there is no limit on the amount of physical capital that a single person can own. But for human capital, such a limit does exist. A person can only be so healthy or have so much education. Thus, there is no reason that the amount of physical capital each worker has to work with will not continue to grow over the next century as quickly as it has grown over the last, but we might worry that the limits on human capital accumulation are coming within sight.

In the case of health, the last century has seen great improvements, as measured by height and life expectancy, in the most developed countries. But most scholars agree that these improvements will not continue into the future. In the richest countries, almost everyone is now well enough nourished to attain his or her biological maximum height. Life expectancy in the United States rose from 51 years in 1900 to 77 years in 2000. It is unlikely to rise by an equal amount (to 103 years!) over the next century. The great health triumphs of the late 19th and 20th centuries—improvements in sanitation, widespread vaccination, the introduction of antibiotics—are unlikely to be matched in the future.

With respect to education, too, there is good reason to believe that the rate at which human capital is being accumulated in the richest countries will slow down in the future. The average level of education in the advanced countries increased by 1.8 years over the period 1960–1980 but by only 0.9 years over the period 1980–2000. Even without this evidence of a slowdown, one would suspect that education cannot go on increasing forever—if for no other reason, people have to work sometime before they die of old age.

For these reasons, then, the rise in human capital, which has been one of the major sources of economic growth over the last century, will contribute less to growth over the next century. This change will not bring an end to economic growth itself, however, because other sources of growth, such as technological change (discussed in Chapters 8 and 9), will remain in place. But the decline in the growth of human capital could well mean a decline in the overall growth rate.*

*Jones (2002).

for non-economic reasons. The fact that being in good health makes a person more productive is of secondary importance when we make decisions about our own or our children's health. Decisions to invest in human capital through education are economic but only partly so. People value education both as a means toward higher income and as a way of enriching their intellectual and spiritual lives.

KEY TERMS