Van den Berg (2001)

CHAPTER 2

Economic Growth throughout History

The years have been good for humanity.
Julian Simon, 1995

This chapter describes how the world economy has grown since the beginning of history. The unprecedented rise in standards of living over the past 200 years and the rapid rate at which some of today's developing economies are "catching up" to the most developed economies are among the most exciting topics in economics because these episodes of economic growth represent such enormous increases in human welfare. But the purpose of this chapter is not just to tell an interesting story; it is to familiarize you with the most important details about past and present economic growth. It is important to have the facts in hand before embarking on the search for the answer to the question posed in the previous chapter, "How do economies grow?"

Before the nineteenth century, changes in standards of living, if they occurred at all, were so slow that they were imperceptible to most people. Few people expected to die in conditions that were different from those they were born into. A few lucky people were able to move up in the ranks of society; a Roman slave could gain freedom, in India a son or daughter could marry into a higher-caste family, and in Medieval Europe a son could enter the priesthood. But such social mobility was rare and had little, if any, effect on the well-being of the average person. It was not until the nineteenth century that rapid economic growth began to increase the welfare of entire populations at a rate fast enough to make people aware of their improving conditions. Today, in most countries, we have come to expect that we will die in a more prosperous world than we arrived in as babies, and we expect that our children and grandchildren will enjoy even higher standards of living. We have come to accept the trend illustrated in Figure 2-1, repeated here from the previous chapter (Figure 1-1), as the normal course of events. In many countries today, a brief slowdown of economic growth is viewed as an economic crisis.

The surge in economic growth over the past two centuries brought the greatest and most rapid improvement in human welfare the world has ever experienced. In nearly all countries of the world, we live more comfortably than ever before because economic growth provides us with the means to better control our lives and the environment within which we live. We live longer and with less physical suffering because economic growth provides us with the means to find solutions to health problems and disabilities.

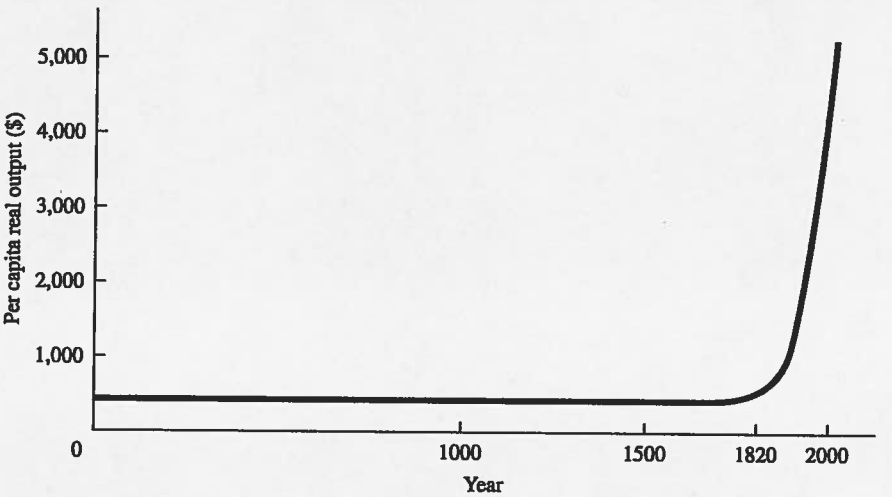

Figure 2-1
The Stunning Surge in Living Standards after 1800.

We enjoy more leisure because economic growth permits us to satisfy our material wants with less effort. We have more choices, both in consumption and work, because economic growth has expanded the variety of economic activities we can pursue and the goods and services we can consume.

This chapter reviews the evidence that details how standards of living have improved over the past two centuries. It begins with a detailed look at the data on real per capita output that we used to draw Figure 2-1, which so vividly illustrates the sudden acceleration of economic growth after 1800. There are potential shortcomings from using a single measure such as per capita output to represent human welfare. Indeed, the measurement of human welfare has been a widely debated issue in the field of economic growth and development. This chapter therefore supplements the available output data with a variety of other measures that reflect human welfare. The picture that all of the measures paint is not qualitatively different from Figure 2-1, however: Individual welfare progressed very slowly, if at all, for most of our history and then suddenly began improving dramatically during the past 200 years. But the detailed examination of the evidence on economic growth also suggests that economic growth is a complex process. It will prove to be quite a task to explain the shape of the curve in Figure 2-1.

This chapter is organized to give you a panoramic picture of economic growth throughout history as well as an appreciation of the data and evidence that economists and economic historians have at their disposal. The sequence of topics is as follows:

1. The chapter begins by presenting the historical output data for 56 countries compiled by Angus Maddison. His compilation is the best attempt yet to overcome the many difficulties encountered in bringing together fragments of available information to create a set of economic data that are compatible over a very long period of time and across a very diverse group of countries.

2. Maddison's data make it clear not only that per capita real output grew rapidly over the past two centuries but that economic growth varied quite a bit from country to country. This leads to a discussion of the convergence debate.

3. In order to assess how well per capita real output measures true human welfare, a wide variety of other measures shed further light on human welfare, including life expectancy, infant mortality, years of schooling, civil liberties, and economic freedom.

4. Finally, the mechanics of economic growth are discussed in order to give the reader a good understanding of the power of compounding, the process whereby small differences in *growth rates* result, in the long run, in very large differences in the *levels* of human welfare.

2.1 MEASURING REAL OUTPUT

Economic growth is most often measured in terms of **per capita real income** or **per capita real output.** Discussions of economic development often focus on differences in income, but the data reflect *output.* Income and output are, of course, nearly the same in most economies; income is the result of generating output. Real gross national product (real **GNP**) and real gross domestic product (real **GDP**) are the most common measures of output. The difference between GNP and GDP is a subtle one. A country's gross *national* product (GNP) measures the value of output produced by the country's citizens and domestically owned factors of production, regardless of where the production takes place. Thus, part of the output produced in a foreign-owned factory is added to the foreign country's GNP, and excluded from the GNP of the country where the factory is actually located. Gross *domestic* product (GDP), on the other hand, measures the total value of output within a country's borders regardless of the nationality of the owners of the factors of production. GDP is often compiled in place of GNP for the simple reason that it is easier to keep track of activity within a certain geographic area than it is to attribute the value of the activity to specific factors classified according to their nationality.

The need to use **real** figures is obvious; **nominal** measures of output are distorted by inflation and thus do not give an accurate picture of the growth of actual welfare-enhancing output. The reason for using **per capita** GNP or GDP to measure human welfare should also be obvious: Total GNP or GDP can give a very distorted picture of human welfare. For example, Brazil's total real GNP is bigger than Uruguay's, about US$773 billion compared to US$19 billion in 1997.[1] But to judge whether the "average" Brazilian is better off than the "average" person in neighboring Uruguay, we need to divide by the number of people in each country. In per capita terms, Uruguay comes out ahead of Brazil, with a real per capita output of US$6,020 compared to Brazil's US$4,720. The output data presented in this chapter are usually in terms of per capita real GNP or GDP. Of course, as explained in the previous chapter, the use of per capita measures of output is also more in line with economists' interest in the welfare of individual people.

2.1.1 Are National Accounts Data Comparable?

National accounting measures, such as GDP and GNP, are compiled by countries' official statistical agencies in accordance with procedures developed over the years by various working groups under the auspices of the United Nations. These procedures have helped to standardize economic data from around the world. Nevertheless, there are still many practical problems that make it difficult to compare data from one country to those from another or data from one period of time to those from another. One serious problem is how to accurately account for price changes. The price indexes that are used to convert nominal figures to real figures are constructed using samples of products that

[1]These figures are from World Bank (1998), *World Development Report 1998/99,* Washington, D.C.: World Bank, Table 1, pp. 190–191.

are representative of the products produced or consumed in a certain country at a given point in time. That is, price indexes are *averages* of the prices of representative bundles of goods and services produced. But because production and consumption patterns depend on levels of income, country size, cultural factors, geographic location, and a number of other factors unique to individual countries and time periods, price indexes can differ so much across countries that the real GNP or GDP figures are not easily comparable.[2] Over time, historical time series of price indexes have been shown to overstate inflation, and thus cause real GNP or GDP to understate economic growth, because they assume constant samples of goods and services. Such unchanging samples cannot reflect (1) the substitution of cheaper products for more expensive products as relative prices change, (2) changes in the patterns of consumption and production as the economy evolves over time, and (3) improvements in product quality and performance.

Comparisons of countries' *levels* of real per capita GNP or GDP are also often distorted by the common practice of translating different countries' real measures into a common currency according to nominal exchange rates. For example, when the GNPs of Uruguay and Brazil were compared a few paragraphs above; the measures were converted to U.S. dollars in order to make them comparable. It would have made little sense to compare one figure in Uruguayan pesos with another denominated in Brazil's money, the real. Exchange rates are determined by a variety of forces that affect the supply and demand of currencies in the foreign exchange markets, and relative price levels are just one of the forces driving supply and demand. Thus, exchange rates seldom reflect the exact purchasing power of one currency relative to another. Also, if we used only exchange rates to adjust national GNPs or GDPs, the volatility of exchange rates would continually change relative levels of output even in the absence of fundamental changes in national output or price levels. Of course, when comparing *growth rates* of real GDP or GNP, rather than *levels,* the exchange-rate problem is avoided because growth rates are given in percentage terms and the unit of account does not matter. But comparisons of growth rates of *real* GDP and GNP in different countries still need to account for price changes, production and consumption patterns, and quality improvements.

Technical Note

From Nominal GDP Growth to per Capita Real GDP Growth

In order to calculate the rate of growth of per capita real GDP, you need to know (1) the rate of growth of nominal GDP, denoted as g_Y, (2) the rate of growth of the population, denoted as g_{POP}, and (3) the rate of growth of prices, more commonly referred to as the rate of inflation and usually denoted by the symbol g_P. A simple formula to calculate per capita real GDP will clarify the relationship between the three components of per capita GDP growth, g_Y, g_{POP}, and g_P.

Per capita GDP is simply GDP, commonly denoted by Y, divided by the total population, or Y/POP (Y is used to denote nominal GDP). Real GDP is GDP divided by a price index for economywide output, or Y/P, where P represents the level of prices in the economy. Thus, real per capita GDP is defined as

[2] A very thorough discussion of the comparability of national accounts is provided by Irving B. Kravis (1984), "Comparative Studies of National Incomes and Prices," *Journal of Economic Literature,* Vol. 22, pp. 1–39.

$$y = Y/(POP \cdot P) \tag{2-1}$$

Using the mathematical results that the growth rate of a product ab is equal to the sum of the growth rates of a and b, or $g_{ab} = g_a + g_b$, and that the growth rate of a ratio c/d is equal to the difference of the growth rates of c and d, or $g_{c/d} = g_c - g_d$, the growth rate of real per capita GDP given in (2-1) is

$$g_y = g_Y - (g_{POP} + g_P) = g_Y - g_{POP} - g_P \tag{2-2}$$

In words, the growth of per capita real GDP is equal to the rate of growth of nominal GDP minus the sum of the growth rates of population and prices. This result is easy to remember.

Technically, equation (2-2) holds only for so-called *instantaneous* or *point* rates of growth. However, most growth rates are calculated over some time interval, usually 1 year. As long as the rates of population growth and inflation are not very high, then equation (2-2) holds "approximately" even for growth rates calculated for discrete periods of time such as a month or even a year. In fact, we observe virtually no population growth rates higher than 4 percent per year, which is sufficiently small so that our approximate formula remains reasonably accurate. But inflation can be much higher, even exceeding 100 percent in some countries, such as Argentina and Brazil in the early 1990s. Equation 2-2 will not work in those cases, and in order to accurately calculate the growth of per capita real GDP, you would have to use the more complex formula

$$g_y = [1 + g_Y - 1 - g_{POP} - g_P - g_{POP} \cdot g_P] / (1 + g_{POP})(1 + g_P) \tag{2-3}$$

This formula is derived in Appendix 2-1 of this chapter. But if indeed inflation is close to zero (less than 10 percent, or .1), then the simple equation, (2-2), works fine.

For example, suppose that a country's nominal GDP grew last year at 6.7 percent, its population grew at 1.2 percent, and a survey of prices established that the rate of inflation was 2.3 percent for the year. In this case, equation (2-2) tells us that per capita real GDP grew at 6.7 – 1.2 – 2.3 = 3.2 percent.

2.1.2 Attempts to Compile Comparable Output Data

The annual World Bank *World Development Report* provides comparative measures of real per capita gross national product for a large number of the world's economies, translated into U.S. dollars using both (1) exchange rates and (2) detailed information on what can actually be purchased with each currency, that is, the currency's true purchasing power. Called **purchasing power parity** estimates of GNP, these measures give us a more accurate picture of differences in people's standards of living across countries. For example, according to World Bank data, per capita real GNP translated at the nominal exchange rate and not adjusted for price differences was more than 100 times as great in the United States as in Bangladesh in 1970, $28,740 compared to $270![3] After being adjusted for the real purchasing power of money in each country, the real per capita GNPs in the United States and Bangladesh differed only by a factor of 27. Either way, the difference is staggering, but a factor of 27 seems more reasonable than 106.

In order to compare the *growth* of per capita real GDP of different countries or at different times for the same economy, the World Bank's purchasing power parity

[3]World Bank (1998), op. cit.

estimates of per capita real GNP are not of much help because they extend back only into the 1980s. We need a **time series** of comparable annual measures extending over many years in order to calculate rates of growth. The first attempt to compile national output measures that were comparable both across a large set of countries and over a long period of time was the United Nations International Comparison Project, which began work in the late 1960s and eventually compiled a data set for 130 countries covering the post-World War II years. The first data were made available in 1978 by Irving B. Kravis, Allan Heston, and Robert Summers.[4] There have been several updates prepared by Summers and Heston, and these data sets have come to be known simply as the "Summers and Heston data." The latest set, extending through 1990, is available over the Internet and has been used by numerous researchers for a great variety of economic studies that required compatible national accounts data for large numbers of countries in the post-World War II period.[5]

Because Summers and Heston's comparable GDP data extend back only to 1950, these measures do not permit us to depict all of the last 200 years of rapid growth. In this regard, the data compiled by Angus Maddison, which we referenced in the previous chapter, are more useful. Although his compilation provides data for only 56 countries compared to Summers and Heston's 130, Maddison's data include world and regional estimates going back to the early 1800s.[6] Because we are interested in tracing economic growth as far back in history as possible, we will use Maddison's data to begin our detailed look at the history of economic growth.

Like Summers and Heston, Maddison adjusts GDP data for differences in purchasing power parity. Specifically, he values all countries' GDPs using 1990 U.S. dollar prices of the actual goods and services consumed in each economy in each year. Thus, even though total output consisted of a very different set of goods and services in 1890 than in 1990, each country's output in 1890 is valued using the 1990 dollar prices for the goods and services actually produced in 1890. This is a reasonable approach given the inherent difficulty in comparing GDPs consisting of different goods and services and denominated in different currencies suffering different rates of price inflation. There are some problems with Maddison's GDP estimates that could cause growth to be overestimated or underestimated, as we will discuss below, but they are the best figures we have available.

2.2 WHAT THE OUTPUT DATA TELL US ABOUT ECONOMIC GROWTH

The high standards of living currently enjoyed by the residents of the developed economies are a very recent phenomenon, a reflection of the dramatic economic growth experienced over the past 200 years. Maddison's data, presented in Table 2-1, help us

[4]Irving B. Kravis, Allan Heston, and Robert Summers (1978), *International Comparisons of Real Product and Purchasing Power,* Baltimore: Johns Hopkins University Press.

[5]Robert Summers and Alan Heston (1988), "A New Set of International Comparisons of Real Product and Price Levels Estimates for 130 Countries, 1950–1985," *Review of Income and Wealth,* Vol. 34, pp. 1–25; Robert Summers and Alan Heston (1991), "The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950–1988," *Quarterly Journal of Economics,* Vol. 106(2), pp. 327–368. The latest versions of these data sets can be found through links provided on Nuffield College, Oxford's website: www.nuff.ox.uk/Economics/Growth, given under Internet Resources at the end of the previous chapter.

[6]Angus Maddison (1995), *Monitoring the World Economy 1820–1992,* Paris: OECD.

TABLE 2-1 Real per Capita GDP for 56 Countries
(in 1990 U.S. Dollars)

	1820	1870	1900	1913	1950	1973	1992
West European Countries							
Austria	1,295	1,875	2,901	3,488	3,731	11,308	17,160
Belgium	1,291	2,640	3,652	4,130	5,346	11,905	17,165
Denmark	1,225	1,927	2,902	3,764	6,683	13,416	18,293
Finland	759	1,107	1,620	2,050	4,131	10,768	14,646
France	1,218	1,858	2,849	3,452	5,221	12,940	17,959
Germany	1,112	1,913	3,134	3,833	4,281	13,152	19,351
Italy	1,092	1,467	1,746	2,507	3,425	10,409	16,229
Netherlands	1,561	2,640	3,533	3,950	5,850	12,763	16,898
Norway	1,004	1,303	1,762	2,275	4,969	10,229	17,543
Sweden	1,198	1,664	2,561	3,096	6,738	13,494	16,927
Switzerland	na	2,172	3,531	4,207	8,939	17,953	21,036
United Kingdom	1,756	3,263	4,593	5,032	6,847	11,992	15,738
Western Offshoots							
Australia	1,528	3,801	4,299	5,505	7,218	12,485	16,237
Canada	893	1,620	2,758	4,213	7,047	13,644	18,159
New Zealand	na	3,115	4,320	5,178	8,495	12,575	13,947
United States	1,287	2,457	4,096	5,307	9,573	16,607	21,558
South European Countries							
Greece	na	na	na	1,621	1,951	7,779	10,314
Ireland	954	1,773	2,495	2,733	3,518	7,023	11,711
Portugal	na	1,085	1,408	1,354	2,132	7,568	11,130
Spain	1,063	1,376	2,040	2,255	2,397	8,739	12,498
Turkey	na	na	na	979	1,299	2,739	4,422
East European Countries							
Bulgaria	na	na	na	1,498	1,651	5,284	4,054
Czechoslovakia	849	1,164	1,729	2,096	3,501	7,036	6,845
Hungary	na	1,269	1,682	2,098	2,480	5,596	5,638
Poland	na	na	na	na	2,447	5,334	4,726
Romania	na	na	na	na	1,182	3,477	2,565
U.S.S.R.	751	1,023	1,218	1,488	2,834	6,058	4,671
Yugoslavia	na	na	na	1,029	1,546	4,237	3,887
Latin American Countries							
Argentina	na	1,311	2,756	3,797	4,987	7,970	7,616
Brazil	670	740	704	839	1,673	3,913	4,637
Chile	na	na	1,949	2,653	3,827	5,028	7,238
Colombia	na	na	973	1,236	2,089	3,539	5,025
Mexico	760	710	1,157	1,467	2,085	4,189	5,002
Peru	na	na	817	1,037	2,263	3,953	2,854
Venezuela	na	783	1,311	1,733	3,478	5,017	5,949

(continued)

TABLE 2-1 Real per Capita GDP for 56 Countries (continued)
(in 1990 U.S. Dollars)

	1820	1870	1900	1913	1950	1973	1992
Asian Countries							
Bangladesh	na	531	581	617	551	478	720
Burma	na	na	647	635	393	589	748
China	523	523	652	688	614	1,186	3,096
India	531	558	625	663	597	853	1,348
Indonesia	614	657	745	917	874	1,538	2,749
Japan	704	741	1,138	1,334	1,873	11,017	19,425
Pakistan	na	531	687	729	650	981	1,642
Philippines	na	na	1,033	1,418	1,293	1,956	2,213
South Korea	na	na	850	948	876	2,840	10,010
Taiwan	na	na	759	794	922	3,669	11,590
Thailand	na	717	812	846	848	1,750	4,694
African Countries							
Cote d'Ivoire	na	na	na	na	859	1,727	1,134
Egypt	na	na	509	508	517	947	1,927
Ethiopia	na	na	na	na	277	412	300
Ghana	na	na	462	648	1,193	1,260	1,007
Kenya	na	na	na	na	609	947	1,055
Morocco	na	na	na	na	1,611	1,651	2,327
Nigeria	na	na	na	na	547	1,120	1,152
South Africa	na	na	na	1,451	2,251	3,844	3,451
Tanzania	na	na	na	na	427	655	601
Zaire	na	na	na	na	636	757	353
World Average	651	895	1,263	1,539	2,138	4,123	5,145

Source: Angus Maddison (1995), *Monitoring the World Economy 1820–1992*, Paris: OECD, Tables 1-3 and G-3, pp. 23–24, 228.

to understand how we arrived at our present economic conditions. The world averages at the bottom of the table were used in drawing part of Figure 2-1, which depicts the recent explosive improvement in living standards.

2.2.1 Recent Economic Growth

In order to better understand the changes in the levels of real per capita GDP since 1820, in Table 2-2 we present the average annual growth rates in real per capita GDP implied by Maddison's estimated levels of real per capita income from Table 2-1. Notice that most West European countries and the countries Maddison labels "Western Offshoots" enjoyed positive rates of growth throughout the 1820–1992 period. These economies have very high *levels* of real per capita output today because they have been growing relatively more rapidly than other countries for nearly 200 years. The growth rate of the U.S. economy has been quite consistent, ranging from 1.29% during the years 1820–1870 to 1.99% at the beginning of the twentieth century. A high standard of living is not built in a day!

Japan provides an interesting contrast in that it began to grow only after 1870, when it abandoned its long isolation from the rest of the world. The data in Tables 2-1

TABLE 2-2 Average Annual Growth Rates of Real per Capita GDP, 1820–1992

	1820–1870	*1870–1913*	*1913–1950*	*1950–1973*	*1973–1992*
West European Countries					
Austria	0.7%	1.5%	0.2%	4.9%	2.2%
Belgium	1.4	1.0	0.7	3.5	1.9
Denmark	0.9	1.6	1.6	3.1	1.6
Finland	0.8	1.4	1.9	4.3	1.6
France	0.8	1.5	1.1	4.0	1.7
Germany	1.1	1.6	0.3	5.0	2.1
Italy	0.6	1.3	0.8	5.0	2.4
Netherlands	1.1	0.9	1.1	3.4	1.4
Norway	0.5	1.3	2.1	3.2	2.9
Sweden	0.7	1.5	2.1	3.1	1.2
Switzerland	na	1.5	2.1	3.1	0.8
United Kingdom	1.2	1.0	0.8	2.5	1.4
Western Offshoots					
Australia	1.8	0.9	0.7	2.4	1.4
Canada	1.2	2.2	1.4	2.9	1.5
New Zealand	na	1.2	1.3	1.7	0.5
United States	1.3	1.8	1.6	2.4	1.4
South European Countries					
Greece	na	na	0.5	6.2	1.5
Ireland	1.2	1.0	0.7	3.1	2.7
Portugal	na	0.5	1.2	5.7	2.1
Spain	0.5	1.2	0.2	5.8	1.9
Turkey	n.a.	n.a.	0.8	3.3	2.6
East European Countries					
Bulgaria	na	na	0.3	5.2	–1.4
Czechoslovakia	0.6	1.4	1.4	3.1	–0.1
Hungary	na	1.2	0.5	3.6	0.0
Poland	na	na	na	3.4	–0.6
Romania	na	na	na	4.8	–1.6
U.S.S.R.	0.6	0.9	1.8	3.4	–1.4
Yugoslavia	na	na	1.0	4.4	–0.5
Latin American Countries					
Argentina	na	2.5	0.7	2.1	–0.2
Brazil	0.2	0.3	1.9	3.8	0.9
Chile	na	na	1.0	1.2	1.9
Colombia	na	na	1.4	2.3	1.9
Mexico	–0.1	1.7	1.0	3.1	1.1
Peru	na	na	2.1	2.5	–1.7
Venezuela	na	na	5.3	1.6	–0.8

(continued)

TABLE 2-2 Average Annual Growth Rates of Real per Capita GDP, 1820–1992 (continued)

	1820–1870	*1870–1913*	*1913–1950*	*1950–1973*	*1973–1992*
Asian Countries					
Bangladesh	na	na	–0.3	–0.6	2.2
Burma	na	na	–1.3	1.8	1.3
China	0.0	0.6	–0.3	2.9	5.2
India	0.1	0.4	–0.3	1.6	2.4
Indonesia	0.1	0.8	–0.1	2.5	3.1
Japan	0.1	1.4	0.9	8.0	3.0
Pakistan	na	na	–0.3	1.8	2.7
Philippines	na	na	–0.2	1.8	0.7
South Korea	na	na	–0.2	5.2	6.9
Taiwan	na	na	0.4	6.2	6.2
Thailand	na	0.4	0.0	3.2	5.3
African Countries					
Cote d'Ivoire	na	na	na	3.1	–2.2
Egypt	na	na	0.0	2.7	3.8
Ethiopia	na	na	na	1.7	–1.7
Ghana	na	na	1.7	0.2	–1.2
Kenya	na	na	na	1.9	0.6
Morocco	na	na	na	0.1	1.8
Nigeria	na	na	na	3.2	0.1
South Africa	na	na	1.2	2.4	–0.6
Tanzania	na	na	na	1.9	–0.5
Zaire	na	na	na	0.8	–3.9
World Average	0.6	1.3	0.9	2.9	1.2

Source: Maddison (1995), *Monitoring the World Economy 1820–1992*, Paris: OECD, Tables 3-1 and 3-2, pp. 60, 62–63.

and 2-2 also reflect Japan's sharp decline in per capita income immediately after World War II, followed by 40 years of very rapid growth, about 8 percent per year, that has brought its real per capita income up to the level of the most developed economies of the world. Argentina provides yet another pattern of economic growth. During the period from 1870 to 1913, Argentina was truly the star performer. Its per capita real GDP in 1913 was on par with most of Europe, thanks to its world-leading growth rate of 2.5 percent per year during the 1870–1913 period. But then Argentina's economic growth slowed dramatically, and it even turned negative after 1973. On a brighter note, we should mention that Table 2-2 does not reflect the fact that Argentina's growth rate has picked up sharply since 1991. Perhaps Argentina is shifting gears and again breaking with its prior trend. Tables 2-1 and 2-2 make it clear that many different growth patterns are possible.

CASE STUDY 2-1

ECONOMIC MIRACLES AND ECONOMIC DISASTERS, 1820 TO THE PRESENT

Some economies have clearly grown more rapidly than others. But the long-run results reflect *average* growth rates over the entire period since 1820; a more detailed look at the growth evidence makes it clear that, from period to period, many countries' relative growth performances changed frequently. To illustrate the ever-changing race toward higher standards of living, we list in Table 2-3 the five fastest-growing economies for five different historical periods according to Maddison's data.

Notice that several countries appear on both the fastest-growing and the slowest-growing lists for different periods: Peru's economy grew rapidly in the first half of the twentieth century but declined during the 1973–1992 period. On the other hand, the Chinese and Korean economies improved from their dismal performance in the first half of the twentieth century and rose to stardom in the latter part of the century.

To be fair to all countries, the lists in Table 2-3 are not complete because Maddison includes only 56 countries in his data set. If we use the Summers and Heston data set for 130 countries, we can give some other countries their due as well. Table 2-4 gives the 10 fastest-growing

TABLE 2-3 Fastest- and Slowest-Growing Economies, 1820–1992, Maddison Data
(Annual Growth Rates)

	Fastest-Growing Economies	*Slowest-Growing Economies*
1820–1870	Australia (1.8%)	na
	Belgium (1.4%)	
	United States (1.3%)	
	United Kingdom (1.2%)	
	Canada (1.2%)	
1870–1913	Argentina (2.5%)	na
	Canada (2.2%)	
	United States (1.8%)	
	Mexico (1.7%)	
	Germany (1.6%)	
1913–1950	Venezuela (5.3%)	Burma (–1.3%)
	Peru (2.1%)	China (–0.3%)
	Norway (2.1%)	India (–0.3%)
	Sweden (2.1%)	Philippines (–0.2%)
	Switzerland (2.1%)	Korea (–0.2%)
1950–1973	Japan (8.0%)	Bangladesh (–0.6%)
	Taiwan (6.2%)	Morocco (0.1%)
	Greece (6.2%)	Ghana (0.2%)
	Spain (5.8%)	Zaire (0.8)
	Portugal (5.7%)	Chile (1.2%)
1973–1992	South Korea (6.9)	Zaire (–3.9%)
	Taiwan (6.2%)	Ivory Coast (–2.2%)
	Thailand (5.3%)	Ethiopia (–1.7%)
	China (5.2%)	Peru (–1.7%)
	Egypt (3.8%)	Romania (–1.6%)

TABLE 2-4 Fastest- and Slowest-Growing Economies, 1960–1990, Summers-Heston Data
(Annual Growth Rates of Real per Capita Output)

Fastest-Growing Economies	*Slowest-Growing Economies*
Korea (6.1%)	Guyana (–2.1%)
Botswana (5.9%)	Chad (–1.7%)
Hong Kong (5.8%)	Madagascar (–1.3%)
Taiwan (5.8%)	Mali (–1.0%)
Singapore (5.4%)	Zambia (–0.8%)
Japan (5.2%)	Mauritania (–0.8%)
Malta (4.8%)	Nicaragua (–0.7%)
Cyprus (4.4%)	Mozambique (–0.7%)
Seychelles (4.4%)	Venezuela (–0.5%)
Lesotho (4.4%)	Ghana (–0.3%)

Source: Jonathan Temple (1999), "The New Growth Evidence," *Journal of Economic Literature*, Vol. 37, Table 2, p. 116.

TABLE 2-5 Per Capita GNP Growth, 1985–1995, World Bank Data
(Annual Growth Rates of Real per Capita Output)

Fastest-Growing Economies	*Slowest-Growing Economies*
Thailand (8.4%)	Georgia (–17.0%)
China (8.3%)	Azerbaijan (–16.3%)
South Korea (7.7%)	Armenia (–15.0%)
Singapore (6.2%)	Lithuania (–11.7%)
Botswana (6.1%)	Ukraine (–9.2%)
Chile (6.1%)	Kazakhstan (–8.6%)
Indonesia (6.0%)	Gabon (–8.2%)
Malaysia (5.7%)	Kyrgyz Republic (–6.9%)
Mauritius (5.4%)	Cameroon (–6.6%)
Ireland (5.2%)	Latvia (–6.6%)

Source: World Bank (1997), *World Development Report 1997*, Washington, D.C.: World Bank, Table 1, pp. 214–215.

and 10 slowest-growing economies over the 1960–1990 period covered by the Summers and Heston data.

We can also look at the World Bank's calculations of per capita real GNP growth for the more recent 1985–1995 period (see Table 2-5), which shows some further interesting changes in country rankings. The World Bank data are not adjusted in the same fashion as the Maddison or Summers and Heston data sets, but over the relatively short 10-year period, the growth rates are probably not too distorted, even if the differences in the purchasing power of currencies would make the absolute levels of GNP per capita uncomparable. Notice another economy that moved from the slowest category to the fastest: Chile was among the slowest growers during the 1950–1973 period according to the Maddison data, but the more recent World Bank data for 1985–1995 show Chile among the very fastest growers. Unfortunately, other Latin American countries, namely,

Venezuela and Peru, headed in the other direction: After growing very fast in the first half of the twentieth century, as shown in the Maddison rankings for 1913–1950, they experienced very negative growth during 1985–1995. Notice also that most of the worst growth performances occurred in former Soviet republics.

These rankings of the fastest and the slowest economies at different times in history highlight what we concluded in the main text. Many of today's developed economies experienced relatively high economic growth in the 1800s and 1900s. Growth has not been consistent, however, and a number of countries appear on both sides of the rankings, being among the best and the worst at different times in history. It is thus possible to "catch up," even after falling behind, as evidenced by Korea and China. It is also possible to go from very fast growth to a disastrous performance in a later period, as did Peru and Venezuela. Finally, these rankings also make it clear that exceptionally rapid and exceptionally slow growth have occurred in all regions of the world.

2.2.2 Are Standards of Living Becoming More Equal?

Tables 2-1 and 2-2 suggest that differences between countries' per capita real-output levels are becoming larger. Differences in per capita real output have been getting bigger throughout the past 200 years. Tables 2-1 and 2-2 show that in 1820 the differences in real per capita output between countries were relatively small, with per capita income in the highest-income country, the United Kingdom, little more than three times that in the lowest-income country for which Maddison had data, China. There may, of course, have been countries with lower levels of per capita output, but not enough data are available for reliable national estimates. As in the previous chapter, we can use Lant Pritchett's estimate that long-run per capita real output could not have been less than $250 in any country.[7] Thus, at most, per capita real output in the United Kingdom was seven times that of the poorest country of the world in 1820. In 1992, per capita real output in the highest-income country, the United States, was 72 times that of the lowest-output country included in Table 2-1, Ethiopia.

The increasing differences in per capita output across countries over the past two centuries is obvious even when Maddison's historical data are aggregated by major regions of the world, as in Table 2-6. If anything, we should expect the differences between regional averages to be smaller than the differences between the most successful and the least successful individual countries, such as the comparison of China and the United Kingdom. Yet in Table 2-3 we see a growing dispersion of per capita incomes across entire regions. The ratio of average per capita output in the highest output region, the Western Offshoots, to the lowest, Africa, has risen from just 2.9 in 1820 to over 16 today. Compared to the case today, people throughout the world had rather similar standards of living before 1820. The widening dispersion of per capita real GDP is even more obvious in Figure 2-2, which gives you a visual representation of the data in Table 2-6.

2.2.3 The Convergence Debate

The widening of per capita output differences across countries is often referred to as the **divergence** of real per capita output. A narrowing of per capita output differences is, likewise, referred to as **convergence.** The data in Tables 2-1, 2-2, and 2-6 suggest that economic growth over the past 200 years has been characterized by divergence, not convergence.

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[7]Lant Pritchett (1997), "Divergence, Big Time," *Journal of Economic Perspectives,* Vol. 11(3), pp. 3–17.

TABLE 2-6 Average per Capita Real GDP by Region*

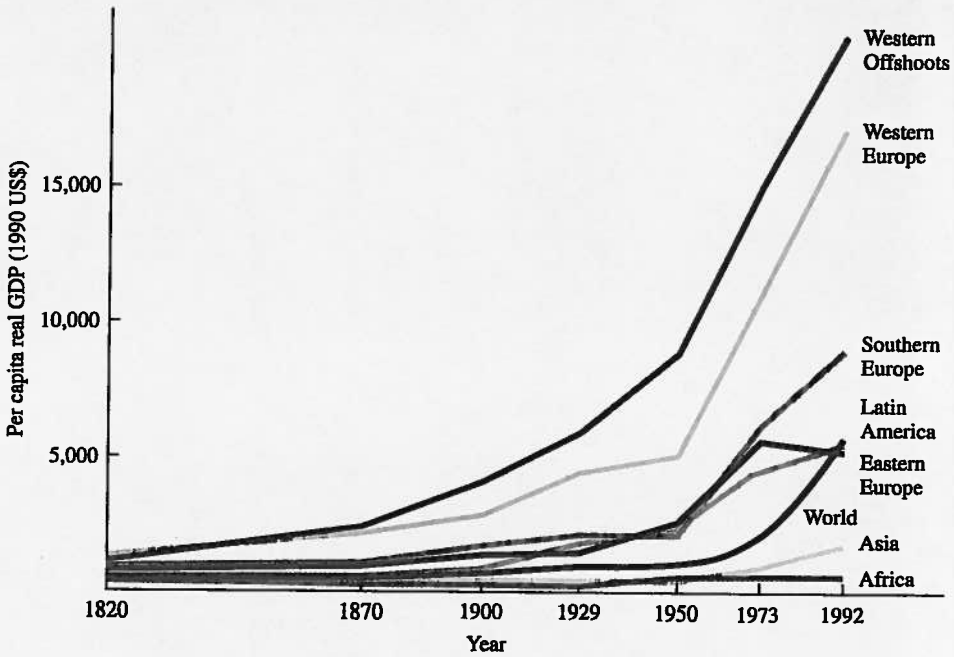
	Levels (1990 US$)						
	1820	*1870*	*1900*	*1929*	*1950*	*1973*	*1992*
Western Europe	1,292	2,110	3,092	4,385	5,126	12,289	17,387
Western Offshoots	1,205	2,440	4,022	6,653	9,255	16,075	20,850
Southern Europe	804	1,108	1,572	2,153	2,021	6,015	8,287
Eastern Europe	772	1,085	1,373	1,732	2,631	5,745	4,665
Latin America	679	760	1,077	1,832	2,487	4,387	4,820
Asia	550	580	681	858	765	1,801	3,252
Africa	450	480	500	660	830	1,311	1,284
World	651	895	1,263	1,806	2,138	4,123	5,145
Highest/lowest	2.9	5.1	8.0	10.1	11.2	12.3	16.2

	Growth Rates								
	1820–1870	*1870–1900*	*1900–1929*	*1929–1950*	*1950–1973*	*1973–1992*	*1820–1900*	*1900–1992*	*1820–1992*
Western Europe	1.0%	1.3%	1.2%	0.7%	3.9%	1.8%	1.1%	1.9%	1.5%
Western Offshoots	1.4	1.7	1.8	1.5	2.4	1.4	1.5	1.8	1.7
Southern Europe	0.6	1.2	1.1	–0.3	4.9	1.7	0.8	1.8	1.4
Eastern Europe	0.7	0.8	0.8	2.0	3.5	–1.1	0.7	1.3	1.1
Latin America	0.2	1.2	1.8	1.5	2.5	0.5	0.6	1.6	1.1
Asia	0.1	0.5	0.8	–0.5	3.8	3.2	0.3	1.7	1.0
Africa	0.1	0.1	1.0	0.9	2.0	–0.1	0.1	1.0	0.6
World	0.6	1.2	1.2	0.8	2.9	1.2	0.8	1.5	1.2

*See Table 2-1 for the countries included in each regional group.

Source: Angus Maddison (1995), *Monitoring the World Economy 1820–1992*, Paris: OECD, Table G-3, p. 228; growth rates calculated by the author from Maddison's data.

Figure 2-2
Per Capita GDP by Region



Some authors have qualified the obvious conclusion that per capita output levels are becoming less equal across countries. For one thing, a number of economies, such as China, Korea, Chile, and Taiwan, among others, are indeed converging to the highest per capita levels of GDP. Charles Jones shows that the number of countries that are converging relative to the number of countries that are diverging has been increasing in recent decades.[8] That is, more and more countries are growing faster than the most developed countries, and fewer countries are growing relatively slower. Furthermore, according to Jones, if we "weight" country growth rates according to population size, then since 1980 average per capita real output in developing economies has grown at 3.7 percent compared to developed-country growth of about 2 percent. This result reflects the surge in economic growth in China, with over 1.2 billion people, and India, with nearly 1 billion people, two countries that have recently altered their economic policies and raised their rates of economic growth.

We should be concerned with the welfare of individuals regardless of where they live, and therefore Jones's population-weighted average is very appropriate. Nevertheless, Jones also finds that about half of all developing economies, albeit many with small populations, exhibited negative economic growth between 1980 and 1993. This means that the difference in standards of living between the highest-income countries and the lowest-income countries has continued to grow in recent years. Diverging levels of per capita real GDP are still a common characteristic of many countries of the world, even though it may be true that more individual people are catching up than falling behind.

[8]Charles I. Jones (1997), "On the Evolution of the World Income Distribution," *Journal of Economic Perspectives,* Vol. 11(3), pp. 19–36.

The lively discussion about whether the economies of the world are converging or diverging has come to be known as the **convergence debate.** This debate is detailed in Chapter 5, which examines the predictions of the most popular model of economic growth. The great variance in the economic growth of individual countries during the past two centuries presents economists with a challenge. Not only must we try to explain the general surge in economic growth throughout much of the world after 1800, but we must try to explain the different growth experiences of individual countries. Numerous questions come to mind: Why did Argentina grow so fast and then stagnate? How has the United States been able to keep growing at such a consistent rate? How was Japan able to suddenly grow at 8 percent during the 1950–1973 period after destroying its economy during World War II? What caused the fall in per capita real GDP in Africa after 1973? As you learn more in the remainder of this book about how economies grow, you will be able to explain some of the different country growth experiences.

2.3 ALTERNATIVE MEASURES OF ECONOMIC GROWTH

We have already discussed some of the problems with making GDP and GNP data compatible across countries and time periods, problems which Maddison overcame to a considerable degree. But GDP and GNP measures still suffer many other shortcomings. It is well known that GDP and GNP do not include everything that is produced in an economy: They are designed to measure only market output and the imputed value of housing. Not included in GDP or GNP is household production. Nor is illegal or "informal" activity included, and this form of output can be substantial in many developing economies. Other output may fail to be recorded accurately for the simple reason that it would be prohibitively costly to measure everything that goes on in an economy. Indirect estimation methods are often very inaccurate. Also, in many countries governments intentionally distort statistical data in order to mislead the public about the true performance of the economy. In sum, economic data in many developing economies, and some developed economies, is just not very accurate.

But even if GDP and GNP were accurate measures of the value of total real output produced in an economy, they may still not accurately represent the true quality of life enjoyed by the residents of a country. It is not obvious precisely how human welfare is related to the total sum of goods and services consumed. Is welfare a simple linear function of output in the sense that twice as much "stuff" makes people exactly twice as well off? Or is the relationship nonlinear, perhaps reflecting diminishing returns to additional goods and services, as some development economists have suggested? Given the somewhat nebulous relationship between welfare and the consumption of goods and services, growth economists frequently use other measures to supplement the common GDP or GNP data in order to gain a more reliable picture of human welfare.

2.3.1 The Quality of Life in the World Today

Table 2-7 presents several measures, or indicators, that reflect the quality of life. Specifically, we have included (1) life expectancy at birth, (2) the mean years of schooling, and (3) the infant mortality rate. Maddison's 1992 estimates of real per capita GDP are also shown for easy reference. These three measures reflect the levels of health and

TABLE 2-7 Alternative Measures of the Quality of Life

	Per Capita Real GDP (US$), 1992	Life Expectancy		Mean Years of Schooling		Infant Mortality (Deaths per 1,000)
		Male	Female	Male	Female	
		1996		1990		1996
West European Countries						
Austria	17,160	74	80	11.7	10.5	5
Belgium	17,165	75	80	10.7	10.7	7
Denmark	18,293	73	78	10.5	10.3	6
Finland	14,646	73	81	10.7	10.5	4
France	17,959	74	82	11.5	11.7	5
Germany	19,351	73	80	11.7	10.6	5
Italy	16,229	75	81	7.4	7.3	6
Netherlands	16,898	75	80	10.4	10.8	5
Norway	17,543	75	81	11.7	11.5	4
Sweden	16,927	76	82	11.1	11.1	4
Switzerland	21,036	75	82	11.5	10.7	5
United Kingdom	15,738	74	80	11.4	11.6	6
Western Offshoots						
Australia	16,237	75	81	11.5	11.7	6
Canada	18,159	76	82	12.3	11.9	6
New Zealand	13,947	75	79	10.2	10.6	6
United States	21,558	74	80	12.2	12.4	7
South European Countries						
Greece	10,314	75	81	7.3	6.5	8
Ireland	11,711	74	79	8.6	8.8	5
Portugal	11,130	72	79	6.8	5.2	7
Spain	12,498	73	81	7.0	6.5	5
Turkey	4,422	66	71	4.7	2.3	42
East European Countries						
Bulgaria	4,054	67	75	7.6	6.4	16
Czech Republic	6,845	70	77	9.5	8.4	6
Hungary	5,638	65	75	9.5	9.7	11
Poland	4,726	68	77	8.3	7.7	12
Romania	2,565	65	73	7.4	6.6	22
Russia	4,671	60	73	9.0	9.0	17
Latin American Countries						
Argentina	7,616	69	77	8.5	8.9	22
Brazil	4,637	63	71	4.0	3.8	36
Chile	7,238	72	78	7.8	7.2	12
Colombia	5,025	67	73	6.9	7.3	25
Mexico	5,002	69	75	4.8	4.6	32
Peru	2,854	66	71	7.1	5.7	42
Venezuela	5,949	70	76	6.4	6.2	22

(continued)

TABLE 2-7 Alternative Measures of the Quality of Life (continued)

	Per Capita Real GDP (US$), 1992	Life Expectancy		Mean Years of Schooling		Infant Mortality (Deaths per 1,000) 1996
		Male 1996	Female 1996	Male 1990	Female 1990	
Asian Countries						
Bangladesh	720	57	59	3.1	0.9	77
Myanmar	748	60	60	3.0	2.1	—
China	3,096	68	71	6.0	3.6	33
India	1,348	62	63	3.5	1.2	65
Indonesia	2,749	63	67	5.0	2.9	49
Japan	19,425	77	83	10.8	10.6	4
Pakistan	1,642	62	65	3.0	0.7	88
Philippines	2,213	64	68	7.8	7.0	37
South Korea	10,010	69	76	11.0	6.7	9
Taiwan	11,590	72	78	10.5	10.1	8
Thailand	4,694	67	72	4.3	3.3	34
African Countries						
Cote d'Ivoire	1,134	53	55	2.9	0.9	84
Egypt	1,927	64	67	3.9	1.6	53
Ethiopia	300	48	51	1.5	0.7	109
Ghana	1,007	57	61	4.8	2.2	71
Kenya	1,055	57	60	3.2	1.3	57
Morocco	2,327	64	68	4.1	1.5	53
Nigeria	1,152	51	55	1.8	0.5	78
South Africa	3,451	62	68	4.1	3.7	49
Tanzania	601	49	52	2.8	1.3	86
Zaire	353	49	54	2.4	0.8	90

Source: Angus Maddison (1995), *Monitoring the World Economy 1820–1992*, Paris: OECD, pp. 102–103; World Bank (1998), *World Development Report 1998/99*, Washington, D.C.: World Bank, pp. 192–193, 202–203; United Nations (1993), *Human Development Report 1993*, New York: United Nations, pp. 144, 194. Data on Taiwan are from official Taiwanese government publications.

education, two important components of the standard of living that may not be accurately reflected by a country's per capita GDP. The United Nations' well-known Human Development Index (HDI) is based on almost exactly the same measures, namely, real per capita income, life expectancy, the literacy rate, and school enrollment rates. This index is published annually in the *Human Development Report*.[9] Rather than presenting the HDI, which is a somewhat arbitrary combination of quality-of-life indicators, we prefer to present the actual measures of per capita output, life expectancy, schooling, infant mortality, and other aspects of the quality of life and let the reader decide how to judge a country's overall standard of living using the various measures of human welfare.

The data in Table 2-7 give us a picture of the current state of human welfare in the world that is not too different from what the per capita GDP data show. Infant mortality rates, life expectancies, and years of schooling vary greatly across countries, just like

[9]United Nations (1999), *Human Development Report 1999*, New York: United Nations Development Programme.

per capita real GDP. Of course, the GDP data and the alternative quality-of-life measures do not parallel each other perfectly. For example, many of the Eastern European economies have quality-of-life measures that exceed those of some countries with higher per capita real GDPs. Compare, for example, Brazil with Poland. Perhaps some of the Eastern European economies are not as poor, in terms of the quality of life, as their real GDP measures suggest. Look carefully, and you will find other discrepancies between countries' rank in terms of real per capita GDP and their rank in terms of the quality of life.

Two of the measures of the quality of life included in Table 2-7 contrast male and female differences. These gender differences should be seen as yet another measure of human welfare because they reflect the degree of explicit discrimination and other barriers that limit economic choices. The size of the gender differences is perhaps best seen as an indicator of economic freedom, a concept that we will return to shortly. The extent of the gender differences, just like the other quality-of-life measures, varies more or less directly with the real per capita GDP measures derived by Maddison.

2.3.2 Human Health throughout History

We do not have many historical measures on the quality of life that parallel Maddison's GDP and population data back to 1820. But there are quite a few bits of information that shed considerable light on how people lived in the past. Economic historians have been hard at work uncovering a great variety of evidence on the quality of people's lives before the twentieth century that can assist us in evaluating historical economic growth. This additional evidence enhances our confidence in our earlier conclusions about economic growth because, just like Maddison's GDP data, it generally points to the same very sharp improvement in the quality of life over the past 200 years.

Ten thousand years ago, in the primitive hunter-gatherer societies, about half of all children died before reaching the age of five. Even as late as the 1500s, records suggest that from one-quarter to one-third of all children died before reaching the age of five in countries such as England, Sweden, and Switzerland.[10] Compare these rates with those given for 1996 in Table 2-7. Of Madisson's sample of 56 countries, only one country, Ethiopia, has an infant mortality rate of over 100 per 1,000 births. That is, in Ethiopia, slightly more than one-tenth of all children die before the age of five. Many of the highest-income countries today have infant mortality rates of less than 10. For the world as a whole, the infant mortality rate is about 50 per 1,000 births, which is one-tenth the level of the preagricultural world 10,000 years ago and less than one-fifth the level in the most advanced countries just a few hundred years ago.

Anthropologists and historians provide us with some estimates of life expectancy before 1800. Life expectancy was between 20 and 30 years from prehistoric times until about 1400. One study of skeletal remains in northern Egypt indicates that during the Neolithic period (6000–3000 BC) life expectancy at birth was 21 years.[11] During the Roman Empire, life expectancy was also in the twenties, and a study using detailed data on the lives of Benedictine monks in Canterbury, England, during the period

[10]See Kenneth Hill (1995), "The Decline of Childhood Mortality," in Julian L. Simon, ed., *The State of Humanity,* Oxford: Blackwell, pp. 37–50.

[11]George Acsadi and J. Nemeskeri (1970), *History of Human Life Span and Mortality,* Budapest: Akademai Kiado, as discussed in Samuel H. Preston (1995), "Human Mortality throughout History and Prehistory," in Julian L. Simon, ed., *The State of Humanity,* Oxford: Blackwell, pp. 30–36.

TABLE 2-8 Life Expectancy, 1820–1997

Country	*1820*	*1900*	*1992*	*1997*
Brazil	na	37	66	67
France	40	47	77	78
Germany	na	47	76	77
India	na	24	61	62
Japan	35*	44	79	80
Mexico	na	33†	70	72
Netherlands	32	52	77	78
Spain	na	35	77	77
Sweden	35	56	78	79
Russia	na	32	64	65
United Kingdom	39	51	76	77
United States	na	47	77	77

*1850.

†1930.

Source: Angus Maddison (1995), *Monitoring the World Economy 1820–1992,* Paris: OECD, Table 1-7, p. 27, and World Bank (1998), *World Development Report 1998–1999,* Washington, D.C.: World Bank, Table 2, pp. 192–193.

1395–1505 shows that their life expectancy was 22 years.[12] As late as the mid-1700s in London, life expectancy was still just 25 years.[13] Compare these numbers with the steady improvement in life expectancy beginning in the 1800s, as shown in Table 2-8. By 1997, British life expectancy had reached 77 years. Thus, in terms of such an important measure of human welfare, there was virtually no improvement for 2,000 years, and then, suddenly, life expectancy tripled within 200 years. You should be able to envision a diagram that shows a curve very similar to that of Figure 2-1, consisting of a horizontal path stretching over thousands of years and then, suddenly, shooting up during the last two centuries.

The data in Tables 2-7 and 2-8, as well as the various historical observations, clearly suggest a direct relationship between per capita real output and the level of health. Improvements in the rate of infant mortality and the average number of years that people live appear to parallel both the current levels of per capita output across countries and the historical pattern of economic growth. The direct relationship between per capita real output and health has also been confirmed by many authors using rigorous statistical methods. In one such study, the authors Lant Pritchett and Lawrence Summers summarized their results in their title, "Wealthier Is Healthier."[14] The close relationship between Maddison's historical data on per capita real output and measures of human health should not be too surprising. The same forces that led to the economy's ability to produce more goods and services also led to improvements in medicine and personal hygiene. Case Study 2-2 below provides two interesting examples of how economic growth affects people's health.

[12]See John Hatcher (1986), "Mortality in the Fifteenth Century: Some New Evidence," *Economic History Review,* Vol. 39(1), pp. 19–38. This and a number of other studies on life expectancy are discussed in Samuel H. Preston (1995), op. cit.

[13]Theodore Dalrymple (1999), "Taking Good Health for Granted," *The Wall Street Journal,* March 31.

[14]Lant Pritchett and Lawrence Summers (1996), "Wealthier Is Healthier," *Journal of Human Resources,* Vol. 31(4), pp. 841–868.

CASE STUDY 2-2

THE RELATIONSHIP BETWEEN OUTPUT GROWTH AND HEALTH

The fact that both health and the overall ability of the world economy to produce goods and services improved in tandem, as the Maddison data and the available evidence on life expectancy and infant mortality suggest, is not a coincidence. The improvement in health is a result of the same technological progress and institutional changes that caused per capita output to begin growing so rapidly. Likewise, the increase in life expectancy and the sharp fall in infant mortality are a direct result of the world economy's ability to provide people with more and better products. That is, per capita real GDP and the level of human health move together because (1) they react to the same outside forces and (2) they influence each other.

Health has improved because of the application of the scientific method, which increased our ability to learn and discover new welfare-enhancing products and radically improved medical practices in the world. Better medical practices have led to the virtual eradication of many feared diseases like smallpox, polio, and tuberculosis. The scientific research that led to the development of antibiotics has greatly reduced deaths from infections, the leading cause of death before the twentieth century. In addition, doctors have improved their treatments of patients. According to one physician, "The principle of the controlled trial of treatments is one of the most momentous discoveries of our age, which has revolutionized medicine and for the first time turned therapeutics into a genuine science."[15] Doctors no longer use bloodletting to reduce fever or prescribe arsenic to treat asthma because scientifically monitored experience showed that such treatments did not work.

Not only did human health benefit from the development and application of science; it also benefited from growth elsewhere in the economy. In his stimulating book on how nations become wealthy, David Landes discusses how the introduction of cotton clothing to Europe improved personal cleanliness and, thereby, reduced the incidence of gastrointestinal infection, one of the greatest causes of death before 1800.[16] Apparently, in preindustrial northern Europe most people wore wool underwear. Woolens, as underwear was generally called in England, were difficult to wash, which meant that most people lived almost permanently in dirty underwear. Dirty woolens itched, people scratched, hands became dirty, and dirty hands spread germs to food. Only the wealthy could afford easier-to-wash linen underwear, although the soap for washing clothing was not very effective. Then, with the progress of the Industrial Revolution in the late eighteenth century and the early nineteenth century, cotton clothing became available. Cotton clothing was much easier to wash than wool clothing. Improved transportation and international trade gave Europeans access to raw cotton, which was grown in warm climates. The growth of large-scale industrial production, in turn, greatly reduced the cost of converting raw cotton into cloth and, subsequently, into underwear. At the same time, the Industrial Revolution also brought better and cheaper soap with which to wash the more washable cotton. Thus, the improved ability of the economy to transport, produce, and distribute goods caused the frequency of gastrointestinal infection to fall and life expectancy to rise. By the 1800s, everybody could afford less disease-bearing underwear than even the royal family had available to it a century earlier.

The process of economic growth is complex, as this brief account of the scientific method and cotton underwear makes clear. The creation of new technology, such as the scientific method, is important because it raises the economy's capacity to provide goods and services that enhance human welfare. But there are also spillovers or "externalities" as growth in one sector of the economy provides unexpected benefits elsewhere. The health of humanity improved not only because of science but also because the Industrial Revolution made inexpensive cotton underwear available.

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[15]Theodore Dalrymple (1999), "Taking Good Health for Granted," *The Wall Street Journal*, March 31.
[16]David S. Landes (1999), *The Wealth and Poverty of Nations: Why Some Are So Rich and Some So Poor*, New York: Norton.

2.3.3 Education and Human Welfare

Education adds to the economy's stock of human capital, which is the capacity or ability of people to produce. Therefore, we should not be surprised to find that the level of education and per capita GDP are correlated. We shall see in later chapters that education may increase the rate of economic growth by stimulating innovation and also by increasing the stock of educated labor necessary for research and development activities. For these reasons we should expect education to be correlated with the rate at which human welfare grows over time. But education is itself a contributor to human welfare because educated people live more interesting and productive lives. Also, educated people understand their options better, and hence they make better choices and achieve more valued economic outcomes. Measures of educational achievement and opportunity can thus be expected to be closely correlated with human welfare.

Table 2-7 gives data on the average number of years of schooling in 56 countries around the world, and from these data the correlation between per capita real output and education is obvious. In terms of freedom and opportunity, note the differences in schooling between men and women in a number of economies. Such inequities are a clear sign of differences in economic opportunity in those countries. However, despite the inequities and huge differences across countries, there have been substantial improvements in the level of education in virtually all countries of the world, provided, of course, that enrollment rates are an accurate proxy for true educational achievement. Figures 2-3 and 2-4 show how education has improved over the past century. Where

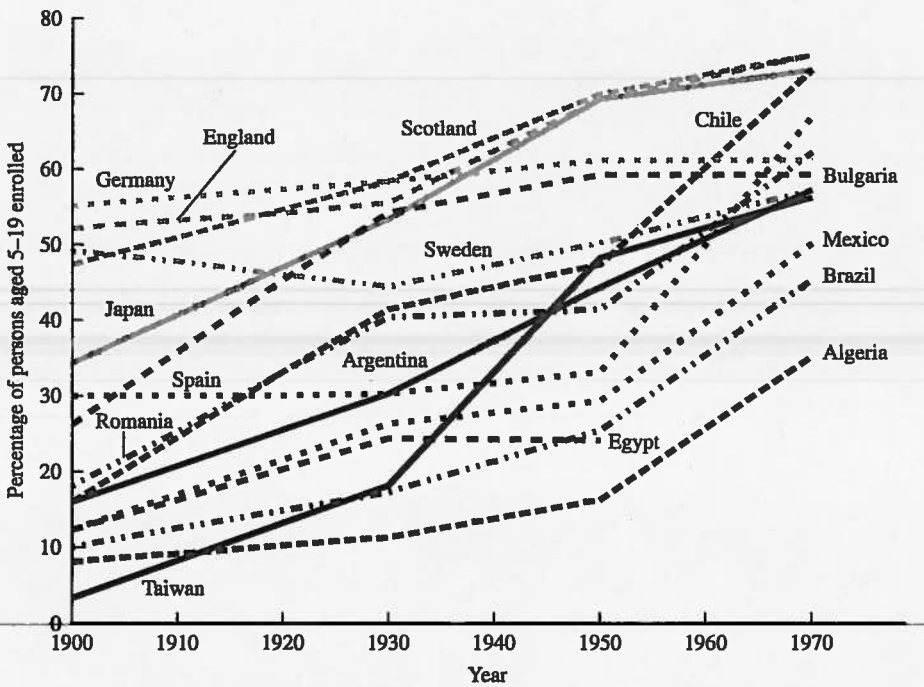


Figure 2-3 Enrollment in Primary and Secondary Schools, 1900–1970

Source: Julian L. Simon and Rebecca Boggs (1995), "Trends in the Quantities of Education—USA and Elsewhere," Chap. 21 in Julian L. Simon (ed.), *The State of Humanity*, Oxford: Blackwell, p. 218.

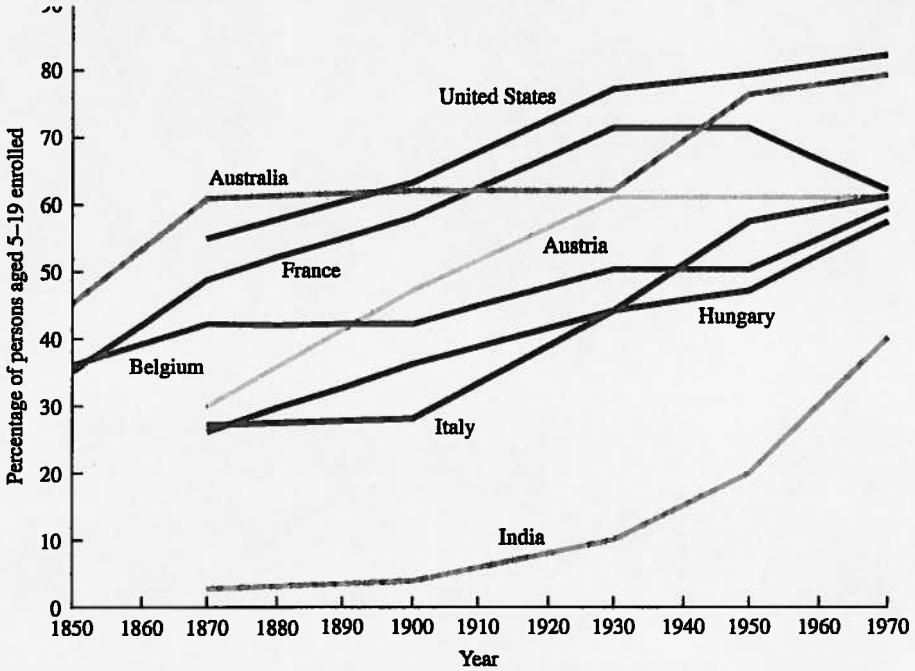


Figure 2-4 Enrollment in Primary and Secondary Schools, 1850–1970

Source: Julian L. Simon and Rebecca Boggs (1995), "Trends in the Quantities of Education—USA and Elsewhere," Chap. 21 in Julian L. Simon (ed.), *The State of Humanity*, Oxford: Blackwell, p. 217.

formal education was a privilege of the well-to-do two centuries ago, today nearly all people around the world receive some formal education. Of course, education should still be improved in many countries, and, as we shall see, growth models suggest that ongoing economic growth may slow unless education continues to be expanded in all countries of the world. But it is obvious that more people are receiving substantially higher levels of education today than ever in the past and that there have been great increases in the recent past.

2.3.4 *Measures of Freedom*

Amartya Sen, the Nobel Prize–winning development economist, has suggested that the capability to make choices is important for human welfare. In a recent work he argues "in favor of judging individual advantage in terms of the respective capabilities, which the person has, to live the way he or she has reason to value."[17] In other words, the capability to make choices about what to consume, where to work, where to live, and how to conduct one's life in general is very important for human welfare. A set of forced lifestyles for one group of people is not comparable to a set of voluntary lifestyles for another group of people who had a great deal of freedom in making economic,

[17]Amartya Sen (1999), "The Possibility of Social Choice," *American Economic Review*, Vol. 89(3), pp. 358–359.

political, and social choices. All other things equal, therefore, the more freedom people have to make choices, the higher their welfare is likely to be.

We will see that personal freedom to make choices is important for innovation and economic growth. That is, freedom to choose not only has a direct effect on people's happiness but enhances the economy's long-run capacity to provide people with greater material wealth as well. For this reason, freedom should be correlated with per capita real GDP and can thus serve as an alternative measure of human welfare in place of GDP.

To test the hypothesis of a positive relationship, we need to quantify freedom, which is not as easy as quantifying the value of output. There have, nevertheless, been several promising attempts at quantifying the things that we most often associate with the freedom to choose how we live our lives. Some studies have focused on *political freedom,* which is the ability to influence the political system in which people live. Others have focused more on what might be termed *civil liberties,* that is, the freedom to choose one's own lifestyle. Finally, there is *economic freedom,* such as the freedom to choose where, how, and how much to work, the freedom to choose among a wide range of options for work and consumption, the security to enjoy the fruits of one's own work, and the ability to securely store one's accumulated wealth for future use. Table 2-9 presents some available data on political and economic freedom in the world. Specifically, listed for a very large group of countries are the indexes of political rights and civil liberties taken from the *Annual Survey of Freedom* compiled by Freedom House. These two indexes are on a scale from 1 (the greatest degree of freedom) to 7 (no freedom). The third index listed is, on a scale from 1 (greatest amount of freedom) to 5, a summary measure of economic freedom published jointly by the Heritage Foundation and *The Wall Street Journal.*

It should be clear from Table 2-9 that there is a close correlation between the three types of freedom. The countries with the highest levels of political rights and civil liberties also tend to have the highest degree of economic freedom. The exceptions are few, and their small number essentially proves the rule. Notice that Singapore, the country with the highest level of economic freedom, provides its citizens with few political rights or civil liberties. Singapore is, of course, often in the news for its lack of democracy and the harsh law enforcement methods it uses to maintain order. For example, it outlaws chewing gum and has one of the very highest rates of execution per capita. Bahrain is the other example of a high level of economic freedom combined with few political or civil rights. There are also a few countries in different corners of the world that have high levels of political and civil rights and below-average (index over 2.50) levels of economic freedom. Take note of Costa Rica, Mauritius, Slovenia, and Uruguay, for example. But, for the most part, all three forms of freedom, or lack thereof, tend to coincide in nearly all countries..

TABLE 2-9 Measures of Political Rights (P), Civil Liberties (C), and Economic Freedom (E), 1998–1999

Country	P	C	E
Developed Economies			
Australia	1	1	2.10
Austria	1	1	2.15
Belgium	1	2	2.10
Canada	1	1	2.10
Denmark	1	1	2.25
Finland	1	1	2.25
France	1	2	2.50
Germany	1	2	2.30
Greece	1	3	2.90
Iceland	1	1	2.30
Ireland	1	1	1.95
Italy	1	2	2.50
Japan	1	2	2.05
Luxembourg	1	1	1.95
Netherlands	1	1	2.15
New Zealand	1	1	1.75
Norway	1	1	2.35
Portugal	1	1	2.55
Singapore	5	5	1.30
Spain	1	2	2.50
Sweden	1	1	2.45
Switzerland	1	1	1.85
United Kingdom	1	2	1.95
United States	1	1	1.90
Transition Economies			
Albania	4	5	3.85
Armenia	4	4	3.45
Azerbaijan	6	4	4.30
Belarus	6	6	4.15
Bosnia	5	5	4.80
Bulgaria	2	3	3.45
Czech Rep.	1	2	2.05
Estonia	1	2	2.15
Georgia	3	4	3.65
Hungary	1	2	2.90
Kazakhstan	6	5	4.05
Kyrgyz Rep.	5	5	4.00
Latvia	1	2	2.85
Lithuania	1	2	3.00
Moldova	2	4	3.35
Poland	1	2	2.95
Romania	2	2	3.30
Russia	4	4	3.45
Slovakia	2	2	3.05
Slovenia	1	2	3.10
Tajikistan	6	6	4.40
Turkmenistan	7	7	4.45
Ukraine	3	4	3.80
Uzbekistan	7	6	4.40
Asia			
Bangladesh	2	4	3.85
Cambodia	6	6	3.35
China	7	6	3.80
India	2	3	3.70
Indonesia	6	4	2.95
Iran	6	6	4.70
Korea, North	7	7	5.00
Korea, South	2	2	2.40
Laos	7	6	4.90
Malaysia	5	5	2.40
Mongolia	2	3	3.20
Myanmar	7	7	4.30
Nepal	3	4	3.40
Pakistan	4	5	3.35
Philippines	2	3	2.75
Sri Lanka	3	4	2.55
Taiwan	2	2	1.95
Thailand	2	3	2.40
Vietnam	7	7	4.60
Africa			
Algeria	6	5	3.25
Angola	6	6	4.45
Botswana	2	2	2.75
Burkina Faso	5	4	3.50
Burundi	7	6	3.90
Cameroon	7	5	3.50
Cape Verde	1	2	3.67
Chad	6	4	3.80
Congo	7	5	3.75
D.R. of Congo	7	6	4.70
Cote d'Ivoire	6	4	3.35
Djibuti	5	6	3.20
Egypt	6	6	3.35
Ethiopia	4	4	3.70
Gabon	5	4	2.95
Gambia	7	5	3.60
Ghana	3	3	3.00
Guinea	6	5	3.35
Guinea-Bissau	3	5	4.55
Kenya	6	5	3.05
Lesotho	4	4	3.45
Libya	7	7	4.90
Madagascar	2	4	3.45
Malawi	2	3	3.65
Mali	3	3	3.10
Mauritania	6	5	3.80
Maurltius	1	2	2.65
Morocco	5	4	2.95
Mozambique	3	4	3.85
Namibia	2	3	2.75
Niger	7	5	3.70
Nigeria	6	4	3.30
Rwanda	7	6	4.30
Senegal	4	4	3.25
Sierra Leone	3	5	4.05
Somalia	7	7	4.80
South Africa	1	2	2.90
Sudan	7	7	4.20
Swaziland	6	4	2.80
Tanzania	5	4	3.25
Togo	6	5	3.95
Tunisia	6	5	2.95
Uganda	4	4	2.80
Zambia	5	4	3.05
Zimbabwe	5	5	3.80
Latin America			
Argentina	3	3	2.50
Bolivia	1	3	2.65
Brazil	3	4	3.25
Chile	3	2	2.15
Colombia	3	4	3.10
Costa Rica	1	2	2.80
Cuba	7	7	5.00
Dominican Rep.	2	3	3.35
El Salvador	2	3	2.25
Ecuador	2	3	2.95
Guatemala	3	4	2.75
Haiti	5	5	4.00
Honduras	2	3	3.15
Mexico	3	4	3.15
Nicaragua	2	3	3.50
Panama	2	3	2.40
Paraguay	4	3	3.05
Peru	5	4	2.60
Uruguay	1	2	2.70
Venezuela	2	3	3.40
Middle East			
Bahrain	7	6	1.70
Iraq	7	7	4.90
Israel	1	3	2.80
Jordan	4	5	2.75
Kuwait	5	5	2.40
Lebanon	6	5	3.25
Oman	6	6	2.75
Qatar	7	6	3.05
Saudi Arabia	7	7	3.00
Syria	7	7	4.20
Turkey	4	5	2.80
United Arab Em.	6	5	2.10
Yemen	5	6	4.10
Caribbean			
Bahamas	1	2	2.00
Barbados	1	1	2.60
Guyana	2	2	3.50
Jamaica	2	2	2.70
Surinam	3	3	3.85
Trinidad & Tobago	1	2	2.55

Source: P and C are from Freedom House (1999), *Annual Survey of Freedom,* Freedom House website; E is from Bryan T. Johnson, Kim R. Holmes, and Melanie Kirkpatrick (1999), *1999 Index of Economic Freedom,* New York: Heritage Foundation and Dow Jones & Company.

CASE STUDY 2-3

HOW THE FORMER INDIAN CASTE SYSTEM STILL RESTRICTS ECONOMIC FREEDOM

The freedom to make choices about where to work and live, what to consume, and whom to associate with is not equally available to all people in the world. Economic, social, and political freedoms depend on a country's traditions, social structure, political system, and level of economic development. The Indian caste system offers an interesting, if infuriating, case study. The Hindu caste system dates back thousands of years, and it originally split society into four "classes" of people on the basis of their economic occupations: At the top were the Brahmans, the priestly order; next came the warriors and rulers; then the farmers, artisans, and merchants; and at the bottom of the hierarchy were the servants. With time the social/economic castes multiplied until there was one for every occupation. Status varied with the dirtiness of the occupation, and the filthiest jobs belonged to the people called *untouchables*. Contact between the untouchables and the rest of society was severely limited, and some castes were not even supposed to be seen. Those who washed the clothing of the untouchables were required to work at night, when it was dark. Marriage outside one's caste was very rare, and even social contact was severely restricted. Hence, India ended up not only with a very rigid social structure but also, because the hierarchical order was based on economic activity, with a very rigid economic system that severely limited economic mobility and the efficient allocation of resources. The choice of profession was thus hereditary, as was a person's income and even the part of town or village where he or she resided.

When India gained independence from Britain in 1952, the traditional caste system and the practice of untouchability were outlawed. Laws were even passed mandating that certain percentages of government jobs be given to the lowest castes. But rapid population growth, combined with a near-stagnant economy for much of the postindependence period, meant that there were few opportunities for members of the lower castes to move up. In fact, the caste system persists today, some 50 years after it was supposedly made illegal and despite the very noticeable modernization that has occurred in many urban areas.

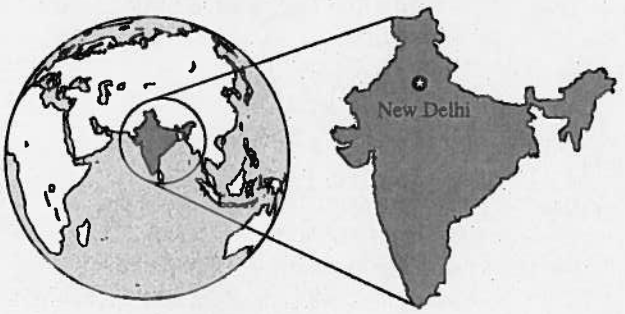
A recent newspaper report from a typical rural town in India makes it clear that economic freedom is still greatly restricted.[18] The reporter describes the plight of the lowest of the low castes, the *bhangis* or scavengers, who earn very meager incomes cleaning up human waste. Most homes in rural India still lack basic sanitation, and human excrement is routinely handled by the scavengers, who carry it away by hand in small buckets and deposit it outside of town. Bhangis are still looked down upon even by tanners and animal cremators, who were untouchables themselves but will not go near the bhangis.

According to the newspaper report:

> Birth here remains a life sentence to poverty. Though more scavenger children are getting some public education—boys usually—it hasn't helped much, they say. Mukeish Tak, the third person ever from this slum's 700 scavenger families to attend college, says most higher-caste students at school don't go near the handful of untouchable students, who stick to themselves. Mr. Tak, 22, does have a few high-caste friends, but even they won't eat with him.
>
> "We'll all probably end up as sweepers," says Mr. Tak, using the Hindi euphemism for scavengers. "Cleaning excrement is the only way to feed our families. It is up to God to decide."

Mahatma Gandhi, the revered Indian independence leader, had made the plight of the untouchables one of his principal concerns over 50 years ago. Gandhi, in fact, often exhibited his anger when confronted with the fatalism with which the members of the lower caste accepted

[18]Peter Waldman (1996), "For the Lowest Caste, Clearing India's Toilets Remains Life's Work," *The Wall Street Journal*, June 20.



their conditions because they believed that diligent work within their designated caste would be rewarded with reincarnation to a higher caste in the future. Gandhi made a point of cleaning up his own excrement and urged others to do the same. The report on present-day India goes on to say, however, that after Gandhi:

> The scavengers' plight was largely forgotten amid problems of independence, which coincided in 1948 with Gandhi's assassination. But in 1969 a sociologist and Gandhi disciple named Bindeshwar Pathak was given an assignment by the centenary commission for Gandhi's birth: Find a way to fulfill the Mohatma's dream of freeing the scavengers.
>
> Dr. Pathak's answer: plumbing.
>
> Using inexpensive earthen-pit technology, Dr. Pathak's Sulabh International Foundation now builds about 100,000 toilets a year for private and public use. The idea is to erase the scavengers' social stigma by eradicating the need for their degrading work.

Economic growth would very naturally lead to the increased use of modern plumbing and the elimination of the need for people to handle human excrement. As members of the higher castes choose plumbing, the members of the scavenger caste will become less "untouchable." Indeed, economic growth and freedom are closely linked.

2.3.5 The Value of Leisure

Another measure of the quality of life is the amount of leisure that people enjoy. Table 2-10 presents some interesting figures from research performed by the Nobel Prize–winning economic historian Robert Fogel. In a little more than 100 years, according to Fogel, leisure increased by 4 hours per day for the average male in the United States.[19] In 1880 the average male had 1.8 hours of leisure per day, whereas in 1995 he had 5.8 hours. More interesting yet are Fogel's estimates of what he calls "earnwork" and "volwork." Fogel uses these terms in order to avoid the misunderstanding often caused by the word "leisure," which can suggest indolence. Leisure often involves a substantial amount of activity, sometimes requiring exceptional energy and sometimes even carrying some payment with it. The first term, *earnwork*, is defined as activity undertaken primarily to earn a living; the second term, *volwork*, refers to voluntary activity or, in some cases, lack of activity. Lifetime hours spent on earnwork and volwork have changed drastically in the United States since 1880. Volwork now exceeds earnwork, as lifetime earnwork has declined by over 50 percent and volwork has increased

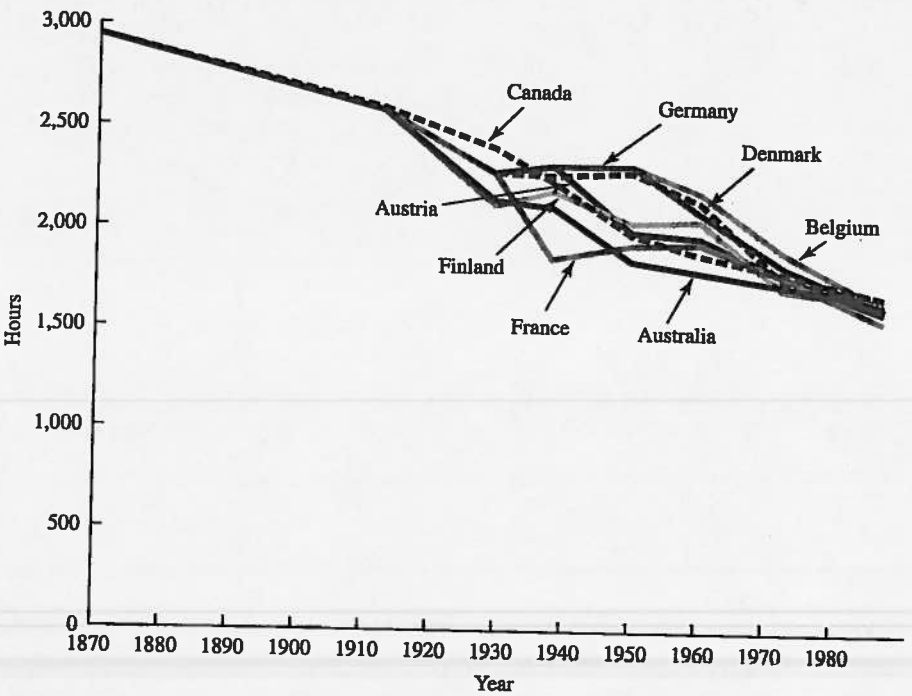
[19]Robert W. Fogel (1999), "Catching Up with the Economy," *American Economic Review*, Vol. 89(1), Tables 2 and 3, pp. 1–21.

TABLE 2-10 Trends in Time Use, United States, 1880 and 1995

Activity	1880	1995	Activity	1880	1995
Sleep	8	8	Lifetime hours	225,900	198,500
Meals and essential hygiene	2	2	Lifetime earnwork	182,100	122,400
Chores	2	2	Lifetime volwork	43,800	176,100
Travel to work	1	1			
Work	8.5	4.7			
Illness	0.7	0.5			
Subtotal	22.2	18.2			
Residual for leisure	1.8	5.8			

Source: Robert W. Fogel (1999), "Catching Up with the Economy," *American Economic Review*, Vol. 89(1), Tables 2 and 3, pp. 5, 6.

Figure 2-5 Annual Hours Worked per Person, Selected Countries, 1870–1989



Source: John P. Robinson (1995), "Trends in Free Time," Chap. 22 in Julian L. Simon (ed.), *The State of Humanity*, Oxford: Blackwell, p. 229.

more than fourfold. Total lifetime discretionary hours have also increased as life expectancies have increased.

Similar long-run patterns in the amount of leisure time can be found for other countries. Figure 2-5 graphs the annual hours worked for eight developed economies from 1870 through 1989. Annual hours of work in these countries have fallen by nearly 50 percent in little more than 100 years. Increases in discretionary leisure, or volwork as Fogel prefers, surely constitute increases in human welfare.

2.3.6 Is Human Welfare Diverging or Converging?

The alternative measures of human welfare are reassuring because they seem to confirm the message presented by real per capita output measures such as those compiled by Maddison. We might also ask if data on infant mortality, life expectancy, and education have varied across countries the way real per capita output has. Specifically, do we observe the same widening of differences in measures of longevity, infant mortality, education, and so on, that we have observed for per capita output over the past 200 years?

Table 2-11, taken from the United Nations' *Human Development Report 1998,* suggests that the quality of life has been converging, not diverging, in recent decades. The numbers in this table are index numbers, with the average value of the indicator for a group of developed economies set equal to 100. You can think of the numbers as representing the percentage of the developed economy level of each variable, and the closer to 100 the numbers are, the more similar the variables are to those of the most developed economies. Table 2-11 shows that four of the five developing-country quality-of-life indicators improved relative to those of the average developed country over the past several decades. Only the infant mortality rate fell relative to that of the most developed economies: The percentage of children who died before the age of five fell by two-thirds in the most developed countries, but it fell by only a little more than half in the developing countries. On balance, however, there seems to have been convergence in the quality of life.

We should, of course, not forget that before 1800 most countries had roughly the same life expectancies, infant mortality rates, caloric intakes, access to safe water, and adult literacy rates. Therefore, if these quality-of-life measures have recently converged, they must first have diverged quite a bit during the 1800s and early 1900s. In summary, the evidence suggests that while both per capita real GDP and the quality-of-life indicators diverged during the nineteenth century and early twentieth century, during the latter part of the twentieth century the quality-of-life indicators mostly converged across countries.

2.3.7 What Can We Conclude about Human Welfare?

All the evidence on economic growth presented here paints a vivid picture. Per capita output grew at a very slow rate throughout most of human history, and that slow growth appears in the form of both low per capita output and poor quality-of-life indicators. As recently as 200 years ago, nearly all people of the world lived near subsistence levels, in continual fear of famine, disease, and death. Life expectancy was close to the minimum required for populations to replace themselves. Caloric intake was barely enough to stay alive. And there was little that even the wealthiest people could do about infection and disease.

Around the year 1800, something changed to cause sustained economic growth in many countries. In fact, growth rates have accelerated over the two centuries since then. Per capita real output in the world increased more than *eightfold* between 1820 and 2000, and no matter how you measure it, the quality of human life improved immensely. Life expectancy tripled in the highest-output countries and more than doubled in virtually all other countries. Major diseases were wiped out, death before old age became a rare occurrence, and in many countries people gained a large degree of economic freedom through education, the rule of law, and institutions that encouraged market outcomes based on personal choice free from coercion or reprisals.

TABLE 2-11 Quality-of-Life Gap between Developed and Less Developed Economies
(Index: Developed Economies = 100)

	Life Expectancy at Birth		Adult Literacy		Daily Calories per Capita		Access to Safe Water		Infant Mortality (under Age Five)	
	1960	*1995*	*1970*	*1996*	*1970*	*1995*	*1975–1980*	*1990–1996*	*1960*	*1996*
Latin American Countries										
Argentina	95	98	94	98	100	98	—	—	68	63
Brazil	80	90	69	84	79	89	63	74	28	30
Chile	83	100	89	97	87	86	—	—	36	100
Colombia	82	95	82	93	68	87	65	86	38	51
Mexico	83	97	76	91	89	99	63	84	33	49
Peru	70	91	72	90	73	68	—	—	21	27
Venezuela	87	98	77	92	—	—	80	80	70	56
Asian Countries										
Bangladesh	58	77	25	39	72	63	—	—	20	14
Burma	64	79	72	84	66	86	17	61	21	11
China	69	93	64	84	76	60	—	—	27	22
India	64	83	34	53	69	75	—	—	21	14
Indonesia	60	86	57	85	62	85	11	63	23	22
Pakistan	64	85	21	38	73	78	25	75	22	12
Philippines	77	91	85	96	55	73	—	—	46	42
Singapore	94	100	75	92	—	—	—	—	100	100
South Korea	79	97	88	99	93	100	67	94	39	100
Thailand	76	94	79	95	71	71	25	90	33	42
African Countries										
Cote d'Ivoire	57	70	16	41	80	79	—	—	16	11
Egypt	67	87	33	52	78	100	76	80	17	20
Ethiopia	52	66	17	36	—	—	8	25	18	9
Ghana	66	77	31	65	70	82	35	68	23	14
Kenya	65	73	44	79	72	63	17	54	24	18
Morocco	68	89	21	44	80	99	—	—	22	21
Nigeria	58	69	21	58	75	79	—	—	24	8
South Africa	71	86	71	83	93	91	—	—	39	24
Tanzania	59	68	38	69	58	63	39	38	20	11
Zaire	60	71	44	78	72	59	19	42	16	8
Developing Countries	67	84	48	71	71	82	—	—	23	17
Least Developed Countries	57	69	30	50	69	67	—	—	18	10

Source: United Nations (1998), *Human Development Report 1998,* New York: United Nations, Table 9, pp. 150–151.

Not all people of the world experienced the same large increases in their welfare as the citizens of today's developed economies, but virtually all countries saw the welfare of their citizens improve. The rapid improvement in life expectancy, the large reductions in infant mortality, the steady expansion of education, and other enhancements in the quality of people's lives in nearly all countries suggest that standards of living are converging, not diverging as the earlier per capita real GDP figures seemed to indicate.

2.4 REFLECTIONS ON THE MEASUREMENT OF ECONOMIC GROWTH

Our discussion of the various measures of human welfare should make it clear that measuring economic growth is far from a precise science. Nevertheless, we seem to have been able to uncover the main trends in the improvement of human welfare. Per capita real GDP or GNP appears to give us a fairly accurate picture of the general trends in human welfare, as many of the alternative measures are closely correlated with national output. Yet there continues to be a general lack of respect for per capita GDP or GNP within the field of development economics.

2.4.1 *Informal Activity and the Measurement of GDP*

Standard GDP data are, in fact, inaccurate because they fail to account for household and "informal" economic activities. This shortcoming of standard national accounting methods is particularly important for developing economies, where much economic activity goes unrecorded. Without accurate year-to-year data it is of course impossible to accurately determine the economy's rate of economic growth.

Several studies have attempted to adjust for these shortcomings in GDP data. While there have, in fact, been many attempts to estimate household and informal activity, seldom has anyone attempted to calculate year-to-year estimates of total output, including market activity, household activity, and informal activity. In one set of studies, Scott Fuess and Hendrik Van den Berg calculated time series of adjusted GDP to account for household and informal activity in the United States and Mexico, and the adjusted data strongly suggest that actual economic growth from the 1950s through the 1990s tends to be somewhat slower than the growth rates based on reported GDP data alone.[20] This overestimate of economic growth using traditional GDP figures is due to the general trend in growing economies for an increasing proportion of economic activity to be carried out in the market economy and less in the household and informal sectors of the economy. GDP figures erroneously count productive activity that is transferred from households and the informal sector to the formal or market sector of the economy as an increase in overall economic activity when in fact it is nothing more than a shift of production from the household or the informal sector, where it was not counted, to the market economy, where it *is* counted as part of GDP.

On the other hand, Fuess and Van den Berg's adjusted GDP data also make it clear that when countries experience sharp recessions or serious economic crises, household and informal activity tends to grow relative to the formal sector of the economy. Therefore, in times of recession, true growth rates may not be as low as the official data suggest. In fact, their study of Mexico finds that the severe recession following the 1982 debt crisis was not nearly as devastating as the official GDP figures for Mexico suggested. Per capita output in Mexico indeed fell during most of the 1980s, but the decline was on the order of 1 percent per year, not the 2.5 percent shown by the official GDP figures. The alternative measures of quality of life, which suggest that human

[20]Scott M. Fuess, Jr., and Hendrik Van den Berg (1996), "Does GNP Exaggerate Growth in 'Actual' Output? The Case of the United States," *Review of Income and Wealth*, Vol. 42(1), pp. 35–48; Scott M. Fuess, Jr., and Hendrik Van den Berg (1998), "Does GDP Distort Mexico's Economic Performance?" *Southern Economic Journal*, Vol. 64(4), pp. 973–986.

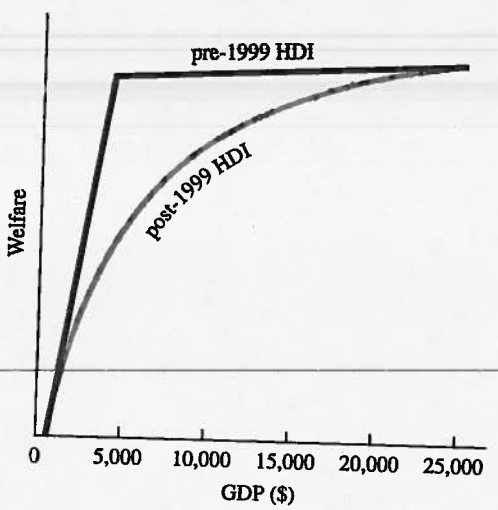
welfare improved during the 1970s and 1980s even though many developing economies in Latin America, Asia, and Africa showed little or no per capita GDP growth, may reflect the GDP's failure to capture all productive activity in an economy.

2.4.2 Welfare and GDP

The mismeasurement of true welfare-enhancing output is not the only reason for disenchantment with GDP data as a measure of economic well-being. Many writers on economic development object to equating material wealth with human welfare. Typical of many other studies' view of per capita real GDP was the approach taken, until recently, by the United Nations Development Programme (UNDP) in calculating its Human Development Index (HDI). Specifically, the UNDP gave increases in per capita real output a substantial weight in the overall HDI only for low levels of per capita output. After per capita real GDP reached the average world level, any further increases received virtually no weight in the HDI, which meant that the great differences in per capita real output between Japan and Brazil, for example, mattered almost nothing for the two countries' relative HDI indexes. Specifically, before 1999, the relationship between per capita real GDP and human welfare that the UNDP assumed was the one depicted by the solid "kinked" line in Figure 2-6. That is, increases in per capita GDP up to the world average of about $5,000 had a strong effect on the value of the overall HDI because, as the curve in Figure 2-6 shows, in that range small increases in per capita GDP were assumed to bring large increases in human welfare. But after a per capita GDP of $5,000 was reached, further increases in output were assumed to matter very little for human welfare. The idea was that once you have satisfied your "basic needs," further increases in consumption are largely superfluous.

Beginning with the 1999 HDI, however, a more "curved" relationship between income and welfare was assumed. Based on Amartya Sen's theory that a rising per capita GDP not merely provides more material things but also "enables" people to gain access to better choices, health, economic freedom, independence, and education, the 1999 HDI was modified so that the relationship between per capita real GDP and welfare was assumed to be like the lightly-shaded curve in Figure 2-6. In the 1999 HDI, increases in real GDP had an effect on the index even if they occurred in economies where people already enjoyed high levels of income.

Figure 2-6
Welfare and GDP: UNDP



While Sen's suggested revision of the HDI reflects the belief that welfare is positively related to per capita real GDP, the HDI is still not based on a one-to-one relationship. The lightly-shaded line in Figure 2-6 is not linear: Increases in per capita real GDP have a greater impact on welfare when per capita real output is low than when it is high. Thus, as per capita real GDP increases, the effect of each additional increment on human welfare diminishes. This may make some sense when comparing personal incomes at one moment in time in a given location: An additional dollar probably does not add as much to the welfare of a wealthy person as it does to that of a hungry, destitute person.

The marginal benefits from increased income may diminish even less than Sen's new curve suggests, however. In fact, the growth of per capita real GDP may actually *understate* the gains in human welfare in the long run. The next three subsections discuss several reasons why the growth of per capita real GDP, as it is commonly measured, could understate economic growth's effect on human welfare.

2.4.3 *Adjustments for Product Quality and Changing Consumption Patterns*

A group of economists in the United States recently analyzed the accuracy of one of the price indexes that is often used to adjust *nominal* figures and obtain *real* measures of key economic variables. Michael Boskin, Ellen Dulberger, Robert Gordon, Zvi Griliches, and Dale Jorgenson found that the U.S. government's consumer price index has consistently *overstated* annual inflation by slightly more than 1 percentage point.[21] The reasons for the mismeasurement of the price changes are several. First of all, the consumer price index often neglected improvements in the quality of goods and services. For example, suppose that the price of an automobile this year is higher than the price of a similar model last year and that this model of car is included in the sample of goods and services that make up the price index used to "deflate" actual money values of national output in order to arrive at real GDP. But suppose that this year's automobile is not exactly the same as last year's model. It is likely to be better than last year's in terms of quality, extra features, or the way it drives. Thus, if we properly measure the *value* of the transportation and the driving enjoyment provided by this year's automobile as compared to last year's, the price of automobile transportation may not have risen at all. According to Boskin et al., the understatement of quality changes leads to a very serious overstatement of inflation and, thus, understatement of real-output growth.

Another reason why traditional inflation adjustments lead to an understatement of the growth in the real value of output is that price indexes are usually based on fixed samples of goods and services. Such a convenient procedure ignores the fact that people alter their consumption decisions when the relative prices of goods and services change. If the price of one good rises relative to another, consumers tend to substitute the good with the relatively lower price for the good with the now relatively higher price, and the average price of the entire bundle of goods actually consumed does not rise as fast as the average price of the bundle of goods consumed before the changes in relative prices. Consumers will also substitute lower-priced vendors for higher-price

[21]Michael J. Boskin, Ellen R. Dulberger, Robert J. Gordon, Zvi Griliches, and Dale W. Jorgenson (1996), "Toward a More Accurate Measure of the Cost of Living," final report to the Senate Finance Committee, December. This report is summarized in Boskin et al. (1998), "Consumer Prices, the Consumer Price Index, and the Cost of Living," *Journal of Economic Perspectives*, Vol. 12(1), pp. 3–26.

vendors, even though price statistics are normally compiled by comparing prices at different points in time at the same retail locations. Hence, consumer price indexes tend to overstate the increases in prices that consumers actually pay. Certainly, not only in the United States do consumers "shop around" for better prices and substitute cheaper goods for more expensive goods. Hence, price indexes are likely to overestimate inflation in many countries.

According to Boskin et al., the failure to properly capture quality changes and adjustments in price-responsive consumption patterns may have caused estimates of U.S. economic growth to be understated by as much as 1 percent per year. And a 1 percent increase in annual growth will more than double real output in a century. Thus if Boskin et al. are correct for the United States, and similar miscalculations occurred elsewhere, present per capita income could be as much as twice as high, compared to that at the beginning of the twentieth century, as published GDP data suggest.

2.4.4 Variety and the New Age of Mass Customization

Because GDP is a measure of aggregate output, it makes no difference for GDP whether you eat the same $5.75 lunch consisting of a hamburger, French fries, and a Coca-Cola every day of the week or whether you eat the $5.75 hamburger dish only on Monday and then eat a $4.50 Mexican taco platter on Tuesday, a $4.00 spaghetti dish on Wednesday, a $5.00 Chinese meal on Thursday, and a $9.50 Japanese sushi lunch on Friday. The value of the five lunches is $28.75 in either case, and GDP will be the same in either case. But, for most people, the variety of five different meals provides a greater amount of welfare than the identical hamburger platter every day of the week. You do not often hear someone say that "*quantity* is the spice of life."

A recent report by the Federal Reserve Bank of Dallas points out that GDP may misstate the actual growth in human welfare because it fails to measure changes in variety.[22] When economies entered the industrial age, production became more standardized. Clothes were made on assembly lines in factories according to a limited number of patterns; no longer were clothes custom-tailored to each consumer's precise measurements and choices of cloth, design, quality, and the like. Of course, the industrialization of much production greatly decreased the costs of production, and good clothing could be purchased by people who had never been able to afford consumer products before. But the lower prices of goods came at the *unrecognized* cost of less variety. The nostalgia that people often exhibit for the "good old days" no doubt reflects the perception that industrial societies have lost some of the individuality and uniqueness of products and lifestyles that characterized preindustrial societies. Henry Ford has been rightfully praised for drastically reducing the cost of mass-producing automobiles, making them affordable to the average U.S. consumer, but he is also known for unashamedly telling those same consumers that they could have "any color they want as long as it is black." It is possible, therefore, that the increases in per capita output, as measured in terms of the real goods and services consumed, may have *overstated* the actual gains in per capita welfare if variety matters.

The same report by the Dallas Federal Reserve Bank suggests that in the most recent decade GDP may have *understated* the true gains in human welfare for the same reason. Modern economies are now moving out of the age of mass production of simi-

[22]Federal Reserve Bank of Dallas (1999), "The Right Stuff, America's Move to Mass Customization," *1998 Annual Report,* Dallas: Federal Reserve Bank.

lar goods and services to a new age in which computer power permits increased customization of production. The report calls this the "Age of Mass Customization," and this may be the true legacy of the computer revolution. Essentially, where the industrial age raised the fixed costs of production in order to dramatically reduce the variable costs of production, the computer age has permitted producers to greatly reduce the fixed costs of production as well. Bill Gates, the founder of Microsoft, predicted a few years ago that "computers will enable goods that today are mass produced to be both mass produced and custom-made for particular customers."[23]

The reduction in the cost of starting up production can best be seen by the much greater variety of goods and services available in many of the more developed economies of the world. In the United States, for example, there were 140 models of motor vehicles on the market in 1970, but now, 30 years later, there are 260 different models. In 1970, 267 new movies were released; in 1998, there were 458 new movies. There were 339 magazine titles available in the local news store in 1970; by 1999, 790 titles could be found at a good bookstore. For athletes, there were 5 styles of running shoes on the market in 1970; in 1998, there were 285 different brands and styles! And if the greater variety causes anybody too much anxiety, there are now 141 different pain relievers on the market, compared to just 17 in 1970. What the exact welfare gains from variety are not clear, but the fact that profit-maximizing firms are eager to provide consumers with increased variety proves that people clearly prefer variety to driving only black automobiles. The current age of mass customization may thus be increasing human welfare more rapidly than the GDP numbers suggest because consumers have more choices and can thus achieve a greater level of welfare for the same level of expenditure.

2.4.5 Combining GDP and Life Expectancy to Measure Human Welfare

The various measures of human welfare, such as life expectancy, infant mortality, average years of schooling, hours of leisure per day, and so on, were presented above as if they are all substitute measures of the same phenomenon, human welfare. Indeed, it is reassuring that each of the measures seems to reflect similar trends over time and across countries, and we can have a great deal of confidence in our conclusion that human welfare has improved immensely over the past 200 years. But are the measures necessarily all substitutes in that they all reflect the same thing?

Per capita real output and life expectancy, for example, are not really substitute measures. It might be more accurate to treat them as complements that, together, determine a single measure of human welfare. Specifically, a good case can be made that human welfare is the *product* of life expectancy and per capita real output. The reasoning is straightforward: Given that we are interested in the welfare of individuals, we should take into consideration not just the annual level of goods and services that the economy provides but also how long people live to enjoy such annual amounts of welfare. If an economy provides the conditions under which individuals expect to live longer, that in itself is an increase in individual welfare. Clearly, it would be preferable from the individual's point of view to enjoy a certain standard of living for 80 years, the current life expectancy in the most developed countries, than for the 25 years that the average individual lived 200 years ago. Simply put, not only is the quality of our lives much greater today than it was 200 years ago, but we get to enjoy that quality for many more years.

[23]As quoted in Federal Reserve Bank of Dallas (1999), op. cit., p. 7.

Thus, the proper measure of individual welfare is the standard of living, most easily represented by average per capita real GDP, multiplied by the average number of years the economy can sustain a human life. For example, using the data on per capita real GDP from Table 2-1 and life expectancy from Table 2-7, it is possible to calculate a measure called **expected individual welfare,** which is the product of per capita real GDP and average life expectancy. Thus, the Indian economy in 1992 had the capacity to provide people with 56 years of life consuming $1,348 worth of goods and services, or a total expected individual welfare of $75,488. In the United States in 1992, the economy provided, on average, $21,558 worth of goods and services under conditions that let people live, on average, for 75 years; hence, U.S. expected welfare in 1992 was $1,616,850. While the U.S. per capita real GDP is 16 times as great as that of India, its individual expected individual welfare is nearly 22 times as great because people living in the United States live longer than the residents of India do.

Table 2-12 presents several interesting examples of how expected individual welfare compares to the traditional per capita real GDP and life expectancy measures. The five countries were selected in part because they have estimates of life expectancy available back to the year 1900 and also because they are large economies whose performance affects the lives of many individuals. Table 2-12 makes it clear that the picture of economic growth changes when we look at a more complex measure such as expected individual welfare. The expected individual welfare index suggests that the growth of human welfare has been considerably greater than the rate of growth calculated using just per capita real GDP suggests.

Other combinations of growth indicators may be called for as well. You might consider the combination of education and per capita real GDP: Because educated people make better choices, they will enjoy greater welfare than less educated people in an economy with the same total productive capacity. Hence, you might devise some indicator that consists of per capita real GDP multiplied in some way by an index of education. Similarly, economic freedom and per capita real GDP may jointly have an expanded effect on human welfare for the same reason: Greater economic freedom permits consumers, workers, and producers to make better choices, so a given amount of output actually creates a greater sum of individual welfare.

2.4.6 Conclusion: Use GDP Data with Care

It is, therefore, quite possible that the shortcomings of the data that we have to work with cause economic growth to be consistently underestimated. The overestimation of inflation will cause growth to be underestimated, as will the underestimation of improvements in quality and variety. Individual lifetime welfare is also underestimated by annual real per capita GDP figures because increasing life spans imply that higher per capita output level can be enjoyed for more years. On the other hand, the omission of household and informal activity tends to cause GDP data to understate economic growth if, as seems to often be the case, household activity declines while market activity grows over time. Having said this, we should avoid being overly critical of the data available to us. The differences in per capita real output and the various measures of quality of life across countries and over time are so large that the many potential inaccuracies are unlikely to seriously change our general conclusions about economic growth. No matter how we measure it, human welfare has greatly increased over the last two centuries, but it remains very unequally distributed throughout the world today.

TABLE 2-12 Expected Individual Welfare

	Levels (US$)				Growth Rates (%)			
	1900	*1950*	*1973*	*1992*	*1900–1950*	*1950–1973*	*1973–1992*	*1900–1992*
India:								
Per capita GDP	625	597	853	1,348	−0.09	1.56	2.44	0.84
Life expectancy	23	32	50	56	0.66	1.96	0.60	0.97
Expected welfare	*14,375*	*19,104*	*42,650*	*75,488*	0.57	3.55	3.05	1.82
Mexico:								
Per capita GDP	1,157	2,085	4,189	5,112	1.18	3.08	1.05	1.63
Life expectancy	30	50	63	67	1.03	1.01	0.32	0.88
Expected welfare	*34,710*	*104,250*	*263,907*	*342,504*	2.22	4.12	1.38	2.52
Spain:								
Per capita GDP	2,040	2,397	8,739	12,498	0.32	5.79	1.90	1.99
Life expectancy	35	62	72	76	1.15	0.65	0.28	0.85
Expected welfare	*71,400*	*148,614*	*629,208*	*949,848*	1.48	6.48	2.19	2.85
Russia (USSR, Russian Fed.):								
Per capita GDP	1,218	3,935*	6,058	4,671	1.97	3.37	−1.36	1.47
Life expectancy	32	68*	69	67	1.26	0.11	−0.15	0.81
Expected welfare	*38,976*	*267,580*	*418,002*	*312,957*	3.26	3.49	−1.51	2.29
United States:								
Per capita GDP	4,096	9,573	16,607	21,558	1.71	2.42	1.38	1.82
Life expectancy	49	67	71	75	0.63	0.25	0.29	0.46
Expected welfare	*200,704*	*641,391*	*1,179,097*	*1,616,850*	2.35	2.68	1.68	2.29

*1960.

2.5 THE MECHANICS OF ECONOMIC GROWTH

Now that you have been acquainted with some of the available data on real GDP and the rates of growth of GDP and population, you can perform some simple exercises that will greatly enhance your understanding of the growth process. Specifically, the exercises will help you answer questions such as: How fast must developing economies grow if they are to "catch up" to the developed economies in the next century? If China continues to grow at 10 percent per year, how long before its per capita income is equal to that of the United States? How long before the United States is overtaken in terms of per capita income if it and other countries continue to grow at their present rates of growth? The answers may surprise you.

2.5.1 *The Power of Compounding*

As pointed out in Chapter 1, it is impossible to fully appreciate the implications of economic growth without a complete understanding of the concept of compounding. Recall also, from subsection 1.5.4 in the first chapter, the simple example of an economy that grew at the rate of 10 percent per year. Using the general relationship that, after T years of R percent growth,

$$\text{PCGDP}_T = \text{PCGDP}_{t=0}(1 + R)^T \tag{2-4}$$

we derived the result that 10 years of 10 percent growth caused per capita income to rise from $1,000 to

$$\text{PCGDP}_{t=10} = \$1{,}000(1 + .10)^{10} = \$2{,}594 \tag{2-5}$$

Thus, we gained some respect for the power of compounding. Ten years of 10 percent growth cause per capita GDP to grow by nearly 160 percent. In order to gain some further insights into the power of compounding, we can use some variations on equation 2-4.

2.5.2 *Calculating Doubling Time*

An especially interesting way to grasp the effects of different growth rates is to calculate the **doubling time,** which is the time it will take for a variable to double in value if it grows continuously at the rate of R percent per year. The answer is easily found using equation (2-4). Specifically, suppose we want to find out how long it will take for a country to double its GDP if it continues to grow at a rate of 10 percent. First divide each side of equation (2-4) by $\text{PCGDP}_{t=0}$, which gives us

$$\text{PCGDP}_T/\text{PCGDP}_{t=0} = (1 + R)^T \tag{2-6}$$

A doubling of per capita GDP implies that the left-hand side of (2-6) equals 2. Since we assume $R = 10$ percent, we thus want to find the value of T that makes

$$(1.1)^T = \text{PCGDP}_T/\text{PCGDP}_{t=0} = 2 \tag{2-7}$$

The variable we seek is an exponent, which seems to make the task of solving equation (2-7) somewhat difficult. Logarithms make the task quite easy, however. Taking the natural logarithms of both sides of the equation gives us

$$T \ln(1.1) = \ln(\text{PCGDP}_T/\text{PCGDP}_0) = \ln 2 \tag{2-8}$$

The natural logarithm of 2 is .69314, and ln 1.1 = .09531. Therefore,

$$\ln(PCGDP_T/PCGDP_0) = .69314 = T(.09531) \quad (2\text{-}9)$$

and, dividing both sides by .09531,

$$T = .69314/.09531 = 7.2725 \quad (2\text{-}10)$$

Thus, if an economy grows at a steady rate of 10 percent per year, it takes about 7.27 years to double per capita output. This result can be approximated using the **rule of 72.** This simple rule states that the time for a variable growing at a constant rate to double in value is equal to $72/x$, where x is the growth rate in terms of percentage points. Applying this rule to the above example, 72/10 = 7.2, which tells us that with a constant growth rate of 10 percent per year it takes about 7.2 years to double the value of a variable.

Likewise, a growth rate of 5 percent per year means that

$$\ln(1 + R) = \ln(1.05) = .04879 \quad (2\text{-}11)$$

and thus the time it takes to double per capita GDP is equal to

$$T = .69314/.04879 = 14.2067 \quad (2\text{-}12)$$

Similarly, you should be able to confirm that if the growth rate is just 2 percent, it will take about 35 years to double PCGDP.

We can of course also find how long it takes to triple, quadruple, or cut in half PCGDP by taking the natural log of 3, 4, or .5. For example, at a 10 percent growth rate, per capita income will quadruple, that is, increase by a factor of four or "fourfold," in little more than 14 years:

$$T = \ln 4/\ln(1.1) = 14.5451 \quad (2\text{-}13)$$

Thus, for two countries that start off at the same level of per capita GDP, if one grows at 10 percent while the other grows at 5 percent, after just 14 years the first will have four times its initial per capita GDP while the second will have only double its initial per capita GDP. Thus, after just 14 years, the faster-growing economy will have twice as high a per capita output as the slower-growing economy.

2.5.3 *Finding a Target Growth Rate*

We can answer other hypothetical growth questions using the logic developed above. For example, we can alter the above formulas to find what rate of annual growth is necessary to achieve a certain level of PCGDP at a certain time in the future. Suppose we want to know how fast PCGDP must grow in order to double in 10 years. In this case we use equation (2-4) and set $T = 10$ and the ratio $PCGDP_T/PCGDP_0 = 2$. Thus, we get

$$2 = (1 + R)^{10} \quad (2\text{-}14)$$

We now need to solve for R. Raising both sides of (2-14) to the power $1/T = 1/10$, or

$$2^{1/T} = 2^{1/10} = (1 + R)^{T/T} = 1 + R = 1.0717 \quad (2\text{-}15)$$

Hence, $R = (1 + R) - 1 = 1.0717 - 1 = .0717$, or $R = 7.17$ percent. That is, it takes an annual growth rate of 7.17 percent for PCGDP to double in 10 years. We conclude, therefore, that the R required to double per capita income in 10 years is approximately 7.2 percent (this is another version of the rule of 72).

2.5.4 Some Interesting Insights

Using the methods explained above, we can put the world's recent economic growth experiences into perspective. The power of compounding means that small differences in growth rates can cause, over not very much time, very large differences in per capita levels of output. Using the rule of 72, a mere 1-percentage-point difference in growth rates will lead one economy to have double the per capita output of another after just 72 years! A 1-percentage-point difference seems minor, but a 100 percent difference in per capita income is enormous. If nothing else, the importance of economic growth should once again be clear. Even small improvements in the rate of growth eventually have major effects on human welfare.

The power of compounding also means that small differences in per capita output are quickly magnified. Or, looked at from the opposite side, large differences in per capita output can be eliminated much more quickly than is often imagined. For example, according to Table 2-1, in 1992 the United States had a per capita real GDP of about $21,000. China, on the other hand, had an adjusted per capita real GDP of $3,000, one-seventh that of the United States. Suppose that for the next 100 years the United States economy grows at a modest 2 percent per year while China grows at 4 percent per year, a rate of growth that is not at all exceptional by China's own recent standards. What would the per capita real GDPs be in each country by the end of the next century?

In the case of the United States,

$$PCGDP_{2092} = \$21{,}000(1.02)^{100} = \$152{,}138 \tag{2-16}$$

In the case of China,

$$PCGDP_{2092} = \$3{,}000(1.04)^{100} = \$151{,}515 \tag{2-17}$$

Thus, if China grows just 2 percentage points faster than the United States, the citizens of the two countries will enjoy virtually the same per capita incomes in the year 2100. One century is not very much time in the course of human history.

If you think that it is unrealistic for China to maintain a 4 percent rate of per capita output growth for a whole century, you might ask what a mere 2 percent annual rate of growth would do for Chinese per capita output. Using the above equations, it is easy to show that China, with a current average per capita income of about $3,000, could raise the welfare of its 1.2 billion citizens to the very high level that we currently enjoy in the United States in 100 years with a rate of growth of per capita output of just 2 percent per year:

$$\$3{,}000(1.02)^{100} = \$21{,}734 \tag{2-18}$$

Certainly, given the experience of so many countries in the twentieth century, a growth rate of 2 percent does not seem difficult to achieve. The possibility of substantial gains in human welfare over the next century is therefore quite good. Put another way, the chances that 100 years from now people will still be suffering from levels of income below $1,000 per year, as is the case for so many people throughout the developing world today, are not high. It would take growth rates of 0 percent for this to happen. Would the people of the lowest-income economies let their economies languish at zero growth for the next 100 years while they continually see television images of life in countries that enjoy ever-higher standards of living?

There are many other questions about economic growth that you can answer using the formulas presented above. For example: How much difference does another percentage point in growth matter in terms of real income after 10 years? After 25 years?