## After studying this chapter, you will be able to:

- Define and calculate the economic growth rate and explain the implications of sustained growth
- Describe the economic growth trends in the United States and other countries and regions
- Explain how population growth and labor productivity growth make potential GDP grow
- Explain the sources of labor productivity growth
- Explain the theories of economic growth, the empirical evidence on its causes, and policies to increase its rate

# 6 ECONOMIC GROWTH

**Real GDP *per person* in the United States tripled between 1960 and 2010. If** you live in a dorm that was built during the 1960s, it is likely to have just two power outlets: one for a desk lamp and one for a bedside lamp. Today, with the help of a power bar (or two), your room bulges with a personal computer, television and DVD player, microwave, refrigerator, coffeemaker, and toaster—and the list goes on. Economic growth has brought about this improvement in living standards.

We see even greater economic growth in modern Asia. At the mouth of the Yangtze River in one of the world's great cities, Shanghai, people are creating businesses, investing in new technologies, developing local and global markets, and transforming their lives. Incomes have tripled not in 50 years but in the 13 years since 1997. In the summer of 2010, China overtook Japan as the world's second largest economy. Why are incomes in China growing so rapidly?

In this chapter, we study the forces that make real GDP grow. In *Reading Between the Lines* at the end of the chapter, we return to the economic growth of China and see how it compares with that of Japan and the United States.

## The Basics of Economic Growth

Economic growth is a sustained expansion of production possibilities measured as the increase in real GDP over a given period. Rapid economic growth maintained over a number of years can transform a poor nation into a rich one. Such have been the stories of Hong Kong, South Korea, and some other Asian economies. Slow economic growth or the absence of growth can condemn a nation to devastating poverty. Such has been the fate of Sierra Leone, Somalia, Zambia, and much of the rest of Africa.

The goal of this chapter is to help you to understand why some economies expand rapidly and others stagnate. We'll begin by learning how to calculate the economic growth rate and by discovering the magic of sustained growth.

### Calculating Growth Rates

We express the **economic growth rate** as the annual percentage change of real GDP. To calculate this growth rate, we use the formula:

$$\text{Real GDP growth rate} = \frac{\text{Real GDP in current year} - \text{Real GDP in previous year}}{\text{Real GDP in previous year}} \times 100.$$

For example, if real GDP in the current year is $11 trillion and if real GDP in the previous year was $10 trillion, then the economic growth rate is 10 percent.

The growth rate of real GDP tells us how rapidly the *total* economy is expanding. This measure is useful for telling us about potential changes in the balance of economic power among nations. But it does not tell us about changes in the standard of living.

The standard of living depends on **real GDP per person** (also called *per capita* real GDP), which is real GDP divided by the population. So the contribution of real GDP growth to the change in the standard of living depends on the growth rate of real GDP per person. We use the above formula to calculate this growth rate, replacing real GDP with real GDP per person.

Suppose, for example, that in the current year, when real GDP is $11 trillion, the population is 202 million. Then real GDP per person is $11 trillion divided by 202 million, which equals $54,455. And suppose that in the previous year, when real GDP was $10 trillion, the population was 200 million. Then real GDP per person in that year was $10 trillion divided by 200 million, which equals $50,000.

Use these two values of real GDP per person with the growth formula above to calculate the growth rate of real GDP per person. That is,

$$\text{Real GDP per person growth rate} = \frac{\$54{,}455 - \$50{,}000}{\$50{,}000} \times 100 = 8.9 \text{ percent.}$$

The growth rate of real GDP per person can also be calculated (approximately) by subtracting the population growth rate from the real GDP growth rate. In the example you've just worked through, the growth rate of real GDP is 10 percent. The population changes from 200 million to 202 million, so the population growth rate is 1 percent. The growth rate of real GDP per person is approximately equal to 10 percent minus 1 percent, which equals 9 percent.

Real GDP per person grows only if real GDP grows faster than the population grows. If the growth rate of the population exceeds the growth of real GDP, then real GDP per person falls.

### The Magic of Sustained Growth

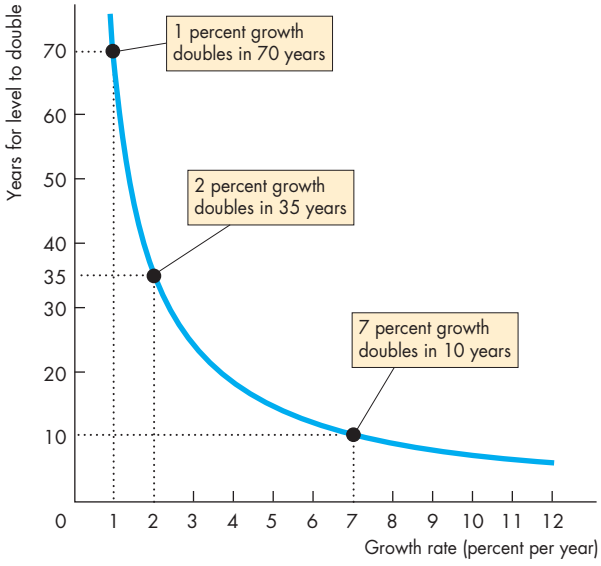
Sustained growth of real GDP per person can transform a poor society into a wealthy one. The reason is that economic growth is like compound interest.

**Compound Interest** Suppose that you put $100 in the bank and earn 5 percent a year interest on it. After one year, you have $105. If you leave that $105 in the bank for another year, you earn 5 percent interest on the original $100 *and on the $5 interest that you earned last year*. You are now earning interest on interest! The next year, things get even better. Then you earn 5 percent on the original $100 and on the interest earned in the first year and the second year. You are even earning interest on the interest that you earned on the interest of the first year.

Your money in the bank is growing at a rate of 5 percent a year. Before too many years have passed, your initial deposit of $100 will have grown to $200. But after how many years?

The answer is provided by a formula called the **Rule of 70**, which states that the number of years it takes for the level of any variable to double is approx-

**FIGURE 6.1** The Rule of 70




| Growth rate (percent per year) | Years for level to double |
|---|---|
| 1 | 70.0 |
| 2 | 35.0 |
| 3 | 23.3 |
| 4 | 17.5 |
| 5 | 14.0 |
| 6 | 11.7 |
| 7 | 10.0 |
| 8 | 8.8 |
| 9 | 7.8 |
| 10 | 7.0 |
| 11 | 6.4 |
| 12 | 5.8 |

The number of years it takes for the level of a variable to double is approximately 70 divided by the annual percentage growth rate of the variable.

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imately 70 divided by the annual percentage growth rate of the variable. Using the Rule of 70, you can now calculate how many years it takes your $100 to become $200. It is 70 divided by 5, which is 14 years.

## Applying the Rule of 70

The Rule of 70 applies to any variable, so it applies to real GDP per person. Figure 6.1 shows the doubling time for growth rates of 1 percent per year to 12 percent per year.

You can see that real GDP per person doubles in 70 years (70 divided by 1)—an average human life span—if the growth rate is 1 percent a year. It doubles in 35 years if the growth rate is 2 percent a year and in just 10 years if the growth rate is 7 percent a year.

We can use the Rule of 70 to answer other questions about economic growth. For example, in 2010, U.S. real GDP per person was approximately 4 times that of China. China's recent growth rate of real GDP per person was 10 percent a year. If this growth rate were maintained, how long would it take China's real GDP per person to reach that of the United States in 2010? The answer, provided by the Rule of 70, is 14 years. China's real GDP per person doubles in 7 years (70 divided by 10). It doubles again to 4 times its current level in another 7 years. So after 14 years of growth at 10 percent a year, China's real GDP per person is 4 times its current level and equals that of the United States in 2010. Of course, after 14 years, U.S. real GDP per person would have increased, so China would still not have caught up to the United States. But at the current growth rates, China's real GDP per person will equal that of the United States by 2026.

## REVIEW QUIZ

1. What is economic growth and how do we calculate its rate?
2. What is the relationship between the growth rate of real GDP and the growth rate of real GDP per person?
3. Use the Rule of 70 to calculate the growth rate that leads to a doubling of real GDP per person in 20 years.

You can work these questions in Study Plan 6.1 and get instant feedback. myeconlab

## Economic Growth Trends

You have just seen the power of economic growth to increase incomes. At a 1 percent growth rate, it takes a human life span to double the standard of living. But at a 7 percent growth rate, the standard of living doubles every decade. How fast is our economy growing? How fast are other economies growing? Are poor countries catching up to rich ones, or do the gaps between the rich and poor persist or even widen? Let's answer these questions.

### Growth in the U.S. Economy

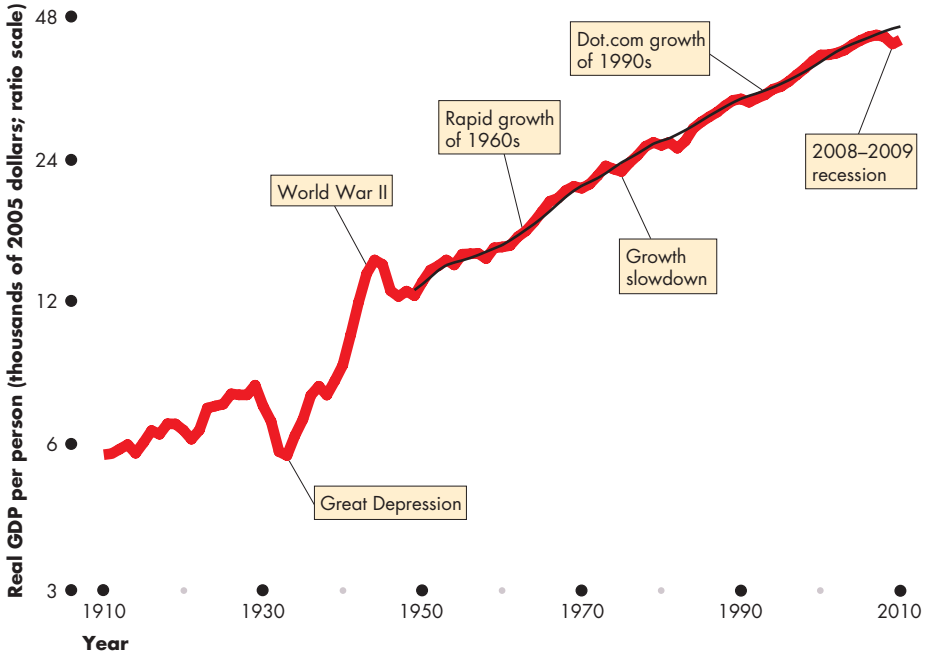
Figure 6.2 shows real GDP per person in the United States for the hundred years from 1910 to 2010. The red line is actual real GDP and the black line (that starts in 1949) is potential GDP. The trend in potential GDP tells us about economic growth. Fluctuations around potential GDP tell us about the business cycle.

Two extraordinary events dominate the graph: the Great Depression of the 1930s, when growth stopped for a decade, and World War II of the 1940s, when growth briefly exploded.

For the century as a whole, the average growth rate was 2 percent a year. But the growth rate has not remained constant. From 1910 to the onset of the Great Depression in 1929, the average growth rate was a bit lower than the century average at 1.8 percent a year. Between 1930 and 1950, averaging out the Great Depression and World War II, the growth rate was 2.4 percent a year. After World War II, the growth rate started out at 2 percent a year. It then increased and growth averaged 3 percent a year during the 1960s. In 1973, and lasting for a decade, the growth rate slowed. Growth picked up somewhat during the 1980s and even more during the 1990s dot.com expansion. But the growth rate never returned to the pace achieved during the fast-growing 1960s.

A major goal of this chapter is to explain why our economy grows and why the growth rate changes. Another goal is to explain variations in the economic growth rate across countries. Let's now look at some of these growth rates.

**FIGURE 6.2** A Hundred Years of Economic Growth in the United States




During the 100 years from 1910 to 2010, real GDP per person in the United States grew by 2 percent a year, on average. The growth rate was greater after World War II than it was before the Great Depression. Growth was most rapid during the 1960s. It slowed during the 1970s and speeded up again during the 1980s and 1990s, but it never returned to its 1960s' rate.

*Sources of data:* GDP (GNP)1908–1928, Christina D. Romer, "World War I and the Postwar Depression: A Reinterpretation Based on Alternative Estimates of GNP," *Journal of Monetary Economics*, 22, 1988; 1929–2008, Bureau of Economic Analysis. Population Census Bureau.

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## Real GDP Growth in the World Economy

Figure 6.3 shows real GDP per person in the United States and in other countries between 1960 and 2010. Part (a) looks at the seven richest countries—known as the G7 nations. Among these nations, the United States has the highest real GDP per person. In 2010, Canada had the second-highest real GDP per person, ahead of Japan and France, Germany, Italy, and the United Kingdom (collectively the Europe Big 4).

During the fifty years shown here, the gaps between the United States, Canada, and the Europe Big 4 have been almost constant. But starting from a long way below, Japan grew fastest. It caught up to Europe in 1970 and to Canada in 1990. But during the 1990s, Japan's economy stagnated.

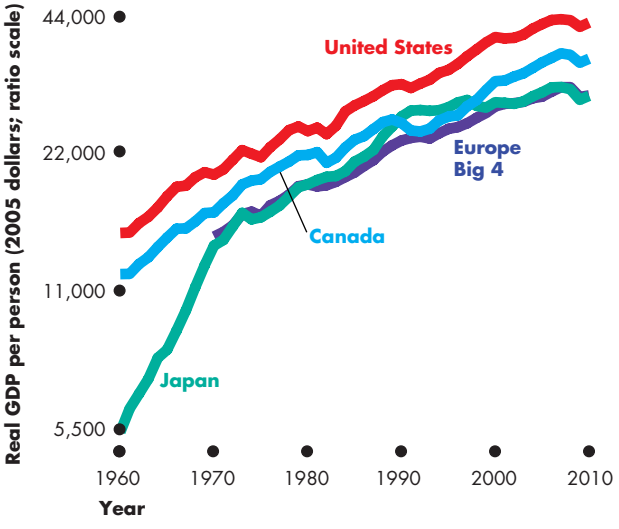
Many other countries are growing more slowly than, and falling farther behind, the United States. Figure 6.3(b) looks at some of these countries.

Real GDP per person in Central and South America was 28 percent of the U.S. level in 1960. It grew more quickly than the United States and reached 30 percent of the U.S. level by 1980, but then growth slowed and by 2010, real GDP per person in these countries was 23 percent of the U.S. level.

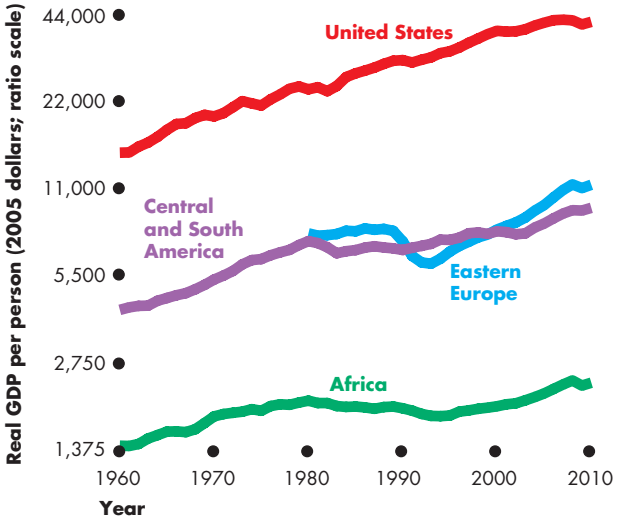
In Eastern Europe, real GDP per person has grown more slowly than anywhere except Africa, and fell from 32 percent of the U.S. level in 1980 to 19 percent in 2003 and then increased again to 22 percent in 2010.

Real GDP per person in Africa, the world's poorest continent, fell from 10 percent of the U.S. level in 1960 to 5 percent in 2007 and then increased slightly to 6 percent in 2010.

**FIGURE 6.3** Economic Growth Around the World: Catch-Up or Not?




**(a) Catch-up?**




**(b) No catch-up?**

Real GDP per person has grown throughout the world. Among the rich industrial countries in part (a), real GDP per person has grown slightly faster in the United States than in Canada and the four big countries of Europe (France, Germany, Italy, and the United Kingdom). Japan had the fastest growth rate before 1973 but then growth slowed and Japan's economy stagnated during the 1990s.

Among a wider range of countries shown in part (b), growth rates have been lower than that of the United States. The gaps between the real GDP per person in the United States and in these countries have widened. The gap between the real GDP per person in the United States and Africa has widened by a large amount.

*Sources of data*: (1960–2007) Alan Heston, Robert Summers, and Bettina Aten, Penn World Table Version 6.3, Center for International Comparisons of the University of Pennsylvania (CICUP), August 2009; and (2008–2010) International Monetary Fund, *World Economic Outlook*, April 2010.

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## Economics in Action

### Fast Trains on the Same Track

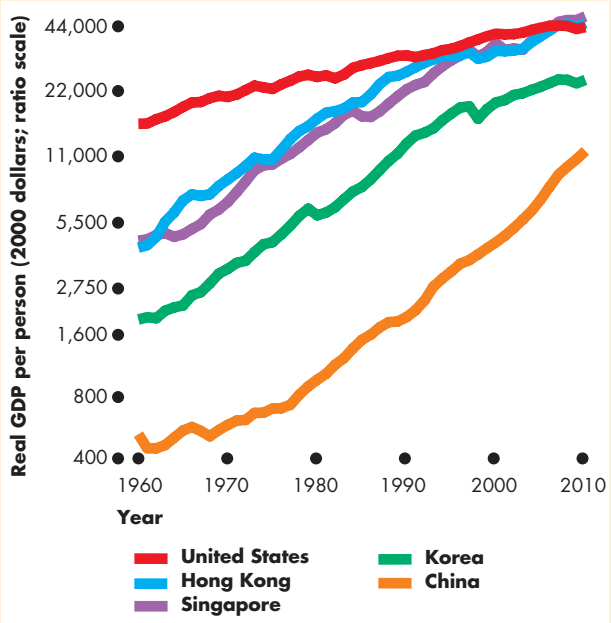
Four Asian economies, Hong Kong, Korea, Singapore, and China, have experienced spectacular growth, which you can see in the figure. During the 1960s, real GDP per person in these economies ranged from 3 to 28 percent of that in the United States. But by 2010, real GDP per person in Singapore and Hong Kong had surpassed that of the United States.

The figure also shows that China is catching up rapidly but from a long way behind. China's real GDP per person increased from 3 percent of the U.S. level in 1960 to 26 percent in 2010.

The Asian economies shown here are like fast trains running on the same track at similar speeds and with a roughly constant gap between them. Singapore and Hong Kong are hooked together as the lead train, which runs about 20 years in front of Korea and about 40 years in front of China.

Real GDP per person in Korea in 2010 was similar to that in Hong Kong in 1988, and real GDP in China in 2010 was similar to that of Hong Kong in 1976. Between 1976 and 2010, Hong Kong transformed itself from a poor developing economy into one of the richest economies in the world.

The rest of China is now doing what Hong Kong has done. China has a population 200 times that of Hong Kong and more than 4 times that of the United States. So if China continues its rapid growth, the world economy will change dramatically.




**Closing the Gap**

*Sources of data*: (1960–2007) Alan Heston, Robert Summers, and Bettina Aten, Penn World Table Version 6.3, Center for International Comparisons of the University of Pennsylvania (CICUP), August 2009; and (2008–2010) International Monetary Fund, *World Economic Outlook*, April 2010.

As these fast-growing Asian economies catch up with the United States, we can expect their growth rates to slow. But it will be surprising if China's growth rate slows much before it has closed the gap on the United States.

Even modest differences in economic growth rates sustained over a number of years bring enormous differences in the standard of living. And some of the differences that you've just seen are enormous. So the facts about economic growth in the United States and around the world raise some big questions.

What are the preconditions for economic growth? What sustains economic growth once it gets going? How can we identify the sources of economic growth and measure the contribution that each source makes? What can we do to increase the sustainable rate of economic growth?

We're now going to address these questions and discover the causes of economic growth. We start by seeing how potential GDP is determined and what makes it grow. You will see that labor productivity growth is the key to rising living standards and go on to explore the sources of this growth.

## REVIEW QUIZ

1. What has been the average growth rate of U.S. real GDP per person over the past 100 years? In which periods was growth most rapid and in which periods was it slowest?
2. Describe the gaps between real GDP per person in the United States and in other countries. For which countries is the gap narrowing? For which is it widening? For which is it the same?
3. Compare real GDP per person and its growth rate in Hong Kong, Korea, Singapore, China, and the United States. In terms of real GDP per person, how far is China behind these others?

You can work these questions in Study Plan 6.2 and get instant feedback.

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## How Potential GDP Grows

Economic growth occurs when real GDP increases. But a one-shot rise in real GDP or a recovery from recession isn't economic growth. Economic growth is a sustained, year-after-year increase in *potential GDP*.

So what determines potential GDP and what are the forces that make it grow?

### What Determines Potential GDP?

Labor, capital, land, and entrepreneurship produce real GDP, and the productivity of the factors of production determines the quantity of real GDP that can be produced.

The quantity of land is fixed and on any given day, the quantities of entrepreneurial ability and capital are also fixed and their productivities are given. The quantity of labor employed is the only *variable* factor of production. Potential GDP is the level of real GDP when the quantity of labor employed is the full-employment quantity.

To determine potential GDP, we use a model with two components:

- An aggregate production function
- An aggregate labor market

**Aggregate Production Function** When you studied the limits to production in Chapter 2 (see p. 30), you learned that the *production possibilities frontier* is the boundary between the combinations of goods and services that can be produced and those that cannot. We're now going to think about the production possibilities frontier for two special "goods": real GDP and the quantity of leisure time.

Think of real GDP as a number of big shopping carts. Each cart contains some of each kind of different goods and services produced, and one cartload of items costs $1 trillion. To say that real GDP is $13 trillion means that it is 13 very big shopping carts of goods and services.

The quantity of leisure time is the number of hours spent not working. Each leisure hour could be spent working. If we spent all our time taking leisure, we would do no work and produce nothing. Real GDP would be zero. The more leisure we forgo, the greater is the quantity of labor we supply and the greater is the quantity of real GDP produced.

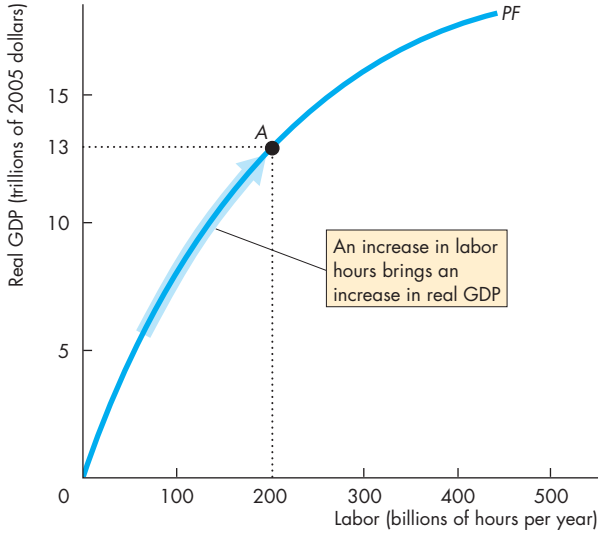
But labor hours are not all equally productive. We use our most productive hours first and as more hours are worked less and less productive hours are used. So for each additional hour of leisure forgone (each additional hour of labor), real GDP increases but by successively smaller amounts.

The **aggregate production function** is the relationship that tells us how real GDP changes as the quantity of labor changes when all other influences on production remain the same. Figure 6.4 shows this relationship—the curve labeled *PF*. An increase in the quantity of labor (and a corresponding decrease in leisure hours) brings a movement along the production function and an increase in real GDP.

**Aggregate Labor Market** In macroeconomics, we pretend that there is one large labor market that determines the quantity of labor employed and the quantity of real GDP produced. To see how this aggregate labor market works, we study the demand for labor, the supply of labor, and labor market equilibrium.

***The Demand for Labor*** The *demand for labor* is the relationship between the quantity of labor demanded and the real wage rate. The quantity of labor demanded is the number of labor hours hired by all the firms in the economy during a given period. This

**FIGURE 6.4** The Aggregate Production Function




At point *A* on the aggregate production function *PF*, 200 billion hours of labor produce $13 trillion of real GDP.

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quantity depends on the price of labor, which is the real wage rate.

The **real wage rate** is the money wage rate divided by the price level. The real wage rate is the quantity of goods and services that an hour of labor earns. It contrasts with the money wage rate, which is the number of dollars that an hour of labor earns.

The *real* wage rate influences the quantity of labor demanded because what matters to firms is not the number of dollars they pay (money wage rate) but how much output they must sell to earn those dollars.

The quantity of labor demanded *increases* as the real wage rate *decreases*—the demand for labor curve slopes downward. Why? The answer lies in the shape of the production function.

You've seen that along the production function, each additional hour of labor increases real GDP by successively smaller amounts. This tendency has a name: the *law of diminishing returns.* Because of diminishing returns, firms will hire more labor only if the real wage rate falls to match the fall in the extra output produced by that labor.

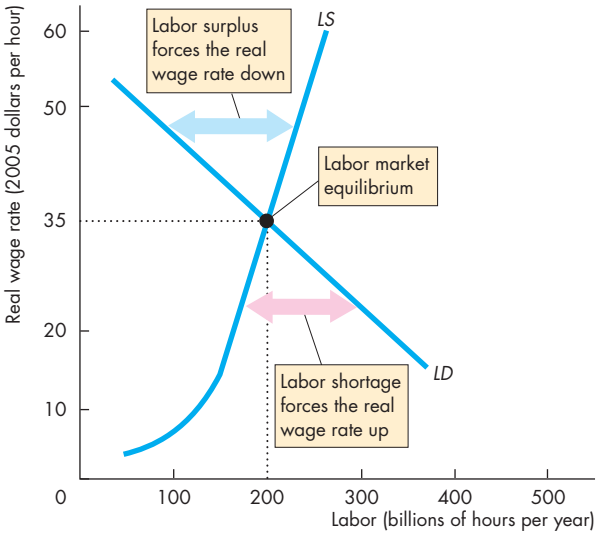
***The Supply of Labor*** The *supply of labor* is the relationship between the quantity of labor supplied and the real wage rate. The quantity of labor supplied is the number of labor hours that all the households in the economy plan to work during a given period. This quantity depends on the real wage rate.

The *real* wage rate influences the quantity of labor supplied because what matters to households is not the number of dollars they earn (money wage rate) but what they can buy with those dollars.

The quantity of labor supplied *increases* as the real wage rate *increases*—the supply of labor curve slopes upward. At a higher real wage rate, more people choose to work and more people choose to work longer hours if they can earn more per hour.

***Labor Market Equilibrium*** The price of labor is the real wage rate. The forces of supply and demand operate in labor markets just as they do in the markets for goods and services to eliminate a shortage or a surplus. But a shortage or a surplus of labor brings only a gradual change in the real wage rate. If there is a shortage of labor, the real wage rate rises to eliminate it; and if there is a surplus of labor, the real wage rate eventually falls to eliminate it. When there is neither a shortage nor a surplus, the labor market is in equilibrium—a full-employment equilibrium.

**FIGURE 6.5** Labor Market Equilibrium




Labor market equilibrium occurs when the quantity of labor demanded equals the quantity of labor supplied. The equilibrium real wage rate is $35 an hour, and equilibrium employment is 200 billion hours per year.

At a wage rate above $35 an hour, there is a surplus of labor and the real wage rate falls to eliminate the surplus. At a wage rate below $35 an hour, there is a shortage of labor and the real wage rate rises to eliminate the shortage.

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Figure 6.5 illustrates labor market equilibrium. The demand for labor curve is *LD* and the supply of labor curve is *LS*. This labor market is in equilibrium at a real wage rate of $35 an hour and 200 billion hours a year are employed.

If the real wage rate exceeds $35 an hour, the quantity of labor supplied exceeds the quantity demanded and there is a surplus of labor. When there is a surplus of labor, the real wage rate falls toward the equilibrium real wage rate where the surplus is eliminated.

If the real wage rate is less than $35 an hour, the quantity of labor demanded exceeds the quantity supplied and there is a shortage of labor. When there is a shortage of labor, the real wage rate rises toward the equilibrium real wage rate where the shortage is eliminated.

If the real wage rate is $35 an hour, the quantity of labor demanded equals the quantity supplied and

there is neither a shortage nor a surplus of labor. In this situation, there is no pressure in either direction on the real wage rate. So the real wage rate remains constant and the market is in equilibrium. At this equilibrium real wage rate and level of employment, the economy is at *full employment*.

**Potential GDP** You've seen that the production function tells us the quantity of real GDP that a given amount of labor can produce—see Fig. 6.4. The quantity of real GDP produced increases as the quantity of labor increases. At the equilibrium quantity of labor, the economy is at full employment, and the quantity of real GDP at full employment is potential GDP. So the full-employment quantity of labor produces potential GDP.

Figure 6.6 illustrates the determination of potential GDP. Part (a) shows labor market equilibrium. At the equilibrium real wage rate, equilibrium employment is 200 billion hours. Part (b) shows the production function. With 200 billion hours of labor, the economy can produce a real GDP of $13 trillion. This amount is potential GDP.

## What Makes Potential GDP Grow?

We can divide all the forces that make potential GDP grow into two categories:

- Growth of the supply of labor
- Growth of labor productivity

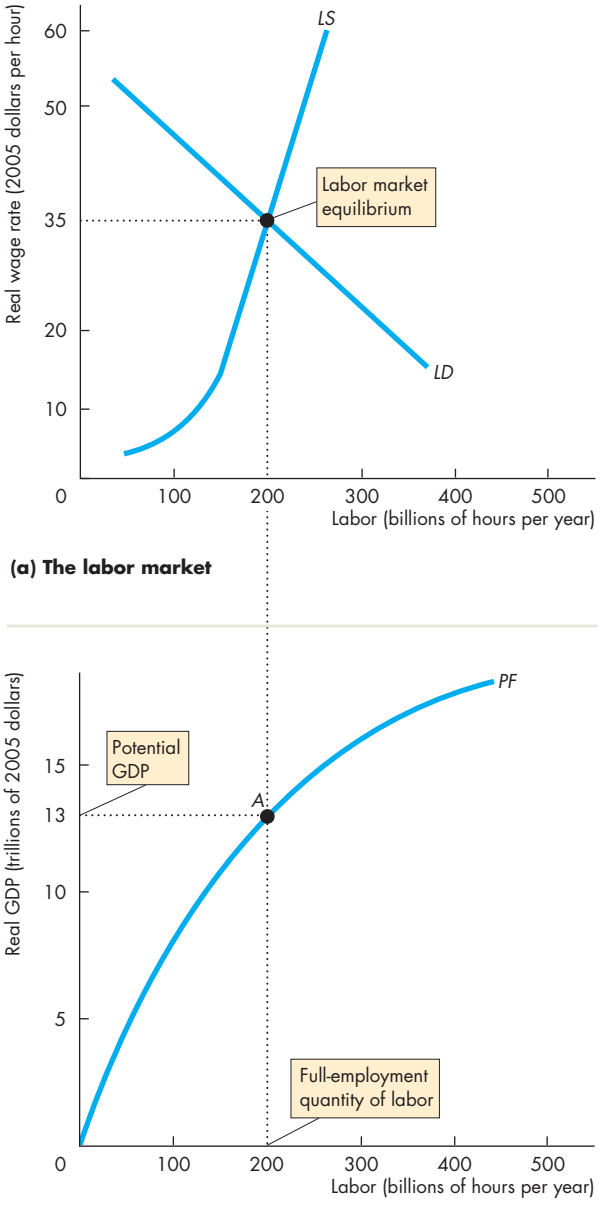
**Growth of the Supply of Labor** When the supply of labor grows, the supply of labor curve shifts rightward. The quantity of labor at a given real wage rate increases.

The quantity of labor is the number of workers employed multiplied by average hours per worker; and the number employed equals the employment-to-population ratio multiplied by the working-age population (see Chapter 5, p. 110). So the quantity of labor changes as a result of changes in

1. Average hours per worker
2. The employment-to-population ratio
3. The working-age population

Average hours per worker have decreased as the workweek has become shorter, and the employment-to-population ratio has increased as more women have entered the labor force. The combined effect of

**FIGURE 6.6** The Labor Market and Potential GDP




The economy is at full employment when the quantity of labor demanded equals the quantity of labor supplied, in part (a). The real wage rate is $35 an hour, and employment is 200 billion hours a year. Part (b) shows potential GDP. It is the quantity of real GDP determined by the production function at the full-employment quantity of labor.

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these two factors has kept the average hours per working-age person (approximately) constant.

Growth in the supply of labor has come from growth in the working-age population. In the long run, the working-age population grows at the same rate as the total population.

***The Effects of Population Growth*** Population growth brings growth in the supply of labor, but it does not change the demand for labor or the production function. The economy can produce more output by using more labor, but there is no change in the quantity of real GDP that a given quantity of labor can produce.

With an increase in the supply of labor and no change in the demand for labor, the real wage rate falls and the equilibrium quantity of labor increases. The increased quantity of labor produces more output and potential GDP increases.

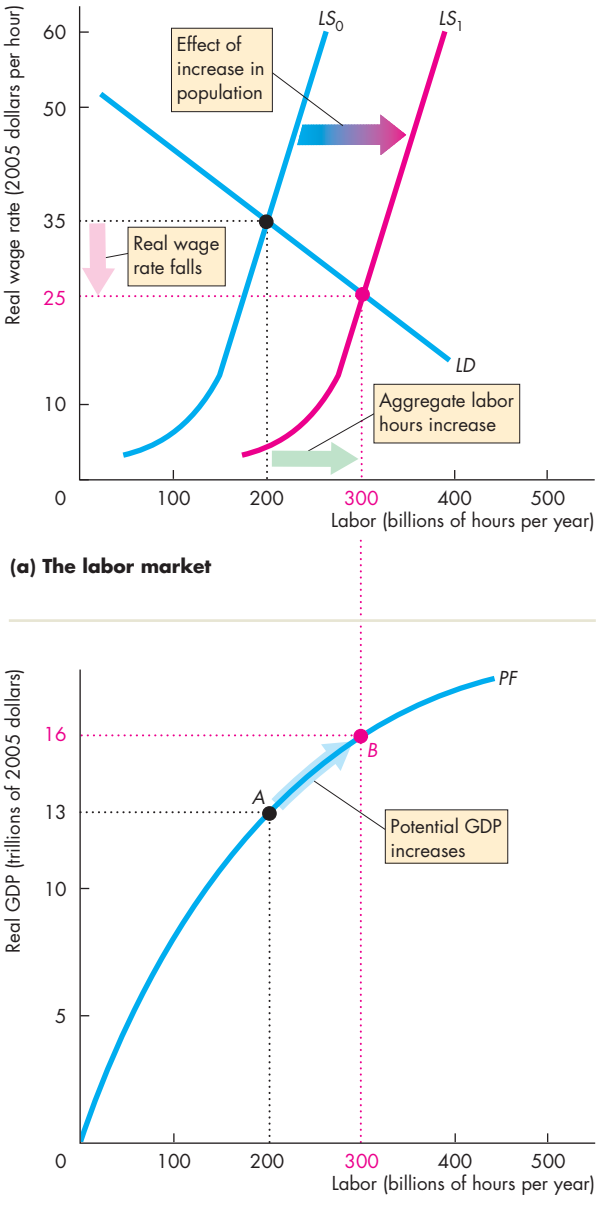
***Illustrating the Effects of Population Growth*** Figure 6.7 illustrates the effects of an increase in the population. In Fig. 6.7(a), the demand for labor curve is *LD* and initially the supply of labor curve is $LS_0$. The equilibrium real wage rate is $35 an hour and the quantity of labor is 200 billion hours a year. In Fig. 6.7(b), the production function (*PF*) shows that with 200 billion hours of labor employed, potential GDP is $13 trillion at point *A*.

An increase in the population increases the supply of labor and the supply of labor curve shifts rightward to $LS_1$. At a real wage rate of $35 an hour, there is now a surplus of labor. So the real wage rate falls. In this example, the real wage rate will fall until it reaches $25 an hour. At $25 an hour, the quantity of labor demanded equals the quantity of labor supplied. The equilibrium quantity of labor increases to 300 billion a year.

Figure 6.7(b) shows the effect on real GDP. As the equilibrium quantity of labor increases from 200 billion to 300 billion hours, potential GDP increases along the production function from $13 trillion to $16 trillion at point *B*.

So an increase in the population increases the full-employment quantity of labor, increases potential GDP, and lowers the real wage rate. But the population increase *decreases* potential GDP per hour of labor. Initially, it was $65 ($13 trillion divided by 200 billion). With the population increase, potential GDP per hour of labor is $53.33 ($16 trillion divided by 300 billion). Diminishing returns are the source of the decrease in potential GDP per hour of labor.

**FIGURE 6.7** The Effects of an Increase in Population




An increase in the population increases the supply of labor. In part (a), the supply of labor curve shifts rightward. The real wage rate falls and aggregate labor hours increase. In part (b), the increase in aggregate labor hours brings an increase in potential GDP. But diminishing returns bring a decrease in potential GDP per hour of labor.

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**Growth of Labor Productivity** **Labor productivity** is the quantity of real GDP produced by an hour of labor. It is calculated by dividing real GDP by aggregate labor hours. For example, if real GDP is $13 trillion and aggregate hours are 200 billion, labor productivity is $65 per hour.

When labor productivity grows, real GDP per person grows and brings a rising standard of living. Let's see how an increase in labor productivity changes potential GDP.

***Effects of an Increase in Labor Productivity*** If labor productivity increases, production possibilities expand. The quantity of real GDP that any given quantity of labor can produce increases. If labor is more productive, firms are willing to pay more for a given number of hours of labor so the demand for labor also increases.

With an increase in the demand for labor and *no change in the supply of labor*, the real wage rate rises and the quantity of labor supplied increases. The equilibrium quantity of labor also increases.

So an increase in labor productivity increases potential GDP for two reasons: Labor is more productive and more labor is employed.

***Illustrating the Effects of an Increase in Labor Productivity*** Figure 6.8 illustrates the effects of an increase in labor productivity.

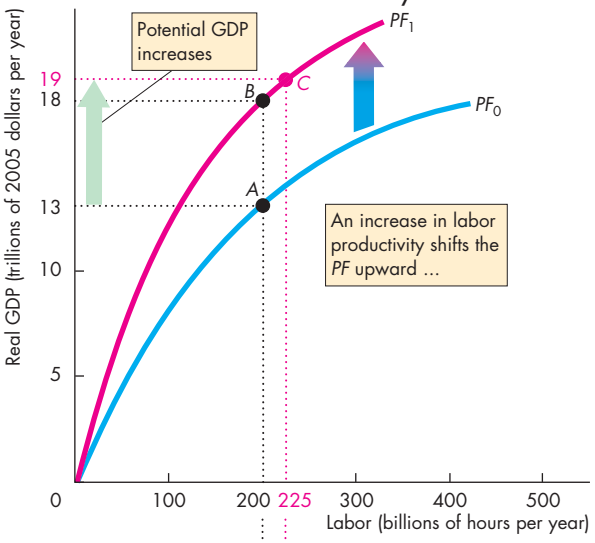
In part (a), the production function initially is $PF_0$. With 200 billion hours of labor employed, potential GDP is $13 trillion at point *A*.

In part (b), the demand for labor curve is $LD_0$ and the supply of labor curve is *LS*. The real wage rate is $35 an hour, and the equilibrium quantity of labor is 200 billion hours a year.

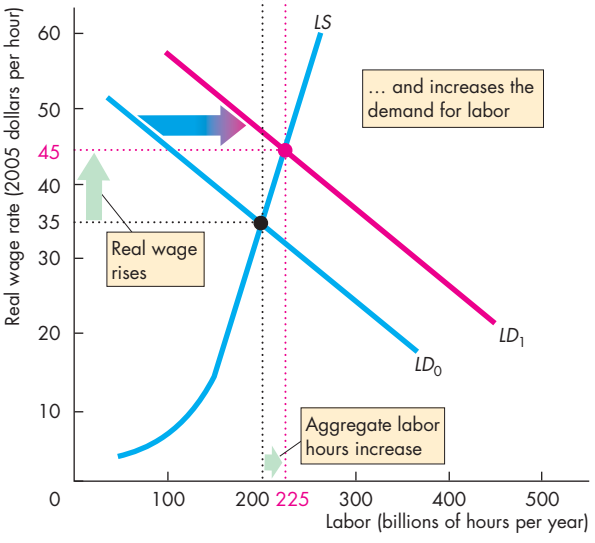
Now labor productivity increases. In Fig. 6.8(a), the increase in labor productivity shifts the production function upward to $PF_1$. At each quantity of labor, more real GDP can be produced. For example, at 200 billion hours, the economy can now produce $18 trillion of real GDP at point *B*.

In Fig. 6.8(b), the increase in labor productivity increases the demand for labor and the demand for labor curve shifts rightward to $LD_1$. At the initial real wage rate of $35 an hour, there is now a shortage of labor. The real wage rate rises. In this example, the real wage rate will rise until it reaches $45 an hour. At $45 an hour, the quantity of labor demanded equals the quantity of labor supplied and the equilibrium quantity of labor is 225 billion hours a year.

**FIGURE 6.8** The Effects of an Increase in Labor Productivity




**(a) Potential GDP**




**(b) The labor market**

An increase in labor productivity shifts the production function upward from $PF_0$ to $PF_1$ in part (a) and shifts the demand for labor curve rightward from $LD_0$ to $LD_1$ in part (b). The real wage rate rises to $45 an hour, and aggregate labor hours increase from 200 billion to 225 billion. Potential GDP increases from $13 trillion to $19 trillion.

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Figure 6.8(a) shows the effects of the increase in labor productivity on potential GDP. There are two effects. At the initial quantity of labor, real GDP increases to point *B* on the new production function. But as the equilibrium quantity of labor increases from 200 billion to 225 billion hours, potential GDP increases to $19 trillion at point *C*.

Potential GDP per hour of labor also increases. Initially, it was $65 ($13 trillion divided by 200 billion). With the increase in labor productivity, potential GDP per hour of labor is $84.44 ($19 trillion divided by 225 billion).

The increase in aggregate labor hours that you have just seen is a consequence of an increase in labor productivity. This increase in aggregate labor hours and labor productivity is an example of the interaction effects that economists seek to identify in their search for the ultimate *causes* of economic growth. In the case that we've just studied, aggregate labor hours increase but that increase is a *consequence*, not a cause, of the growth of potential GDP. The source of the increase in potential GDP is an increase in labor productivity.

Labor productivity is the key to increasing output per hour of labor and rising living standards. But what brings an increase in labor productivity? The next section answers this question.

## REVIEW QUIZ

1. What is the aggregate production function?
2. What determines the demand for labor, the supply of labor, and labor market equilibrium?
3. What determines potential GDP?
4. What are the two broad sources of potential GDP growth?
5. What are the effects of an increase in the population on potential GDP, the quantity of labor, the real wage rate, and potential GDP per hour of labor?
6. What are the effects of an increase in labor productivity on potential GDP, the quantity of labor, the real wage rate, and potential GDP per hour of labor?

You can work these questions in Study Plan 6.3 and get instant feedback.

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## Why Labor Productivity Grows

You've seen that labor productivity growth makes potential GDP grow; and you've seen that labor productivity growth is essential if real GDP per person and the standard of living are to grow. But *why* does labor productivity grow? What are the preconditions that make labor productivity growth possible and what are the forces that make it grow? Why does labor productivity grow faster at some times and in some places than others?

### Preconditions for Labor Productivity Growth

The fundamental precondition for labor productivity growth is the *incentive* system created by firms, markets, property rights, and money. These four social institutions are the same as those described in Chapter 2 (see pp. 41–42) that enable people to gain by specializing and trading.

## Economics in Action

### Intellectual Property Rights Propel Growth

In 1760, when the states that 16 years later would become the United States of America were developing agricultural economies, England was on the cusp of an economic revolution, the *Industrial Revolution*.

For 70 dazzling years, technological advances in the use of steam power, the manufacture of cotton, wool, iron, and steel, and in transportation, accompanied by massive capital investment associated with these technologies, transformed the economy of England. Incomes rose and brought an explosion in an increasingly urbanized population.

By 1825, advances in steam technology had reached a level of sophistication that enabled Robert Stevenson to build the world's first steam-powered rail engine (the Rocket pictured here) and the birth of the world's first railroad.

Why did the Industrial Revolution happen? Why did it start in 1760? And why in England?

Economic historians say that intellectual property rights—England's patent system—provides the answer.

England's patent system began with the Statute of Monopolies of 1624, which gave inventors a monopoly to use their idea for a term of 14 years. For about 100 years, the system was used to reward friends of the

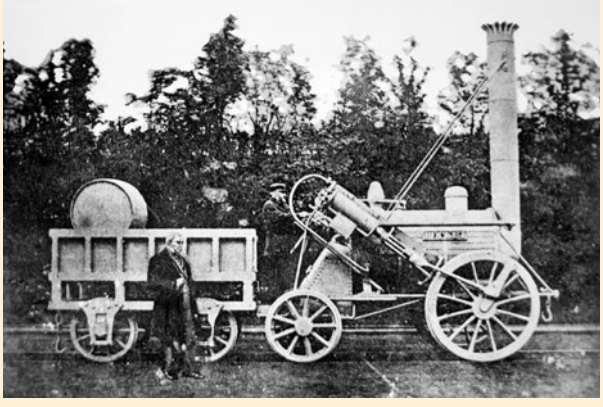
It was the presence of secure property rights in Britain in the middle 1700s that got the Industrial Revolution going (see Economics in Action below). And it is their absence in some parts of Africa today that is keeping labor productivity stagnant.

With the preconditions for labor productivity growth in place, three things influence its pace:

- Physical capital growth
- Human capital growth
- Technological advances

## Physical Capital Growth

As the amount of capital per worker increases, labor productivity also increases. Production processes that use hand tools can create beautiful objects, but production methods that use large amounts of capital per worker are much more productive. The accumulation of capital on farms, in textile factories, in iron foundries and steel mills, in coal mines, on building sites, in chemical plants, in auto plants, in banks and insurance companies, and in shopping malls has added incredibly to the labor productivity of our economy. The next time you see a movie that is set in the Old West or colonial times, look carefully at the small amount of capital around. Try to imagine how productive you would be in such circumstances compared with your productivity today.



## Human Capital Growth

Human capital—the accumulated skill and knowledge of human beings—is the fundamental source of labor productivity growth. Human capital grows when a new discovery is made and it grows as more and more people learn how to use past discoveries.

The development of one of the most basic human skills—writing—was the source of some of the earliest major gains in productivity. The ability to keep written records made it possible to reap ever-larger gains from specialization and trade. Imagine how hard it would be to do any kind of business if all the accounts, invoices, and agreements existed only in people's memories.

Later, the development of mathematics laid the foundation for the eventual extension of knowledge about physical forces and chemical and biological processes. This base of scientific knowledge was the foundation for the technological advances of the Industrial Revolution and of today's information revolution.

But a lot of human capital that is extremely productive is much more humble. It takes the form of millions of individuals learning and becoming remarkably more productive by repetitively doing simple production tasks. One much-studied example of this type of human capital growth occurred in World War II. With no change in physical capital, thousands of workers and managers in U.S. shipyards learned from experience and accumulated human capital that more than doubled their productivity in less than two years.

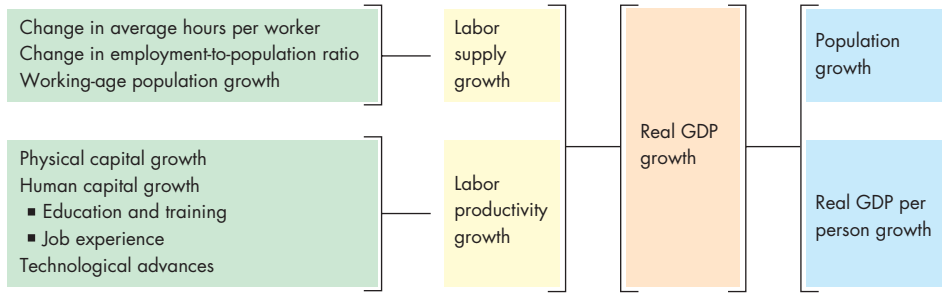
## Technological Advances

The accumulation of physical capital and human capital have made a large contribution to labor productivity growth. But technological change—the discovery and the application of new technologies—has made an even greater contribution.

royal court rather than true inventors. But from around 1720 onward, the system started to work well. To be granted a 14-year monopoly, an inventor only had to pay the required £100 fee (about $22,000 in today's money) and register his or her invention. The inventor was not required to describe the invention in too much detail, so registering and getting a patent didn't mean sharing the invention with competitors.

This patent system, which is in all essentials the same as today's, aligned the self-interest of entrepreneurial inventors with the social interest and unleashed a flood of inventions, the most transformative of which was steam power and, by 1825, the steam locomotive.

**FIGURE 6.9** The Sources of Economic Growth




Labor supply growth and labor productivity growth combine to determine real GDP growth. Real GDP per person growth depends on real GDP growth and population growth.

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## Economics in Action

### Women Are the Better Borrowers

Economic growth is driven by the decisions made by billions of individuals to save and invest, and borrow and lend. But most people are poor, have no credit history, and can't borrow from a bank.

These people—many of whom are women—can, however, start a business, employ a few people, and earn an income with the help of a *microloan*.

Microloans originated in Bangladesh but have spread throughout the developing world. Kiva.org and MicroPlace.com (owned by eBay) are Web sites that enable people to lend money that is used to make microloans in developing economies.

Throughout the developing world, microloans are helping women to feed and clothe their families and to grow their small businesses, often in agriculture. As the incomes of microloan borrowers rise, they pay off their loans and accumulate capital. A billion microloans pack a macro punch.

Labor is many times more productive today than it was a hundred years ago but not because we have more steam engines and more horse-drawn carriages per person. Rather, it is because we have transportation equipment that uses technologies that were unknown a hundred years ago and that are more productive than the old technologies were.

Technological advance arises from formal research and development programs and from informal trial and error, and it involves discovering new ways of getting more out of our resources.

To reap the benefits of technological change, capital must increase. Some of the most powerful and far-reaching fundamental technologies are embodied in human capital—for example, language, writing, and mathematics. But most technologies are embodied in physical capital. For example, to reap the benefits of the internal combustion engine, millions of horse-drawn carriages had to be replaced with automobiles; and to reap the benefits of digital music, millions of Discmans had to be replaced by iPods.

Figure 6.9 summarizes the sources of labor productivity growth and more broadly of real GDP growth. The figure also emphasizes that for real GDP per person to grow, real GDP must grow faster than the population.

## REVIEW QUIZ

1 What are the preconditions for labor productivity growth?
2 Explain the influences on the pace of labor productivity growth.

You can work these questions in Study Plan 6.4 and get instant feedback. myeconlab

## Growth Theories, Evidence, and Policies

You've seen how population growth and labor productivity growth make potential GDP grow. You've also seen that the growth of physical capital and human capital and technological advances make labor productivity grow. How do all these factors interact? What is cause and what is effect? Growth theories address these questions.

Alternative theories of economic growth provide insights into the process of economic growth, but none provides a complete and definite answer to the basic questions: What causes economic growth and why do growth rates vary? Economics has some way to go before it can provide definite answers to these questions. We look at the current state of the empirical evidence. Finally, we'll look at the policies that might achieve faster growth.

Let's start by studying the three main theories of economic growth:

- Classical growth theory
- Neoclassical growth theory
- New growth theory

### Classical Growth Theory

**Classical growth theory** is the view that the growth of real GDP per person is temporary and that when it rises above the subsistence level, a population explosion eventually brings it back to the subsistence level. Adam Smith, Thomas Robert Malthus, and David Ricardo—the leading economists of the late eighteenth century and early nineteenth century—proposed this theory, but the view is most closely associated with the name of Malthus and is sometimes called the *Malthusian theory*. Charles Darwin's ideas about evolution by natural selection were inspired by the insights of Malthus.

**Modern-Day Malthusians** Many people today are Malthusians. They say that if today's global population of 6.9 billion explodes to 11 billion by 2050 and perhaps 35 billion by 2300, we will run out of resources, real GDP per person will decline, and we will return to a primitive standard of living. We must, say Malthusians, contain population growth.

Modern-day Malthusians also point to global warming and climate change as reasons to believe that eventually, real GDP per person will decrease.

### Neoclassical Growth Theory

**Neoclassical growth theory** is the proposition that real GDP per person grows because technological change induces saving and investment that make capital per hour of labor grow. Growth ends if technological change stops because of diminishing marginal returns to both labor and capital. Robert Solow of MIT suggested the most popular version of this growth theory in the 1950s.

Neoclassical growth theory's big break with its classical predecessor is its view about population growth.

**The Neoclassical Theory of Population Growth** The population explosion of eighteenth century Europe that created the classical theory of population eventually ended. The birth rate fell, and while the population continued to increase, its rate of increase moderated.

The key economic influence that slowed the population growth rate is the opportunity cost of a woman's time. As women's wage rates increase and their job opportunities expand, the opportunity cost of having children increases. Faced with a higher opportunity cost, families choose to have fewer children and the birth rate falls.

Technological advances that bring higher incomes also brings advances in health care that extends lives. So as incomes increase, both the birth rate and the death rate decrease. These opposing forces offset each other and result in a slowly rising population.

This modern view of population growth and the historical trends that support it contradict the views of the classical economists. They also call into question the modern doomsday view that the planet will be swamped with more people than it can support.

**Technological Change and Diminishing Returns** In neoclassical growth theory, the pace of technological change influences the economic growth rate but economic growth does not influence the pace of technological change. It is assumed that technological change results from chance. When we're lucky, we have rapid technological change, and when bad luck strikes, the pace of technological advance slows.

To understand neoclassical growth theory, imagine the world of the mid-1950s, when Robert Solow is explaining his idea. Income per person is around $12,000 a year in today's money. The population is growing at about 1 percent a year. Saving and investment are about 20 percent of GDP, enough to keep the quantity of capital per hour of labor constant. Income per person is growing but not very fast.

Then technology begins to advance at a more rapid pace across a range of activities. The transistor revolutionizes an emerging electronics industry. New plastics revolutionize the manufacture of household appliances. The interstate highway system revolutionizes road transportation. Jet airliners start to replace piston-engine airplanes and speed air transportation.

These technological advances bring new profit opportunities. Businesses expand, and new businesses are created to exploit the newly available profitable technologies. Investment and saving increase. The economy enjoys new levels of prosperity and growth. But will the prosperity last? And will the growth last? Neoclassical growth theory says that the *prosperity* will last but the *growth* will not last unless technology keeps advancing.

According to neoclassical growth theory, the prosperity will persist because there is no classical population growth to induce the wage rate to fall. So the gains in income per person are permanent.

But growth will eventually stop if technology stops advancing because of diminishing marginal returns to capital. The high profit rates that result from technological change bring increased saving and capital accumulation. But as more capital is accumulated, more and more projects are undertaken that have lower rates of return—diminishing marginal returns. As the return on capital falls, the incentive to keep investing weakens. With weaker incentives to save and invest, saving decreases and the rate of capital accumulation slows. Eventually, the pace of capital accumulation slows so that it is only keeping up with population growth. Capital per worker remains constant.

### A Problem with Neoclassical Growth Theory

All economies have access to the same technologies, and capital is free to roam the globe, seeking the highest available real interest rate. Capital will flow until rates of return are equal, and rates of return will be equal when capital per hour of labor are equal. Real GDP growth rates and income levels per person around the world will converge. Figure 6.3 on p. 137 shows that while there is some sign of convergence among the rich countries in part (a), convergence is slow, and part (b) shows that it does not appear to be imminent for all countries. New growth theory overcomes this shortcoming of neoclassical growth theory. It also explains what determines the pace of technological change.

## New Growth Theory

**New growth theory** holds that real GDP per person grows because of the choices people make in the pursuit of profit and that growth will persist indefinitely. Paul Romer of Stanford University developed this theory during the 1980s, based on ideas of Joseph Schumpeter during the 1930s and 1940s.

According to the new growth theory, the pace at which new discoveries are made—and at which technology advances—is not determined by chance. It depends on how many people are looking for a new technology and how intensively they are looking. The search for new technologies is driven by incentives.

Profit is the spur to technological change. The forces of competition squeeze profits, so to increase profit, people constantly seek either lower-cost methods of production or new and better products for which people are willing to pay a higher price. Inventors can maintain a profit for several years by taking out a patent or a copyright, but eventually, a new discovery is copied, and profits disappear. So more research and development is undertaken in the hope of creating a new burst of profitable investment and growth.

Two facts about discoveries and technological knowledge play a key role in the new growth theory: Discoveries are (at least eventually) a public capital good; and knowledge is capital that is not subject to diminishing marginal returns.

Economists call a good a *public good* when no one can be excluded from using it and when one person's use does not prevent others from using it. National defense is the classic example of a public good. The programming language used to write apps for the iPhone is another.

Because knowledge is a public good, as the benefits of a new discovery spread, free resources become available. Nothing is given up when they are used: They have a zero opportunity cost. When a student in Austin writes a new iPhone app, his use of the programming language doesn't prevent another student in Seattle from using it.

Knowledge is even more special because it is *not* subject to diminishing returns. But increasing the stock of knowledge makes both labor and machines more productive. Knowledge capital does not bring diminishing returns. Biotech knowledge illustrates this idea well. Biologists have spent a lot of time developing DNA sequencing technology. As more

has been discovered, the productivity of this knowledge capital has relentlessly increased. In 1990, it cost about $50 to sequence one DNA base pair. That cost had fallen to $1 by 2000 and to 1/10,000th of a penny by 2010.

The implication of this simple and appealing observation is astonishing. Unlike the other two theories, new growth theory has no growth-stopping mechanism. As physical capital accumulates, the return to capital—the real interest rate—falls. But the incentive to innovate and earn a higher profit becomes stronger. So innovation occurs, capital becomes more productive, the demand for capital increases, and the real interest rate rises again.

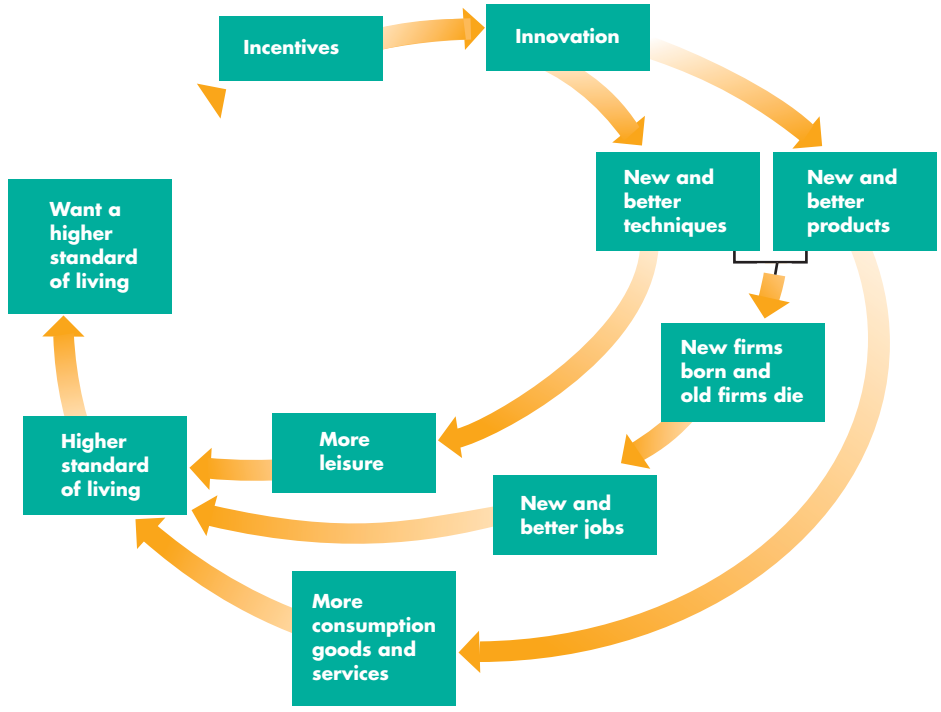
Labor productivity grows indefinitely as people discover new technologies that yield a higher real interest rate. The growth rate depends only on people's incentives and ability to innovate.

**A Perpetual Motion Economy** New growth theory sees the economy as a perpetual motion machine, which Fig. 6.10 illustrates.

No matter how rich we become, our wants exceed our ability to satisfy them. We always want a higher standard of living. In the pursuit of a higher standard of living, human societies have developed incentive systems—markets, property rights, and money—that enable people to profit from innovation. Innovation leads to the development of new and better techniques of production and new and better products. To take advantage of new techniques and to produce new products, new firms start up and old firms go out of business—firms are born and die. As old firms die and new firms are born, some jobs are destroyed and others are created. The new jobs created are better than the old ones and they pay higher real wage rates. Also, with higher wage rates and more productive techniques, leisure increases. New and better jobs and new and better products lead to more consumption goods and services and, combined with increased leisure, bring a higher standard of living.

But our insatiable wants are still there, so the process continues: Wants and incentives create innovation, new and better products, and a yet higher standard of living.

**FIGURE 6.10** A Perpetual Motion Machine




People want a higher standard of living and are spurred by profit incentives to make the innovations that lead to new and better techniques and new and better products.

These new and better techniques and products, in turn, lead to the birth of new firms and the death of some old firms, new and better jobs, and more leisure and more consumption goods and services.

The result is a higher standard of living, but people want a still higher standard of living, and the growth process continues.

*Source:* Based on a similar figure in *These Are the Good Old Days: A Report on U.S. Living Standards,* Federal Reserve Bank of Dallas 1993 Annual Report.

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## New Growth Theory Versus Malthusian Theory

The contrast between the Malthusian theory and new growth theory couldn't be more sharp. Malthusians see the end of prosperity as we know it today and new growth theorists see unending plenty. The contrast becomes clearest by thinking about the differing views about population growth.

To a Malthusian, population growth is part of the problem. To a new growth theorist, population growth is part of the solution. People are the ultimate economic resource. A larger population brings forth more wants, but it also brings a greater amount of scientific discovery and technological advance. So rather than being the source of falling real GDP per person, population growth generates faster labor productivity growth and rising real GDP per person. Resources are limited, but the human imagination and ability to increase productivity are unlimited.

## Sorting Out the Theories

Which theory is correct? None of them tells us the whole story, but each teaches us something of value.

Classical growth theory reminds us that our physical resources are limited and that without advances in technology, we must eventually hit diminishing returns.

Neoclassical growth theory reaches the same conclusion but not because of a population explosion. Instead, it emphasizes diminishing returns to capital and reminds us that we cannot keep growth going just by accumulating physical capital. We must also advance technology and accumulate human capital. We must become more creative in our use of scarce resources.

New growth theory emphasizes the capacity of human resources to innovate at a pace that offsets diminishing returns. New growth theory fits the facts of today's world more closely than do either of the other two theories. But that doesn't make it correct.

## The Empirical Evidence on the Causes of Economic Growth

Economics makes progress by the interplay between theory and empirical evidence. A theory makes predictions about what we will observe if the theory is correct. Empirical evidence, the data generated by history and the natural experiments that it performs, provide the data for testing the theory.

Economists have done an enormous amount of research confronting theories of growth with the empirical evidence. The way in which this research has been conducted has changed over the years.

In 1776, when Adam Smith wrote about "the nature and causes of the Wealth of Nations" in his celebrated book, empirical evidence took the form of carefully selected facts described in words and stories. Today, large databases, sophisticated statistical methods, and fast computers provide numerical measurements of the causes of economic growth.

Economists have looked at the growth rate data for more than 100 countries for the period since 1960 and explored the correlations between the growth rate and more than 60 possible influences on it. The conclusion of this data crunching is that most of these possible influences have variable and unpredictable effects, but a few of them have strong and clear effects. Table 6.1 summarizes these more robust influences. They are arranged in order of difficulty (or in the case of region, impossiblity) of changing. Political and economic systems are hard to change, but market distortions, investment, and openness to international trade are features of a nation's economy that can be influenced by policy.

Let's now look at growth policies.

## Policies for Achieving Faster Growth

Growth theory supported by empirical evidence tells us that to achieve faster economic growth, we must increase the growth rate of physical capital, the pace of technological advance, or the growth rate of human capital and openness to international trade.

The main suggestions for achieving these objectives are

- Stimulate saving
- Stimulate research and development
- Improve the quality of education
- Provide international aid to developing nations
- Encourage international trade

**Stimulate Saving** Saving finances investment so stimulating saving increases economic growth. The East Asian economies have the highest growth rates and the highest saving rates. Some African economies have the lowest growth rates and the lowest saving rates.

Tax incentives can increase saving. Individual Retirement Accounts (IRAs) are a tax incentive to save. Economists claim that a tax on consumption rather than income provides the best saving incentive.

**TABLE 6.1** The Influences on Economic Growth

| Influence | Good for Economic Growth | Bad for Economic Growth |
|---|---|---|
| **Region** | ■ Far from equator | ■ Sub-Sahara Africa |
| **Politics** | ■ Rule of law | ■ Revolutions |
| | ■ Civil liberties | ■ Military coups |
| | | ■ Wars |
| **Economic system** | ■ Capitalist | |
| **Market distortions** | | ■ Exchange rate distortions |
| | | ■ Price controls and black markets |
| **Investment** | ■ Human capital | |
| | ■ Physical capital | |
| **International trade** | ■ Open to trade | |

*Source of data*: Xavier Sala-i-Martin, "I Just Ran Two Million Regressions," *The American Economic Review*, Vol. 87, No 2, (May 1997), pp. 178–183.

**Stimulate Research and Development** Everyone can use the fruits of *basic* research and development efforts. For example, all biotechnology firms can use advances in gene-splicing technology. Because basic inventions can be copied, the inventor's profit is limited and the market allocates too few resources to this activity. Governments can direct public funds toward financing basic research, but this solution is not foolproof. It requires a mechanism for allocating the public funds to their highest-valued use.

**Improve the Quality of Education** The free market produces too little education because it brings benefits beyond those valued by the people who receive the education. By funding basic education and by ensuring high standards in basic skills such as language, mathematics, and science, governments can contribute to a nation's growth potential. Education can also be stimulated and improved by using tax incentives to encourage improved private provision.

**Provide International Aid to Developing Nations** It seems obvious that if rich countries give financial aid to developing countries, investment and growth will increase in the recipient countries. Unfortunately, the obvious does not routinely happen. A large amount of data-driven research on the effects of aid on growth has turned up a zero and even negative effect. Aid often gets diverted and spent on consumption.

**Encourage International Trade** Trade, not aid, stimulates economic growth. It works by extracting the available gains from specialization and trade. The fastest-growing nations are those most open to trade. If the rich nations truly want to aid economic development, they will lower their trade barriers against developing nations, especially in farm products. The World Trade Organization's efforts to achieve more open trade are being resisted by the richer nations.

## REVIEW QUIZ

1 What is the key idea of classical growth theory that leads to the dismal outcome?
2 What, according to neoclassical growth theory, is the fundamental cause of economic growth?
3 What is the key proposition of new growth theory that makes economic growth persist?

You can work these questions in Study Plan 6.5 and get instant feedback. myeconlab

To complete your study of economic growth, take a look at *Reading Between the Lines* on pp. 152–153 and see how economic growth is changing the GDP rankings of nations.