TALKING WITH Richard Clarida*

The U.S. economy was hit in 2007 and 2008 by four significant negative shocks ... [three to aggregate demand and one to aggregate supply.]

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Professor Clarida has published a large number of important articles in leading academic journals and books on monetary policy, exchange rates, interest rates, and international capital flows.

Michael Parkin talked with Richard Clarida about his research and some of the macroeconomic policy challenges facing the United States and the world today.

Looking at the state of the U.S. economy today (fall 2012), why is the recovery so slow and unemployment so stubbornly high?

The U.S. economy was hit in 2007 and 2008 by four significant negative shocks: The bursting of the housing bubble, a major global dislocation in financial markets, a credit crunch as banks suffered losses and tightened lending standards, and record oil and gasoline prices.

The collapse of the housing market was a significant shock to aggregate demand. The dislocation in financial markets and the credit crunch were also negative shocks to aggregate demand. They decreased aggregate demand because tighter lending standards and higher credit spreads made it more expensive for firms and households to borrow for any given level of the interest rate set by the Fed, so spending plans were scaled back.

These three shocks shifted the aggregate demand curve leftward (see Chapter 27, pp. 690–693).

Higher oil and commodity prices were a negative supply shock, which shifted the aggregate supply curve leftward (see Chapter 27, pp. 686–691).

Since 2009, the U.S. economy has been in recovery but has been growing at a disappointing pace. The fall in the unemployment rate has been welcome but slow. Real GDP growth has been slow because the private sector has increased its saving rate to pay off an excess of debt incurred during the credit bubble. U.S. growth has also been slow because a weak economy in Europe and a slowdown in China have slowed global economic growth and lowered the demand for U.S. exports.

*Read the full interview with Richard Clarida in MyEconLab.

23 ECONOMIC GROWTH

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 what makes potential GDP grow
- Explain the sources of labor productivity growth
- Explain the theories of economic growth and policies to increase its rate

U.S. real GDP per person and the standard of living tripled between 1964 and 2014. We see even more dramatic change in China, where incomes have tripled not in 50 years but in the 14 years since 2000. Incomes are also growing rapidly in some African economies, one of which is the small but dynamic Botswana.

In this chapter, we study the forces that make real GDP grow; and in *Economics in the News* at the end of the chapter, we look at lessons we can learn from the slow growth of South Africa and its fast growing neighbor, Botswana.

The Basics of Economic Growth

Economic growth is the expansion of production possibilities. A rapid pace of 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 a growth rate, by distinguishing between economic growth and a business cycle expansion, and by discovering the magic of sustained growth.

Calculating Growth Rates

We express a **growth rate** as the annual percentage change of a variable—the change in the level expressed as a percentage of the initial level. The growth rate of real GDP, for example, is calculated as:

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

Using some numbers, 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 rate of real GDP, then real GDP per person falls.

Economic Growth Versus Business Cycle Expansion

Real GDP can increase for two distinct reasons: The economy might be returning to full employment in an expansion phase of the business cycle or *potential* GDP might be increasing.

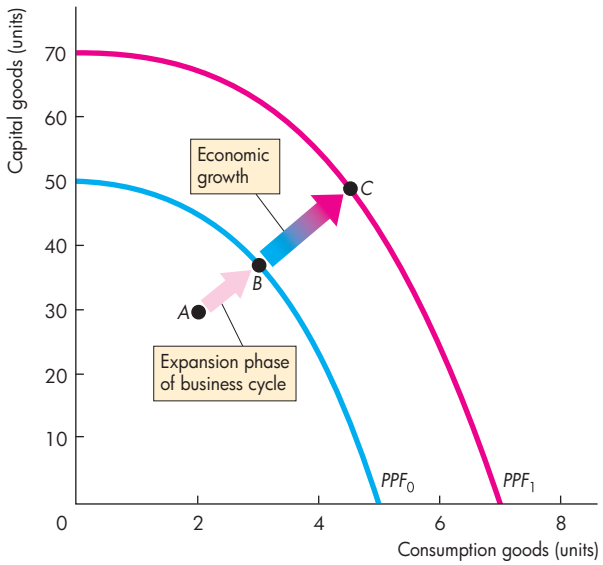
The return to full employment in an expansion phase of the business cycle isn't economic growth. It is just taking up the slack that resulted from the previous recession. The expansion of potential GDP is economic growth.

Figure 23.1 illustrates this distinction using the production possibilities frontier (the *PPF* that you studied in Chapter 2). A return to full employment in a business cycle expansion is a movement from inside the *PPF* at a point such as *A* to a point on the *PPF* such as *B*.

Economic growth is the expansion of production possibilities. It is an outward movement of the *PPF* such as the shift from PPF_0 to PPF_1 and the movement from point *B* on PPF_0 to point *C* on PPF_1.

The growth rate of potential GDP measures the pace of expansion of production possibilities and smoothes out the business cycle fluctuations in the growth rate of real GDP.

FIGURE 23.1 Economic Growth and a Business Cycle Expansion



The increase in aggregate production in the move from point *A* inside PPF_0 to point *B* on PPF_0 is an expansion phase of the business cycle and it occurs with no change in production possibilities. Such an expansion is not economic growth. The increase in aggregate production in the move from point *B* on PPF_0 to point *C* on PPF_1 is economic growth—an expansion of production possibilities shown by an outward shift of the *PPF*.

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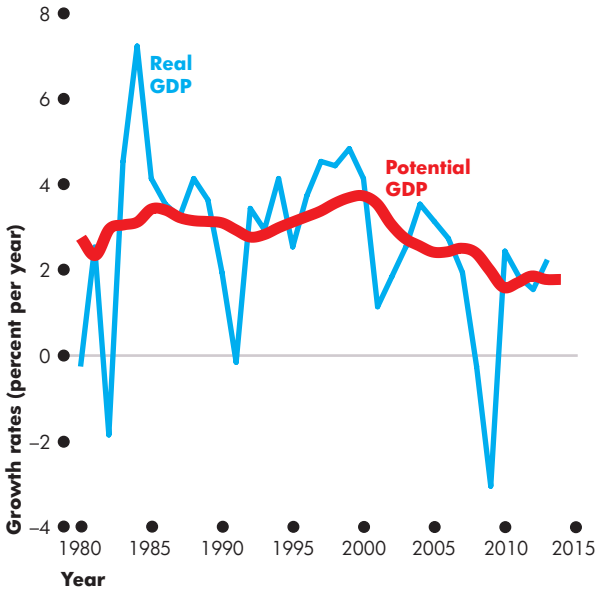
FIGURE 23.2 Growth Rates of Real GDP and Potential GDP



The annual growth rate of real GDP fluctuates widely over the business cycle and masks changes in the underlying trend growth rate. The annual growth rate of potential GDP provides information about changes in the trend growth rate. Both the growth rate of potential GDP and the trend growth rate of real GDP have fallen since 2000.

Sources of data: Real GDP: Bureau of Economic Analysis; Potential GDP: Congressional Budget Office.

MyEconLab Real-time data

Figure 23.2 shows how the growth rate of potential GDP (red curve) smoothes the more erratic fluctuations in the growth rate of real GDP. Business cycle fluctuations in the real GDP growth rate mask the underlying *trend* growth rate revealed by the growth rate of *potential* GDP.

The Magic of Sustained Growth

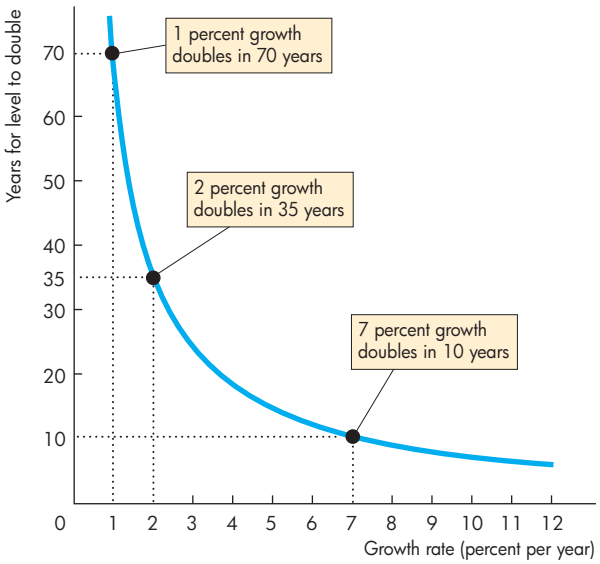
Sustained growth of real GDP per person can transform a poor society into a wealthy one. The reason is that economic growth is like compound interest.

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 approximately

FIGURE 23.3 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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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 23.3 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 2010 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 2010 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 these growth rates, China's real GDP per person would equal that of the United States in 2010 by 2024.

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.

Work these questions in Study Plan 23.1 and get instant feedback. Do a Key Terms Quiz. MyEconLab

Long-Term 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 has our economy grown over the long term? 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?

Long-Term Growth in the U.S. Economy

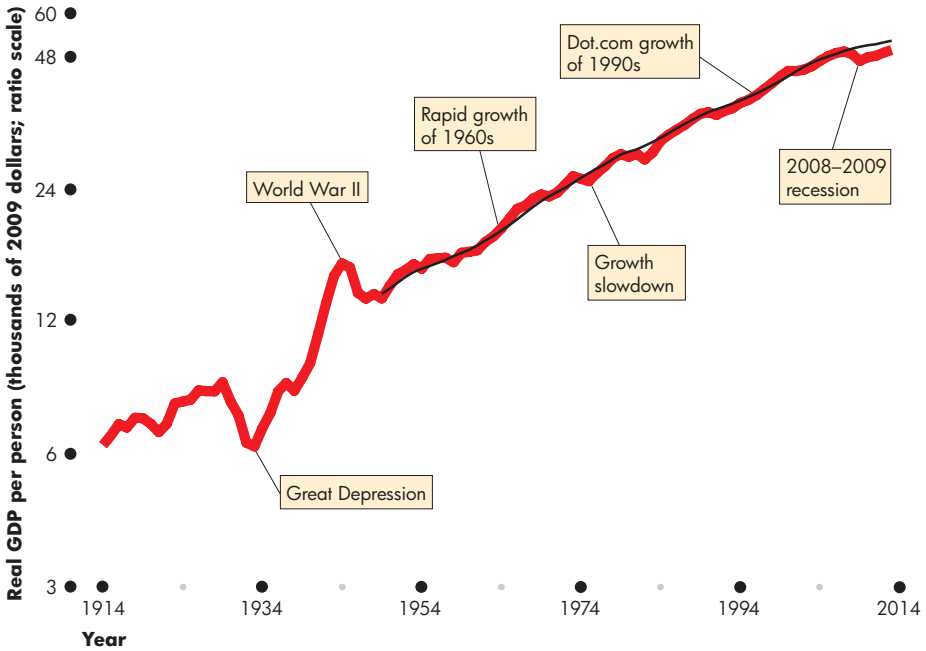
Figure 23.4 shows real GDP per person in the United States for the hundred years from 1914 to 2014. The red line is actual real GDP and the black line (that starts in 1949) is potential GDP. The trend in potential GDP tells us about economic growth. Fluctuations around potential GDP tell us about the 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 other countries' growth rates.

FIGURE 23.4 A Hundred Years of Economic Growth in the United States



During the 100 years from 1914 to 2014, 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 rapid rate of the 1960s.

Sources of data: GDP (GNP) 1912–1928, Christina D. Romer, "World War I and the Postwar Depression: A Reinterpretation Based on Alternative Estimates of GNP," *Journal of Monetary Economics*, 22, 1988; 1929–2012, Bureau of Economic Analysis. Population data, Census Bureau.

MyEconLab Real-time data

Real GDP Growth in the World Economy

Figure 23.5 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.

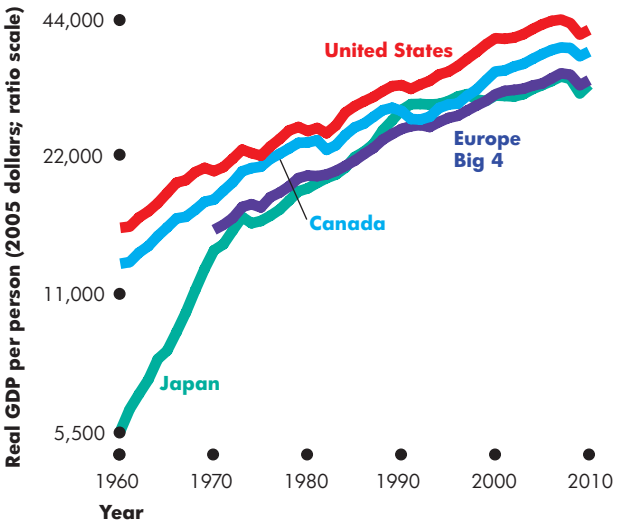
Many other countries are growing more slowly than, and falling farther behind, the United States. Figure 23.5(b) looks at some of these countries.

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.

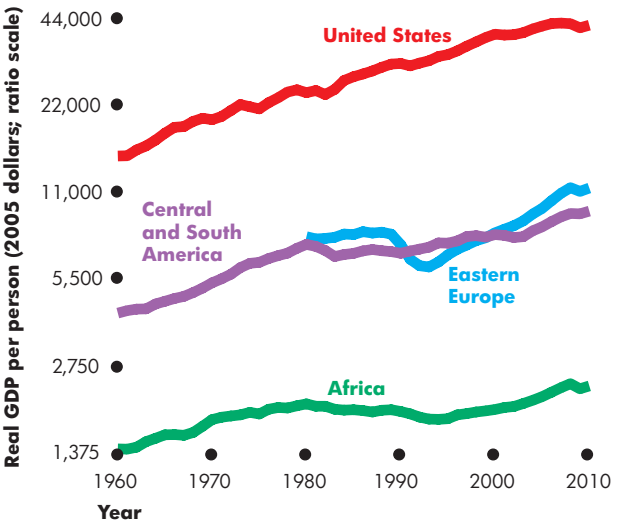
Real GDP per person in Africa, the world's poorest continent, fell from 10 percent of the U.S. level in 1960 to 5 percent in 2007 and then increased slightly to 6 percent in 2010.

FIGURE 23.5 Economic Growth Around the World: Catch-Up or Not?



(a) 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.



(b) No catch-up?

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: Alan Heston, Robert Summers, and Bettina Aten, Penn World Table Version 7.1, Center for International Comparisons of Production, Income, and Prices at the University of Pennsylvania, July 2012.

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ECONOMICS IN ACTION

Fast Trains on the Same Track

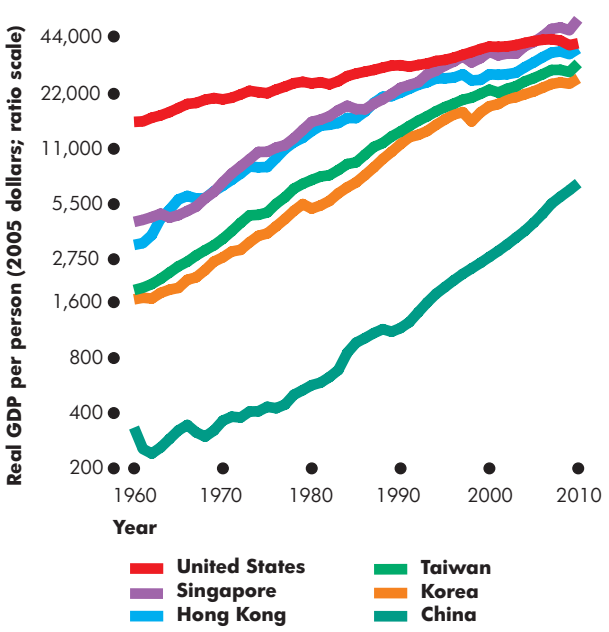
Five Asian economies, Hong Kong, Korea, Singapore, Taiwan, and China, have experienced spectacular growth, which you can see in the figure. During the 1960s, real GDP per person in these economies ranged from 3 to 28 percent of that in the United States. But by 2010, real GDP per person in Singapore 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 Taiwan and Korea and 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: Alan Heston, Robert Summers, and Bettina Aten, Penn World Table Version 7.1, Center for International Comparisons of Production, Income, and Prices at the University of Pennsylvania, July 2012.

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 the growth rates in Hong Kong, Korea, Singapore, Taiwan, China, and the United States. In terms of real GDP per person, how far is China behind these others?

Work these questions in Study Plan 23.2 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. 70), 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.

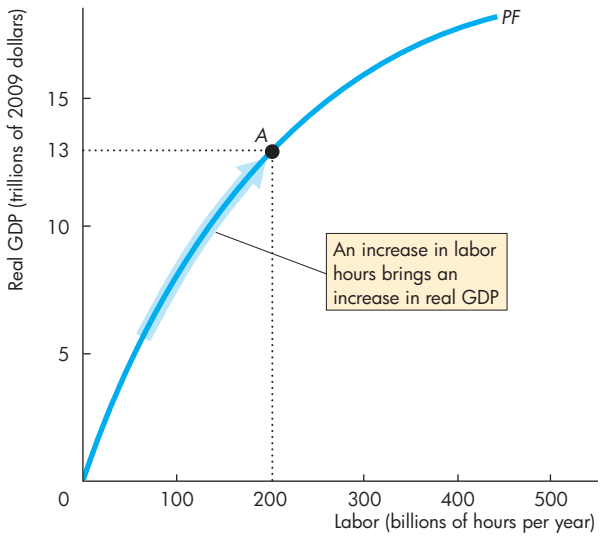
But labor hours are not all equally productive. We use our most productive hours first, and as more hours are worked, these hours are increasingly less productive. So for each additional hour of leisure forgone (each additional hour of labor), real GDP increases but by successively smaller amounts.

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 23.6 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 23.6 The Aggregate Production Function



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

MyEconLab Animation

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.

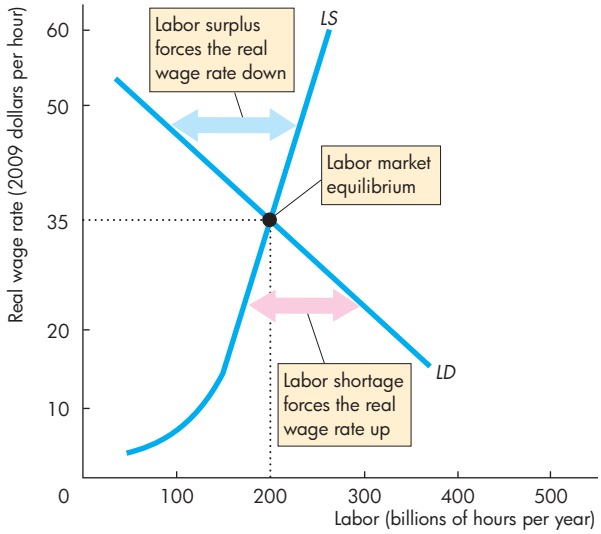
The Supply of Labor The *supply of labor* is the relationship between the quantity of labor supplied and the real wage rate. The quantity of labor supplied is the number of labor hours that all the households in the economy plan to work during a given period. This quantity depends on the real wage rate.

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 23.7 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.

MyEconLab Animation

Figure 23.7 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. 23.6. 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 23.8 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

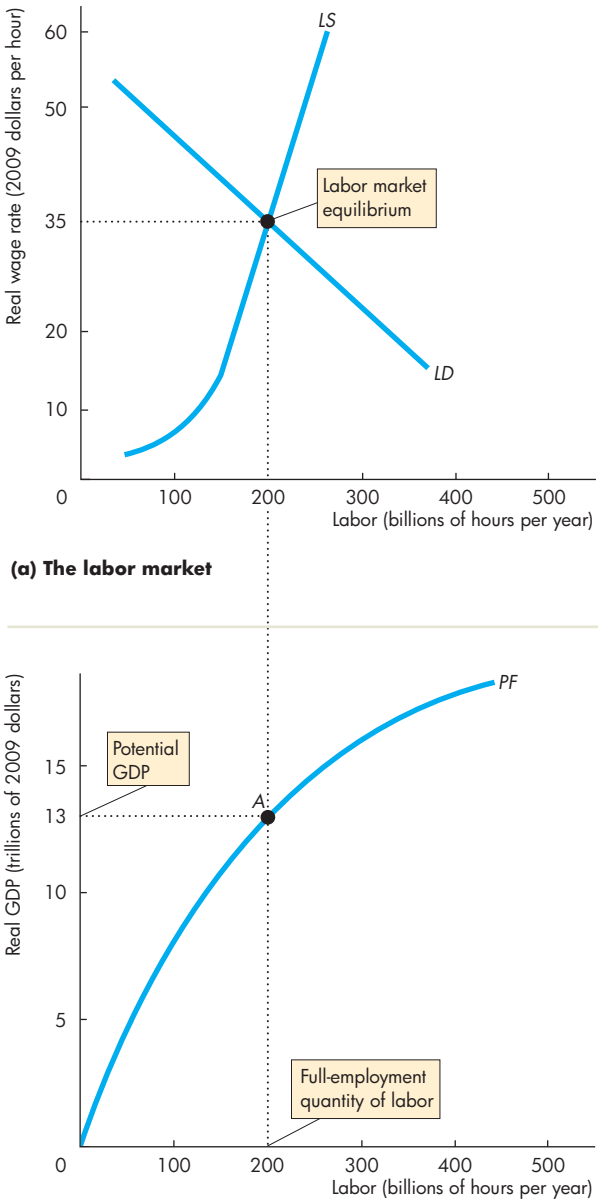
Growth of the Supply of Labor When the supply of labor grows, the supply of labor curve shifts rightward. The quantity of labor at a given real wage rate increases.

The quantity of labor is the number of workers employed multiplied by average hours per worker. The number employed equals the employment-to-population ratio multiplied by the working-age population, divided by 100 (see Chapter 22, p. 556). 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 23.8 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.

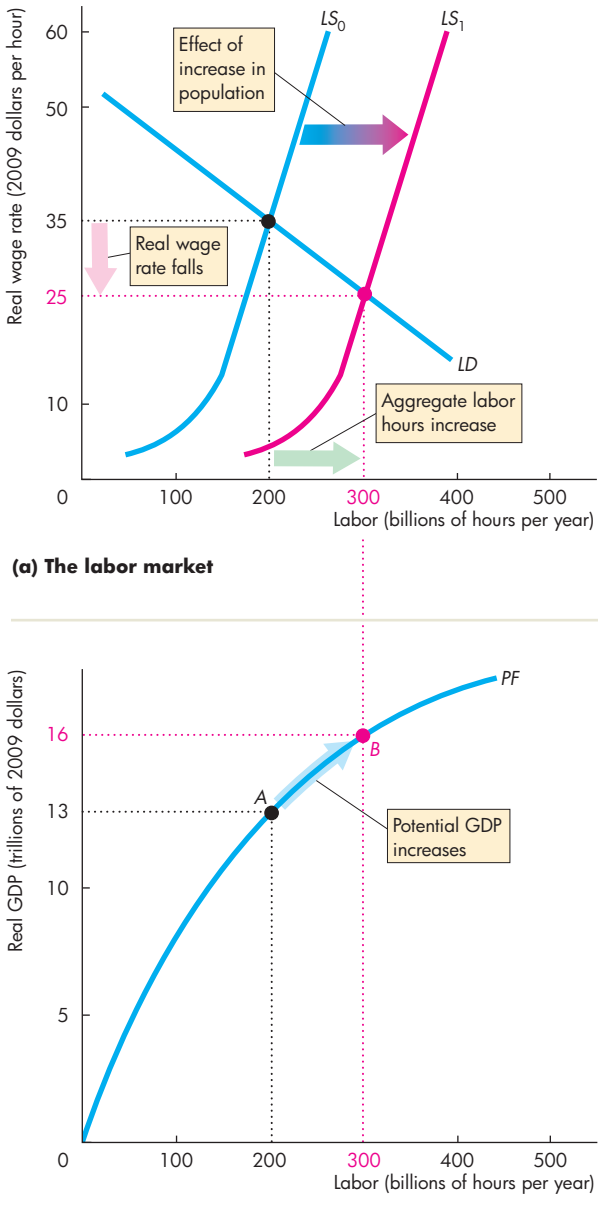
Illustrating the Effects of Population Growth Figure 23.9 illustrates the effects of an increase in the population. In Fig. 23.9(a), the demand for labor curve is *LD* and initially the supply of labor curve is LS_0. The equilibrium real wage rate is $35 an hour and the quantity of labor is 200 billion hours a year. In Fig. 23.9(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 23.9(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 23.9 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.

MyEconLab Animation

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 23.10 illustrates the effects of an increase in labor productivity.

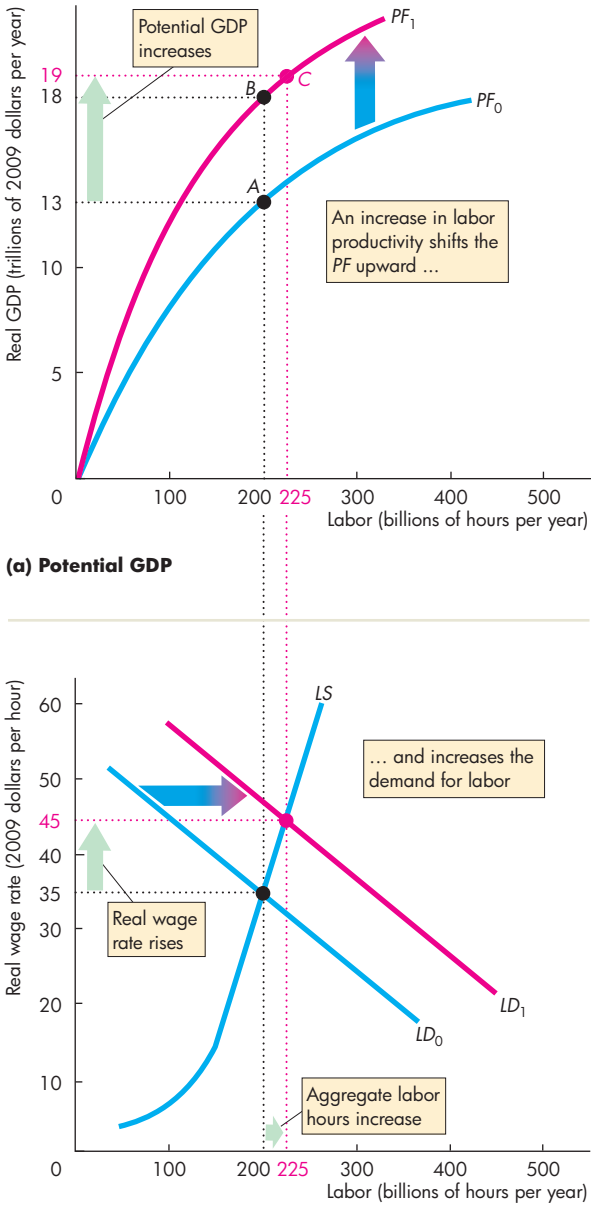
In part (a), the production function initially is PF_0. With 200 billion hours of labor employed, potential GDP is $13 trillion at point *A*.

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. 23.10(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. 23.10(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 23.10 The Effects of an Increase in Labor Productivity



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 23.10(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?

Work these questions in Study Plan 23.3 and get instant feedback. Do a Key Terms Quiz. MyEconLab

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. 82–83) that enable people to gain by specializing and trading.

It was the presence of secure property rights in Britain in the middle 1700s that got the Industrial Revolution going (see *Economics in Action* on p. 591). 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.

ECONOMICS IN ACTION

Women Are the Better Borrowers

Economic growth is driven by the decisions of billions of individuals to save and invest, and to borrow and lend. In developing countries, most people are too poor to save and too big a risk to be able to borrow from a bank. But they can get a *microloan* to start a business, employ a few people, and earn an income. And many of the most successful microloan borrowers are women.

Microloans originated in Bangladesh and 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.

Microloans are helping many women to feed and clothe their families and to grow their businesses. But not all microloan-financed businesses succeed. And the evidence from controlled experiments conducted by Esther Duflo* and her colleagues in the Abdul Latif Jameel Poverty Action Lab is that gains in consumption are temporary. A few years after getting a microloan, borrowers are no better off on average than they were before taking a loan. Making poor people less poor requires more than access to microloans.

This woman was able to set up her seamstress business with a microloan.

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.

*See Talking with Esther Duflo on p. 54.

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.

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.

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 in the Science Museum, London) 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?

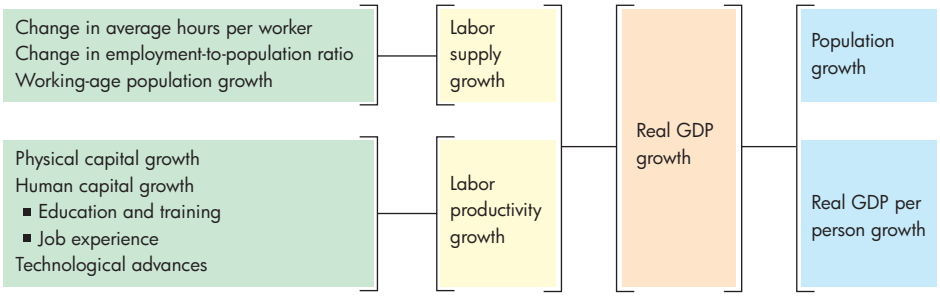
Economic historians say that intellectual property rights—England's patent system—provides the answer.

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

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 essentially 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 23.11 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.

MyEconLab Animation

Figure 23.11 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.

Economics in the News on the next page provides an example of today's labor productivity growth arising from the spread of robot technologies.

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 23.4 and get instant feedback. MyEconLab

ECONOMICS IN THE NEWS

Robots as Skilled Workers

Skilled Work, Without the Worker

A new wave of robots, far more adept than those now commonly used by automakers and other heavy goods manufacturers, are replacing workers around the world in both manufacturing and distribution.

Source: *The New York Times*, August 18, 2012

SOME FACTS

"The Robot Report" (www.therobotreport.com) agrees with the news clip. The auto industry has been the main customer for industrial robots but the scene is changing. Robot manufacturers are creating equipment tailored to the requirements of producers of a wide range of items, just a few of which are metals, food and drink, glass, pharmaceuticals, medical devices, and solar panels.

Around 200 established firms worldwide specialize in the design and production of robots and more than 147 start-up companies have entered this industry in the past year. Almost 2,000 firms have some connection with industrial robots.

THE QUESTIONS

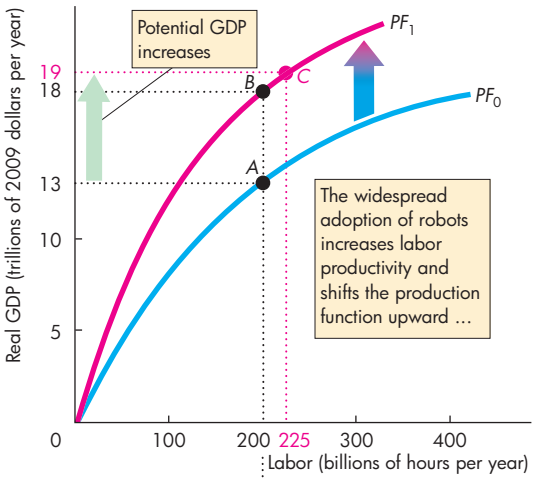
- How will the adoption of industrial robots change employment, the real wage rate, and potential GDP?
- Do robots kill jobs and create unemployment?

THE ANSWERS

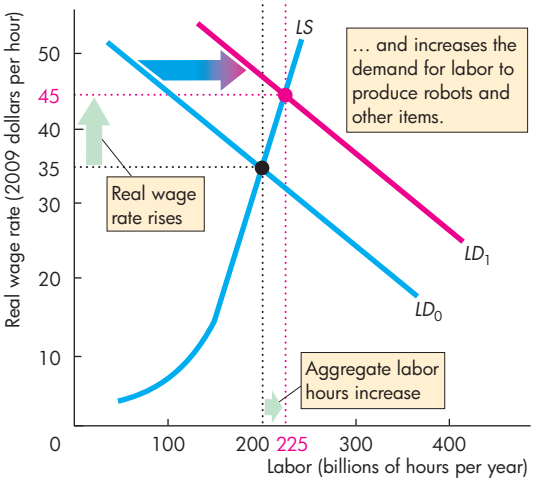
- Robots make workers more productive. One person working with a robot can produce as much as hundreds of workers with non-robot technology.
- Robots replace some workers but create a demand for other workers to design, produce, install, and maintain robots.
- In aggregate, robots increase the productivity of labor. The production function shifts upward and the demand for labor curve shifts rightward.
- The equilibrium real wage rate rises, employment increases, and potential GDP increases.
- As robot production technologies spread, many jobs will disappear but many new jobs will be created.
- Some displaced workers will take new jobs with lower wages. Others will take jobs as skilled robot technicians and producers with higher wages. Average wages will rise.

MyEconLab More Economics in the News

A robot arm seals a box of Lego building toys for shipping.



(a) Potential GDP



(b) The labor market

The Effects of Robots on Employment and GDP

Is Economic Growth Sustainable? 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. But what *causes* economic growth? Why do growth rates vary? How do population growth, capital accumulation, and technological change interact to determine the economic growth rate? What can we say about the future of economic growth? Is growth sustainable? Will the rich economies and the economies of the developing world keep growing, or will growth end to be followed by stagnation or even a falling standard of living?

Economists have wrestled with these questions for the past 250 years and made progress in answering them. We're now going to look at the evolution of ideas about the sustainability of economic growth and the policies that might achieve faster growth.

We start by studying the three main theories about the process 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 and early nineteenth centuries—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 7.2 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.

Neoclassical Theory of Population Growth The population explosion of eighteenth century Europe that created the classical theory of population growth 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 bring advances in healthcare that extend 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. Neoclassical growth theory assumes 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, which is enough to keep the quantity of capital per hour of labor constant. Income per person is growing but not very quickly.

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 across regions until rates of return are equal, and rates of return will be equal when capital per hour of labor is equal. Real GDP growth rates and income levels per person around the world will converge. Figure 23.5 on p. 582 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.

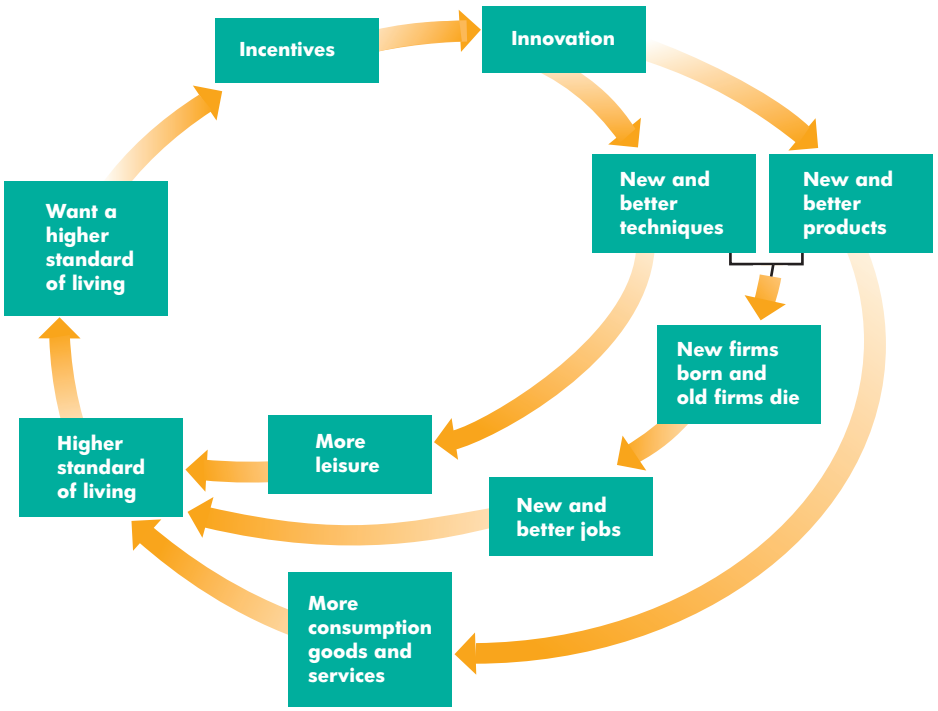
Labor productivity grows indefinitely as people discover new technologies that yield a higher real interest rate. The growth rate depends only on people's incentives and ability to innovate.

A Perpetual Motion Economy New growth theory sees the economy as a perpetual motion machine, which Fig. 23.12 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 23.12 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.

MyEconLab Animation

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.

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, provides 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 23.1 summarizes these more robust influences. They are arranged in order of difficulty (or in the case of region, impossibility) 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 23.1 The Influences on Economic Growth

Influence	Good for Economic Growth	Bad for Economic Growth
Region	■ Far from equator	■ Sub-Saharan 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?

Work these questions in Study Plan 23.5 and get instant feedback. Do a Key Terms Quiz. MyEconLab

To complete your study of economic growth, take a look at *Economics in the News* on pp. 560–561, which compares the contrasting growth performance of two African nations.

Making an Economy Grow

How to Make South Africa's Economy Roar

The Financial Times
July 27, 2012

It is clear South Africa needs a radical change in direction. This weekend the opposition Democratic Alliance aims to show how this is possible, launching a strategy to accelerate annual growth to 8 percent. In particular, it proposes tough reforms to labor laws by removing the automatic extension of collective bargaining agreements across sectors; establishing "jobs zones" featuring special exemptions from restrictive regulations; and lifting administrative requirements for small businesses.

These changes will reduce barriers to entry, encourage flexibility, and stimulate productivity in … mining, manufacturing, and agriculture. Combined with focused employment incentives such as a youth wage subsidy and market-driven skills development programs, the plan provides a radical overhaul of the country's labor market. …

Our plan contains … policies to distribute shares in state-owned companies; introduce tax deductions to incentivize employee shared-ownership schemes; promote a joint ownership model in the agricultural sector; and lower the cost barriers facing first-time homeowners.

These measures are essential for facilitating broad-based participation in the economy. …

Although international rankings such as the World Economic Forum's Global Competitiveness report praise the country's sophisticated financial sector and sound legal environment, South Africa falls short when it comes to the ease of doing business, and the barriers caused by excessive regulation and state inefficiency. My party's proposals in this area will cut the tax and regulatory burdens inhibiting new business growth.

Seven of the 10 fastest-growing economies in the world are in Africa. … High growth is resulting in rapidly declining poverty and unemployment in the developing world. With the right policies in place, South Africa can be part of this story.

Extract from an article by Helen Zille, leader of South Africa's opposition Democratic Alliance and premier of the Western Cape Province. Copyright 2012 Financial Times Limited.

ESSENCE OF THE STORY

- South Africa's opposition Democratic Alliance wants to accelerate real GDP growth to 8 percent per year.
- Labor market reforms would limit union agreements, establish "jobs zones" with exemptions from restrictive regulations, subsidize youth wages, and develop market-driven skills.
- Capital market reforms would ease small-business regulation, cut taxes, distribute shares in state-owned companies, provide tax incentives for employee shared-ownership, and make homeownership easier.
- The reforms aim to reduce barriers to entry and boost labor productivity in all parts of the economy.

MyEconLab More Economics in the News

ECONOMIC ANALYSIS

- South Africa's economic growth rate has not been spectacular.
- Before 1994, South Africa's economy was hit by sanctions aimed at ending apartheid and real GDP per person decreased.
- Since 1995, real GDP per person has increased but at a rate of 3.4 percent per year.
- South Africa's growth compares unfavorably with that of some other African nations, one of which is its neighbor Botswana, that are growing more rapidly.
- Figure 1 shows real GDP per person in South Africa and Botswana from 1980 to 2012. You can see that real GDP per person in Botswana has grown much more quickly than in South Africa.
- A key reason Botswana's real GDP per person has grown more rapidly than South Africa's is the pace of investment in new capital.
- Figure 2 shows that Botswana invests double the percentage of GDP invested by South Africa.
- The growth of physical capital and human capital and technological change are proceeding at a rapid pace in Botswana and bringing rapid growth in real GDP per person.
- Figure 3 illustrates how the production function is changing in these economies. It is shifting upward at a more rapid pace in Botswana than in South Africa.
- Why is Botswana more successful than South Africa and are the policies proposed in the news article enough to raise South Africa's growth rate to the desired 8 percent per year?
- Economists Daron Acemoglu, Simon Johnson, and James Robinson say that Botswana had the right institutions for growth—well defined and widely respected private property right*.
- The proposals in the news article don't directly address strengthening private property rights, but they do have that effect.
- The labor market reforms described in the article would increase human capital and labor productivity.
- The labor market and capital market reforms together would make capital accumulation and technological change more profitable and further contribute to labor productivity growth.
- The specific target of 8 percent growth is probably too ambitious.

*Daron Acemoglu, Simon Johnson, and James Robinson, "An African Success Story: Botswana," in *In Search of Prosperity: Analytic Narratives on Economic Growth* edited by Dani Rodrik, Princeton University Press, 2003, pp. 80–122.

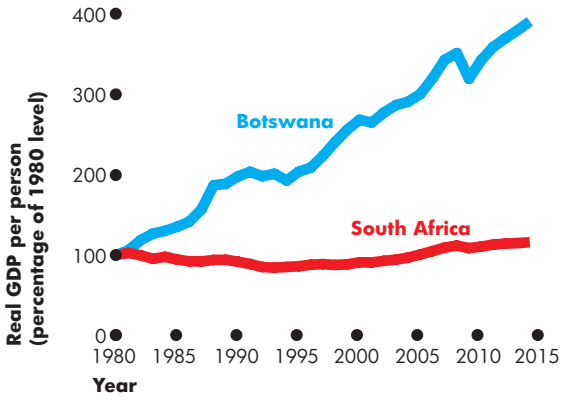


Figure 1 Real GDP in Two African Economies

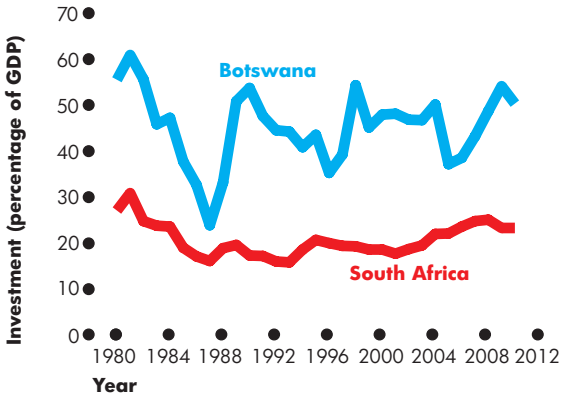


Figure 2 Investment in Two African Economies

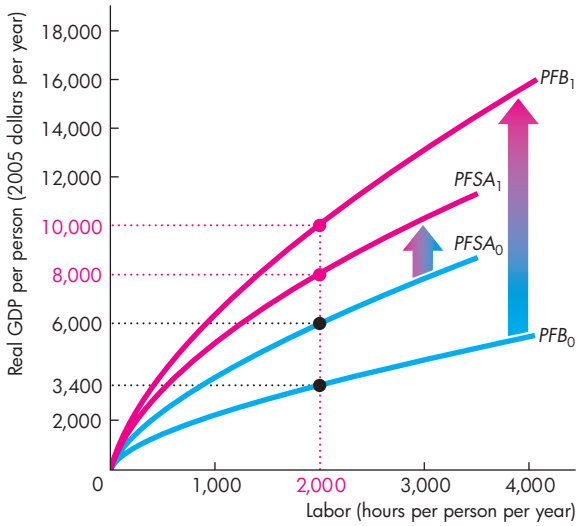


Figure 3 Labor Productivity Growth in Two African Economies

Sources of data: (1980–2010) Alan Heston, Robert Summers, and Bettina Aten, Penn World Table Version 7.1, Center for International Comparisons of Production, Income, and Prices at the University of Pennsylvania, July 2012; and (2011–2012) International Monetary Fund, *World Economic Outlook*, April 2012.

SUMMARY

Key Points

The Basics of Economic Growth (pp. 578–580)

- Economic growth is the sustained expansion of production possibilities and is measured as the annual percentage rate of change of real GDP.
- The Rule of 70 tells us the number of years in which real GDP doubles—70 divided by the annual percentage growth rate.

Working Problems 1 and 2 will give you a better understanding of the basics of economic growth.

Long-Term Growth Trends (pp. 581–583)

- Real GDP per person in the United States grows at an average rate of 2 percent a year. Growth was most rapid during the 1960s and the 1990s.
- The gap in real GDP per person between the United States and Central and South America has persisted. The gaps between the United States and Hong Kong, Korea, and China have narrowed. The gap between the United States and Africa has widened.

Working Problem 3 will give you a better understanding of long-term growth trends.

How Potential GDP Grows (pp. 584–589)

- The aggregate production function and equilibrium in the aggregate labor market determine potential GDP.
- Potential GDP grows if the labor supply grows or if labor productivity grows.
- Only labor productivity growth makes real GDP per person and the standard of living grow.

Working Problems 4 to 6 will give you a better understanding of how potential GDP grows.

Why Labor Productivity Grows (pp. 589–592)

- Labor productivity growth requires an incentive system created by firms, markets, property rights, and money.
- The sources of labor productivity growth are growth of physical capital and human capital and advances in technology.

Working Problem 7 will give you a better understanding of why labor productivity grows.

Is Economic Growth Sustainable? Theories, Evidence, and Policies (pp. 593–597)

- In classical theory, real GDP per person keeps returning to the subsistence level.
- In neoclassical growth theory, diminishing returns to capital limit economic growth.
- In new growth theory, economic growth persists indefinitely at a rate determined by decisions that lead to innovation and technological change.
- Policies for achieving faster growth include stimulating saving and research and development, encouraging international trade, and improving the quality of education.

Working Problem 8 will give you a better understanding of growth theories, evidence, and policies.

Key Terms

MyEconLab Key Terms Quiz

Aggregate production function, 584
Classical growth theory, 593
Economic growth, 578
Growth rate, 578
Labor productivity, 588
Neoclassical growth theory, 593
New growth theory, 594
Real GDP per person, 578
Real wage rate, 585
Rule of 70, 579

WORKED PROBLEM

MyEconLab You can work this problem in Chapter 23 Study Plan.

The *World Economic Outlook* reports the following information:

- China's real GDP was 17.9 trillion yuan in 2012 and 19.3 trillion yuan in 2013.
- China's population was 1,361 million in 2012 and 1,368 million in 2013.

Questions

1. Calculate China's real GDP growth rate and its population growth rate during 2013.
2. Calculate the growth rate of China's standard of living during 2013.
3. If the growth rate of China's standard of living during 2013 is maintained, how many years will it take to double?

Solutions

1. The growth of a variable equals the change in the value from 2012 to 2013 calculated as a percentage of the value in 2012.

   China's growth rate of real GDP during 2013 equals (19.3 trillion yuan − 17.9 trillion yuan) divided by 17.9 trillion yuan, multiplied by 100.

   That is,

   Real GDP growth rate = (1.4 ÷ 17.9) × 100 = 7.8 percent.

   China's population growth rate equals (1,368 million − 1,361 million) divided by 1,361 million, multiplied by 100.

   That is,

   Population growth rate = (7 ÷ 1,361) × 100 = 0.5 percent.

Key Point: The growth rate of a variable equals the annual percentage change in the value of the variable.

2. Real GDP per person measures the standard of living.

   In 2012, real GDP per person was 17.9 trillion yuan divided by 1,361 million, which equals 13,152 yuan.

   In 2013, real GDP per person was 19.3 trillion yuan divided by 1,368 million, which equals 14,108 yuan.

   The growth rate of real GDP per person equals (14,108 yuan − 13,152 yuan) ÷ 13,152 yuan, multiplied by 100.

   The growth rate of real GDP per person equals (956 ÷ 13,152) × 100, which is 7.3 percent.

   So during 2013, China's standard of living increased by 7.3 percent.

   An alternative way of calculating the growth rate of the standard of living is to compare the growth rates of real GDP and the population.

   Notice that a higher real GDP growth rate increases the growth rate of real GDP per person, but a higher population growth rate lowers the growth rate of real GDP per person.

   So when real GDP grows by 7.8 percent and the population doesn't change, the standard of living grows by 7.8 percent.

   When the population grows by 0.5 percent and real GDP doesn't change, the standard of living falls by 0.5 percent.

   That is, the growth rate of China's standard of living during 2013 is approximately equal to the growth rate of real GDP minus the population growth rate, which equals 7.8 percent minus 0.5 percent, or 7.3 percent.

Key Point: The growth rate of the standard of living equals the growth rate of real GDP minus the growth rate of the population.

3. The number of years it will take for the standard of living to double its 2013 level is given by the Rule of 70.

   China's standard of living is growing at 7.3 percent a year. The Rule of 70 says that if this growth rate is sustained, China's standard of living will double in 70 years divided by 7.3, which equals 9.6 years.

   China's standard of living will be twice what it was in 2013 sometime during 2023.

Key Point: The time it takes for the standard of living to double equals 70 years divided by the sustained growth rate of the standard of living.

STUDY PLAN PROBLEMS AND APPLICATIONS

MyEconLab You can work Problems 1 to 8 in Chapter 23 Study Plan and get instant feedback.

The Basics of Economic Growth (Study Plan 23.1)

1. Brazil's real GDP was 1,180 trillion reais in 2013 and 1,202 trillion reais in 2014. Brazil's population was 198 million in 2013 and 200 million in 2014. Calculate
   a. The growth rate of real GDP.
   b. The growth rate of real GDP per person.
   c. The approximate number of years it takes for real GDP per person in Brazil to double if the 2014 growth rate of real GDP and the population growth rate are maintained.
2. The IMF projects that China's real GDP per person will be 15,040 yuan in 2015 and 16,010 yuan in 2016 and that India's real GDP per person will be 54,085 rupees in 2015 and 56,840 rupees in 2016. By maintaining their current growth rates, which country will be first to double its standard of living?

Long-Term Growth Trends (Study Plan 23.2)

3. China was the largest economy for centuries because everyone had the same type of economy—subsistence—and so the country with the most people would be economically biggest. Then the Industrial Revolution sent the West on a more prosperous path. Now the world is returning to a common economy, this time technology- and information-based, so once again population triumphs.
   a. Why was China the world's largest economy until 1890?
   b. Why did the United States surpass China in 1890 to become the world's largest economy?

How Potential GDP Grows (Study Plan 23.3)

Use the following tables to work Problems 4 to 6. The tables describe an economy's labor market and its production function in 2014.

Real wage rate (dollars per hour)	Labor hours supplied	Labor hours demanded
80	45	5
70	40	10
60	35	15
50	30	20
40	25	25
30	20	30
20	15	35

Labor (hours)	Real GDP (2009 dollars)
5	425
10	800
15	1,125
20	1,400
25	1,625
30	1,800
35	1,925
40	2,000

4. What are the equilibrium real wage rate, the quantity of labor employed in 2014, labor productivity, and potential GDP in 2014?
5. In 2015, the population increases and labor hours supplied increase by 10 at each real wage rate. What are the equilibrium real wage rate, labor productivity, and potential GDP in 2015?
6. In 2015, the population increases and labor hours supplied increase by 10 at each real wage rate. Does the standard of living in this economy increase in 2015? Explain why or why not.

Why Labor Productivity Grows (Study Plan 23.4)

7. **Labor Productivity on the Rise**
   The BLS reported the following data for the year ended June 2009: In the nonfarm sector, output fell 5.5 percent as labor productivity increased 1.9 percent—the largest increase since 2003—but in the manufacturing sector, output fell 9.8 percent as labor productivity increased by 4.9 percent—the largest increase since the first quarter of 2005.
   Source: bls.gov/news.release, August 11, 2009
   In both sectors, output fell while labor productivity increased. Did the quantity of labor (aggregate hours) increase or decrease? In which sector was the change in the quantity of labor larger?

Is Economic Growth Sustainable? Theories, Evidence, and Policies (Study Plan 23.5)

8. Explain the processes that will bring the growth of real GDP per person to a stop according to
   a. Classical growth theory.
   b. Neoclassical growth theory.
   c. New growth theory.

ADDITIONAL PROBLEMS AND APPLICATIONS

MyEconLab You can work these problems in MyEconLab if assigned by your instructor.

The Basics of Economic Growth

9. In 2013, Turkey's real GDP was growing at 4.1 percent a year and its population was growing at 1.26 percent a year. If these growth rates continued, in what year would Turkey's real GDP per person be twice what it is in 2013?
10. Turkey's real GDP (in U.S. dollars) was $788.9 billion in 2012 and $822.1 billion in 2013. Turkey's population was 74 million in 2012 and 74.93 million in 2013. Calculate
    a. The growth rate of GDP.
    b. The growth rate of real GDP per person.
    c. The approximate number of years it takes for GDP per person in Turkey to double if the 2013 growth rate of GDP and the population growth rate are maintained.
11. Russia's real GDP (in U.S. dollars) was $2.017 trillion in 2012 and $2.097 trillion in 2013. Russia's population was 143.2 million in 2012 and 143.5 million in 2013. Calculate
    a. The growth rate of real GDP.
    b. The growth rate of real GDP per person.
    c. The approximate number of years it will take for real GDP per person in Russia to double if the current growth rate of real GDP is maintained.

Long-Term Growth Trends

12. **The New World Order**

    While gross domestic product growth is picking up a bit in emerging market economies, it is picking up even more in the advanced economies. Real GDP in the emerging market economies is forecasted to grow at 5.4% in 2015 up from 4.9% in 2012. In the advanced economies, real GDP is expected to grow at 2.3% in 2015 up from 1.4% in 2012. The difference in growth rates means that the large spread between emerging market economies and advanced economies of the past 40 years will continue for many more years.

    Source: *World Economic Outlook*, January, 2014

    Do growth rates over the past few decades indicate that gaps in real GDP per person around the world are shrinking, growing, or staying the same? Explain.

How Potential GDP Grows

13. If a large increase in investment increases labor productivity, explain what happens to
    a. Potential GDP.
    b. Employment.
    c. The real wage rate.
14. If a severe drought decreases labor productivity, explain what happens to
    a. Potential GDP.
    b. Employment.
    c. The real wage rate.

Use the following tables to work Problems 15 to 17. The first table describes an economy's labor market in 2014 and the second table describes its production function in 2014.

Real wage rate (dollars per hour)	Labor hours supplied	Labor hours demanded
80	55	15
70	50	20
60	45	25
50	40	30
40	35	35
30	30	40
20	25	45

Labor (hours)	Real GDP (2009 dollars)
15	1,425
20	1,800
25	2,125
30	2,400
35	2,625
40	2,800
45	2,925
50	3,000

15. What are the equilibrium real wage rate and the quantity of labor employed in 2014?
16. What are labor productivity and potential GDP in 2014?
17. Suppose that labor productivity increases in 2014. What effect does the increased labor productivity have on the demand for labor, the supply of labor, potential GDP, and real GDP per person?