CONSIDER THIS . . .

Patents and Innovation

It costs U.S. and European drug companies about $1 billion to research, patent, and safety-test a new drug because literally thousands of candidate drugs fail for each drug that succeeds. The only way to cover these costs is by relying on patent protections that give a drug's developer the exclusive monopoly right to market and sell the new drug for 20 years after it is developed. The revenues over that time period will hopefully be enough to cover the drug's development costs and—if the drug is popular—generate a profit for the drug company. Once the 20 years are over, however, the drug will go "off patent" and anyone will be able to manufacture and sell it.

Leader and follower countries have gotten into heated disputes in recent years, however, because the follower countries have often refused to recognize the patents granted to pharmaceutical companies in rich countries. India, for instance, has allowed local drug companies to copy and sell drugs that were developed by U.S. companies and are still under patent protection in the United States.

This benefits Indian citizens because the local drug companies compete with each other and end up charging much less for a given drug than would the drug's patent holder if it could enforce its monopoly patent and act as the drug's only seller. On the other hand, the weak patent protections found in India also make it completely unprofitable for local drug companies to try to develop innovative new drugs because, without patent protections, they too will be unable to prevent rivals from copying their new drugs and selling them for extremely low prices. As a result, India has recently moved to strengthen its patent protections, realizing that unless it does so, it will never be able to provide the financial incentive that can transform its local drug companies from copycats into innovators. But note that the innovative new drugs that may result from the increased patent protections are not without a cost. As patent protections in India are improved, cheap copycat drugs will no longer be available to Indian consumers.

free trade promotes the rapid spread of new ideas so that innovations made in one country quickly spread to other countries.

- ***A competitive market system*** Under a market system, prices and profits serve as the signals that tell firms what to make and how much of it to make. Rich leader countries vary substantially in terms of how much government regulation they impose on markets, but in all cases, firms have substantial autonomy to follow market signals in deciding on current production and in making investments to produce what they believe consumers will demand in the future.

Several other difficult-to-measure factors also influence a nation's capacity for economic growth. The overall social-cultural-political environment of the United States, for example, has encouraged economic growth. Beyond the market system that has prevailed in the United States, the United States also has had a stable political system characterized by democratic principles, internal order, the right of property ownership, the legal status of enterprise, and the enforcement of contracts. Economic freedom and political freedom have been "growth-friendly."

In addition, and unlike some nations, there are virtually no social or moral taboos on production and material progress in the United States. The nation's social philosophy has embraced wealth creation as an attainable and desirable goal and the inventor, the innovator, and the businessperson are accorded high degrees of prestige and respect in American society. Finally, Americans have a positive attitude toward work and risk taking, resulting in an ample supply of willing workers and innovative entrepreneurs. A flow of energetic immigrants has greatly augmented that supply.

The nearby Consider This box deals with how fast-growing follower countries such as India sometimes alter their growth-related institutional structures as they grow richer. Chapter 39W looks at the special problems of economic growth in developing nations.

Ingredients of Growth

Our discussion of modern economic growth and the institutional structures that promote it has purposely been general. We now want to focus our discussion on six factors that directly affect the *rate* of economic growth. These six "ingredients" of economic growth can be grouped into four supply factors, one demand factor, and one efficiency factor.

Supply Factors

Four of the ingredients of economic growth relate to the physical ability of the economy to expand. They are:

- Increases in the quantity and quality of natural resources.

- Increases in the quantity and quality of human resources.
- Increases in the supply (or stock) of capital goods.
- Improvements in technology.

These **supply factors**—changes in the physical and technical agents of production—enable an economy to expand its potential GDP.

Demand Factor

The fifth ingredient of economic growth is the **demand factor:**

- To achieve the higher production potential created by the supply factors, households, businesses, and government must *purchase* the economy's expanding output of goods and services.

When that occurs, there will be no unplanned increases in inventories and resources will remain fully employed. Economic growth requires increases in total spending to realize the output gains made available by increased production capacity.

Efficiency Factor

The sixth ingredient of economic growth is the **efficiency factor:**

- To reach its full production potential, an economy must achieve economic efficiency as well as full employment.

The economy must use its resources in the least costly way (productive efficiency) to produce the specific mix of goods and services that maximizes people's well-being (allocative efficiency). The ability to expand production, together with the full use of available resources, is not sufficient for achieving maximum possible growth. Also required is the efficient use of those resources.

The supply, demand, and efficiency factors in economic growth are related. Unemployment caused by insufficient total spending (the demand factor) may lower the rate of new capital accumulation (a supply factor) and delay expenditures on research (also a supply factor). Conversely, low spending on investment (a supply factor) may cause insufficient spending (the demand factor) and unemployment. Widespread inefficiency in the use of resources (the efficiency factor) may translate into higher costs of goods and services and thus lower profits, which in turn may slow innovation and reduce the accumulation of capital (supply factors).

ORIGIN OF THE IDEA

O 25.1
Growth theory

Economic growth is a dynamic process in which the supply, demand, and efficiency factors all interact.

Production Possibilities Analysis

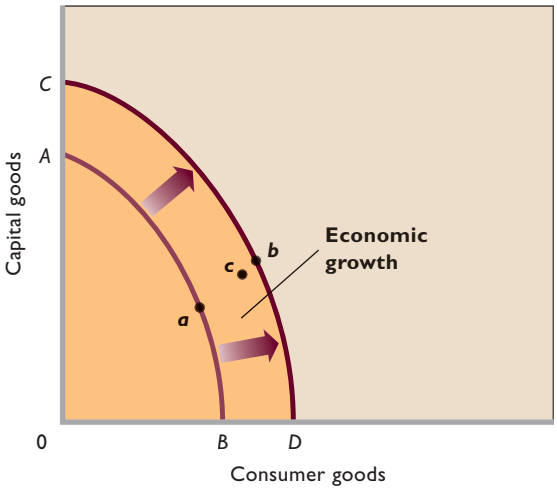
To put the six factors affecting the rate of economic growth into better perspective, let's use the production possibilities analysis introduced in Chapter 1.

Growth and Production Possibilities

Recall that a curve like *AB* in Figure 25.2 is a production possibilities curve. It indicates the various *maximum* combinations of products an economy can produce with its fixed quantity and quality of natural, human, and capital resources and its stock of technological knowledge. An improvement in any of the supply factors will push the production possibilities curve outward, as from *AB* to *CD*.

But the demand factor reminds us that an increase in total spending is needed to move the economy from a point like *a* on curve *AB* to any of the points on the higher curve *CD*. And the efficiency factor reminds us that we need least-cost production and an optimal location on *CD* for the resources to make their maximum possible dollar contribution to total output. You will recall from Chapter 1 that this "best allocation" is determined by expanding production of each good until its marginal benefit equals its marginal cost. Here, we assume that this optimal combination of capital and consumer goods occurs at point *b*.

FIGURE 25.2 Economic growth and the production possibilities curve. Economic growth is made possible by the four supply factors that shift the production possibilities curve outward, as from *AB* to *CD*. Economic growth is realized when the demand factor and the efficiency factor move the economy from point *a* to point *b*.



Example: The net increase in the size of the labor force in the United States in recent years has been 1.5 to 2 million workers per year. That increment raises the economy's production capacity. But obtaining the extra output that these added workers could produce depends on their success in finding jobs. It also depends on whether or not the jobs are in firms and industries where the workers' talents are fully and optimally used. Society does not want new labor-force entrants to be unemployed. Nor does it want pediatricians working as plumbers or pediatricians producing services for which marginal costs exceed marginal benefits.

Normally, increases in total spending match increases in production capacity, and the economy moves from a point on the previous production possibilities curve to a point on the expanded curve. Moreover, the competitive market system tends to drive the economy toward productive and allocative efficiency. Occasionally, however, the curve may shift outward but leave the economy behind at some level of operation such as *c* in Figure 25.2. Because *c* is inside the new production possibilities curve *CD*, the economy has not realized its potential for economic growth. **(Key Question 5)**

Labor and Productivity

Although the demand and efficiency factors are important, discussions of economic growth focus primarily on supply factors. Society can increase its real output and income in two fundamental ways: (1) by increasing its inputs of resources and (2) by raising the productivity of those inputs. Figure 25.3 concentrates on the input of *labor* and provides a useful framework for discussing the role of supply factors in growth. A nation's real GDP in any year depends on the input of labor (measured in hours of work) multiplied by **labor productivity** (measured as real output per hour of work):

$$\text{Real GDP} = \text{hours of work} \times \text{labor productivity}$$

Thought of this way, a nation's economic growth from one year to the next depends on its *increase* in labor inputs (if any) and its *increase* in labor productivity (if any).

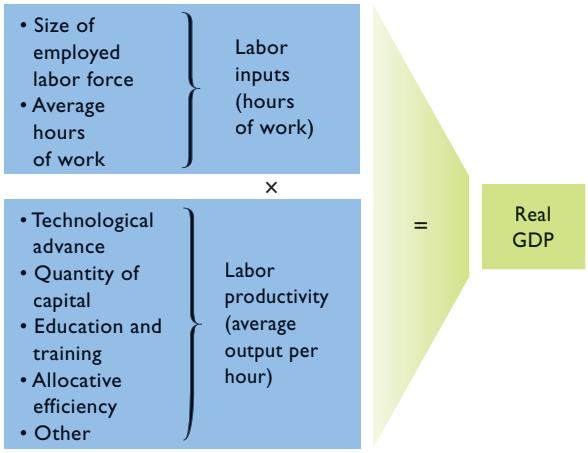
Illustration: Assume that the hypothetical economy of Ziam has 10 workers in year 1, each working 2000 hours per year (50 weeks at 40 hours per week). The total input of labor therefore is 20,000 hours. If productivity (average real output per hour of work) is $10, then real GDP in Ziam will be $200,000 (= 20,000 × $10). If work hours rise to 20,200 and labor productivity rises to $10.40, Ziam's real GDP will increase to $210,080 in year 2. Ziam's rate of economic growth will be about 5% [= ($210,080 − $200,000)/$200,000] for the year.

WORKED PROBLEMS

W 25.2

Productivity and economic growth

FIGURE 25.3 The supply determinants of real output.
Real GDP is usefully viewed as the product of the quantity of labor inputs (hours of work) multiplied by labor productivity.



Hours of Work

What determines the number of hours worked each year? As shown in Figure 25.3, the hours of labor input depend on the size of the employed labor force and the length of the average workweek. Labor-force size depends on the size of the working-age population and the **labor-force participation rate**—the percentage of the working-age population actually in the labor force. The length of the average workweek is governed by legal and institutional considerations and by collective bargaining agreements negotiated between unions and employers.

Labor Productivity

Figure 25.3 tells us that labor productivity is determined by technological progress, the quantity of capital goods available to workers, the quality of the labor itself, and the efficiency with which inputs are allocated, combined, and managed. Productivity rises when the health, training, education, and motivation of workers improve; when workers have more and better machinery and natural resources with which to work; when production is better organized and managed; and when labor is reallocated from less-efficient industries to more-efficient industries.

Accounting for Growth

The Council of Economic Advisers uses a system called **growth accounting** to assess the relative importance of the supply-side elements that contribute to changes in real

GDP. This system groups these elements into two main categories:

- Increases in hours of work.
- Increases in labor productivity.

Labor Inputs versus Labor Productivity

Table 25.3 provides the relevant data for the United States for five periods. The symbol "Q" in the table stands for "quarter" of the year. The beginning points for the first four periods are business-cycle peaks, and the last period includes future projections by the President's Council of Economic Advisers. It is clear from the table that both increases in the quantity of labor and increases in labor productivity are important sources of economic growth. Between 1953 and 2007, the labor force increased from 63 million to 154 million workers. Over that period the average length of the workweek remained relatively stable. Falling birthrates slowed the growth of the native population, but increased immigration partly offset that slowdown. As indicated in the Consider This box to the right, of particular significance was a surge of women's participation in the labor force. Partly as a result, U.S. labor-force growth averaged 1.7 million workers per year over the past 54 years.

The growth of labor productivity also has been important to economic growth. In fact, productivity growth has usually been the more significant factor, with the exception of 1973–1995 when productivity growth greatly slowed. For example, between 2001 and 2007, productivity growth was responsible for all of the 2.6 percent average annual economic growth. Between 2007 and 2013, productivity growth is projected to account for about 90 percent of the growth of real GDP.

Because increases in labor productivity are so important to economic growth, economists go to the trouble of investigating and assessing the relative importance of the factors that contribute to productivity growth. There are five factors that, together, appear to explain changes in productivity growth rates: technological advance, the amount of capital each worker has to work with, education and training, economies of scale, and resource allocation. We will examine each factor in turn, noting how much each factor contributes to productivity growth.

Technological Advance

The largest contributor to productivity growth is technological advance, which is thought to account for about 40 percent of productivity growth. As economist Paul Romer stated, "Human history teaches us that economic growth springs from better recipes, not just from more cooking."

Technological advance includes not only innovative production techniques but new managerial methods and new forms of business organization that improve the process of production. Generally, technological advance is generated by the discovery of new knowledge, which allows resources to be combined in improved ways that increase output. Once discovered and implemented, new knowledge soon becomes available to entrepreneurs and firms at relatively low cost. Technological advance therefore eventually spreads through the entire economy, boosting productivity and economic growth.

Technological advance and capital formation (investment) are closely related, since technological advance usually promotes investment in new machinery and equipment. In fact, technological advance is often *embodied* within new capital. For example, the purchase of new computers brings into industry speedier, more powerful computers that incorporate new technology.

Technological advance has been both rapid and profound. Gas and diesel engines, conveyor belts, and assembly lines are significant developments of the past. So, too, are fuel-efficient commercial aircraft, integrated microcircuits, personal computers, digital photography, and containerized shipping. More recently, technological

TABLE 25.3 Accounting for Growth of U.S. Real GDP, 1953–2013 (Average Annual Percentage Changes)

Item	1953 Q2 to 1973 Q4	1973 Q4 to 1995 Q2	1995 Q2 to 2001 Q1	2001 Q1 to 2007 Q3	2007 Q3 to 2013 Q4*
Increase in real GDP	3.6	2.8	3.8	2.6	2.8
Increase in quantity of labor	1.1	1.3	1.4	−0.1	0.3
Increase in labor productivity	2.5	1.5	2.4	2.7	2.5

*Rates beyond 2007 are projected rates.

Source: Derived from *Economic Report of the President, 2008*, p. 45.

CONSIDER THIS . . .

Women, the Labor Force, and Economic Growth

The substantial rise in the number of women working in the paid workforce in the United States has been one of the major labor market trends of the past half-century. In 1965, some 40 percent of women worked full-time or part-time in paid jobs. Today, that number is 59 percent.

Women have greatly increased their productivity in the workplace, mostly by becoming better educated and professionally trained. Rising productivity has increased women's wage rates. Those higher wages have raised the opportunity costs—the forgone wage earnings—of staying at home. Women have therefore substituted employment in the labor market for traditional home activities. This substitution has been particularly pronounced among married women. (Single women have always had high labor-force participation rates.)

Furthermore, changing lifestyles and the widespread availability of birth control have freed up time for greater labor-force participation by women. Women not only have fewer children, but those children are spaced closer together in age. Thus women who leave their jobs during their children's early years return to the labor force sooner.

Greater access to jobs by women also has been a significant factor in the rising labor-force participation of women. Service industries—teaching, nursing, and office work, for instance—that traditionally have employed many women have expanded rapidly in the past several decades. Also, the population in general has shifted from farms and rural regions to urban areas, where jobs for women are more abundant and more geographically accessible. An increased availability of part-time jobs also has made it easier for women to combine labor market employment with child-rearing and household activities. Also, antidiscrimination laws and enforcement efforts have reduced barriers that previously discouraged or prevented women from taking traditional male jobs such as business managers, lawyers, professors, and physicians. More jobs are open to women today than a half-century ago.

In summary, women in the United States are better educated, more productive, and more efficiently employed than ever before. Their increased presence in the labor force has contributed greatly to U.S. economic growth.

advance has exploded, particularly in the areas of computers, photography, wireless communications, and the Internet. Other fertile areas of recent innovation are medicine and biotechnology.

Quantity of Capital

A second major contributor to productivity growth is increased capital, which explains roughly 30 percent of productivity growth. More and better plant and equipment make workers more productive. And a nation acquires more capital by saving some of its income and using that savings to invest in plant and equipment.

Although some capital substitutes for labor, most capital is complementary to labor—it makes labor more productive. A key determinant of labor productivity is the amount of capital goods available *per worker*. If both the aggregate stock of capital goods and the size of the labor force increase over a given period, the individual worker is not necessarily better equipped and productivity will not necessarily rise. But the quantity of capital equipment available per U.S. worker has increased greatly over time. (In 2006 it was about $97,140 per worker.)

Public investment in the U.S. **infrastructure** (highways and bridges, public transit systems, wastewater treatment facilities, water systems, airports, educational facilities, and so on) has also grown over the years. This publicly owned capital complements private capital. Investments in new highways promote private investment in new factories and retail stores along their routes. Industrial parks developed by local governments attract manufacturing and distribution firms.

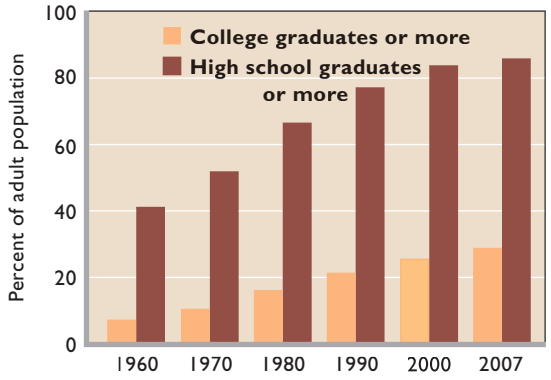
Private investment in infrastructure also plays a large role in economic growth. One example is the tremendous growth of private capital relating to communications systems over the years.

Education and Training

Ben Franklin once said, "He that hath a trade hath an estate," meaning that education and training contribute to a worker's stock of **human capital**—the knowledge and skills that make a worker productive. Investment in human capital includes not only formal education but also on-the-job training. Like investment in physical capital, investment in human capital is an important means of increasing labor productivity and earnings. An estimated 15 percent of productivity growth derives from investments in people's education and skills.

One measure of a nation's quality of labor is its level of educational attainment. Figure 25.4 shows large gains in education attainment over the past several decades. In 1960 only 41 percent of the U.S. population age 25 or older had at least a high school education; and only 8 percent had a college or postcollege education. By 2007, those numbers had increased to 86 and 29 percent, respectively.

FIGURE 25.4 Changes in the educational attainment of the U.S. adult population. The percentage of the U.S. adult population, age 25 or older, completing high school and college has been rising over recent decades.



Source: U.S. Census Bureau, **www.census.gov.**

Clearly, more people are receiving more education than ever before.

But all is not upbeat with education in the United States. Many observers think that the quality of education in the United States has declined. For example, U.S. students perform poorly on science and math tests relative to students in many other nations (see Global Perspective 25.1). And the United States has been producing fewer engineers and scientists, a problem that may trace back to inadequate training in math and science in elementary and high schools. For these reasons, much recent public policy discussion and legislation has been directed toward improving the quality of the U.S. education and training system.

Economies of Scale and Resource Allocation

Economies of scale and improved resource allocation are a fourth and fifth source of productivity growth, and together they explain about 15 percent of productivity growth.

Economies of Scale Reductions in per-unit production costs that result from increases in output levels are called **economies of scale.** Markets have increased in size over time, allowing firms to increase output levels and thereby achieve production advantages associated with greater size. As firms expand their size and output, they are able to use larger, more productive equipment and employ methods of manufacturing and delivery that increase productivity. They also are better able to recoup substantial investments in developing new products and production methods. Examples: A large manufacturer of autos can use elaborate assembly lines with computerization and robotics, while smaller producers must settle for less-advanced technologies using more labor inputs. Large pharmaceutical firms greatly reduce the average amount of labor (researchers, production workers) needed to produce each pill as they increase the number of pills produced.

GLOBAL PERSPECTIVE 25.1

Average Test Scores of Eighth-Grade Students in Math and Science, Top 10 Countries and the United States

The test performance of U.S. eighth-grade students did not compare favorably with that of eighth-graders in several other nations in the Third International Math and Science Study (2003).

Mathematics

Rank		Score
1	Singapore	605
2	South Korea	589
3	Hong Kong	586
4	Taiwan	585
5	Japan	570
6	Belgium	537
7	Netherlands	536
8	Estonia	531
9	Hungary	529
10	Malaysia	508
15	United States	504

Science

Rank		Score
1	Singapore	578
2	Taiwan	571
3	South Korea	558
4	Hong Kong	556
5	Estonia	552
6	Japan	552
7	Hungary	543
8	Netherlands	536
9	United States	527
10	Australia	527