CHAPTER 2

The Basics of Supply and Demand

One of the best ways to appreciate the relevance of economics is to begin with the basics of supply and demand. Supply-demand analysis is a fundamental and powerful tool that can be applied to a wide variety of interesting and important problems. To name a few:

- Understanding and predicting how changing world economic conditions affect market price and production
- Evaluating the impact of government price controls, minimum wages, price supports, and production incentives
- Determining how taxes, subsidies, tariffs, and import quotas affect consumers and producers

We begin with a review of how supply and demand curves are used to describe the *market mechanism*. Without government intervention (e.g., through the imposition of price controls or some other regulatory policy), supply and demand will come into equilibrium to determine both the market price of a good and the total quantity produced. What that price and quantity will be depends on the particular characteristics of supply and demand. Variations of price and quantity over time depend on the ways in which supply and demand respond to other economic variables, such as aggregate economic activity and labor costs, which are themselves changing.

We will, therefore, discuss the characteristics of supply and demand and show how those characteristics may differ from one market to another. Then we can begin to use supply and demand curves to understand a variety of phenomena—for example, why the prices of some basic commodities have fallen steadily over a long period while the prices of others have experienced sharp fluctuations; why shortages occur in certain markets; and why announcements about plans for future government policies or predictions about future economic conditions can affect markets well before those policies or conditions become reality.

Besides understanding *qualitatively* how market price and quantity are determined and how they can vary over time, it is also important to learn how they can be analyzed *quantitatively*. We will see how simple "back of the envelope" calculations can be used to analyze and predict evolving market conditions. We will also show how markets respond both to domestic and international

CHAPTER OUTLINE

LIST OF EXAMPLES

macroeconomic fluctuations and to the effects of government interventions. We will try to convey this understanding through simple examples and by urging you to work through some exercises at the end of the chapter.

2.1 Supply and Demand

The basic model of supply and demand is the workhorse of microeconomics. It helps us understand why and how prices change, and what happens when the government intervenes in a market. The supply-demand model combines two important concepts: a *supply curve* and a *demand curve*. It is important to understand precisely what these curves represent.

The Supply Curve

supply curve Relationship between the quantity of a good that producers are willing to sell and the price of the good.

The **supply curve** shows the quantity of a good that producers are willing to sell at a given price, holding constant any other factors that might affect the quantity supplied. The curve labeled S in Figure 2.1 illustrates this. The vertical axis of the graph shows the price of a good, P, measured in dollars per unit. This is the price that sellers receive for a given quantity supplied. The horizontal axis shows the total quantity supplied, Q, measured in the number of units per period.

The supply curve is thus a relationship between the quantity supplied and the price. We can write this relationship as an equation:

$$Q_S = Q_S(P)$$

Or we can draw it graphically, as we have done in Figure 2.1.

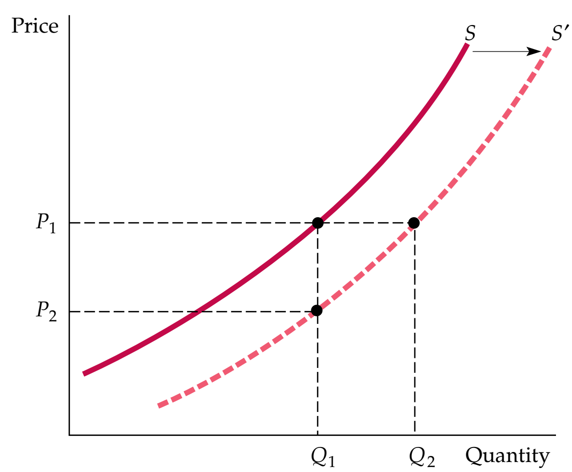

FIGURE 2.1 The Supply Curve

The supply curve, labeled S in the figure, shows how the quantity of a good offered for sale changes as the price of the good changes. The supply curve is upward sloping: The higher the price, the more firms are able and willing to produce and sell. If production costs fall, firms can produce the same quantity at a lower price or a larger quantity at the same price. The supply curve then shifts to the right (from S to S').

Note that the supply curve in Figure 2.1 slopes upward. In other words, the higher the price, *the more that firms are able and willing to produce and sell*. For example, a higher price may enable current firms to expand production by hiring extra workers or by having existing workers work overtime (at greater cost to the firm). Likewise, they may expand production over a longer period of time by increasing the size of their plants. A higher price may also attract new firms to the market. These newcomers face higher costs because of their inexperience in the market and would therefore have found entry uneconomical at a lower price.

Other Variables That Affect Supply The quantity supplied can depend on other variables besides price. For example, the quantity that producers are willing to sell depends not only on the price they receive but also on their production costs, including wages, interest charges, and the costs of raw materials. The supply curve labeled S in Figure 2.1 was drawn for particular values of these other variables. A change in the values of one or more of these variables translates into a shift in the supply curve. Let's see how this might happen.

The supply curve S in Figure 2.1 says that at a price P_1, the quantity produced and sold would be Q_1. Now suppose that the cost of raw materials *falls*. How does this affect the supply curve?

Lower raw material costs—indeed, lower costs of any kind—make production more profitable, encouraging existing firms to expand production and enabling new firms to enter the market. If at the same time the market price stayed constant at P_1, we would expect to observe a greater quantity supplied. Figure 2.1 shows this as an increase from Q_1 to Q_2. When production costs *decrease*, output *increases* no matter what the market price happens to be. *The entire supply curve thus shifts to the right*, which is shown in the figure as a shift from S to S'.

Another way of looking at the effect of lower raw material costs is to imagine that the quantity produced stays fixed at Q_1 and then ask what price firms would require to produce this quantity. Because their costs are lower, they would accept a lower price—P_2. This would be the case no matter what quantity was produced. Again, we see in Figure 2.1 that the supply curve must shift to the right.

We have seen that the response of quantity supplied to changes in price can be represented by movements *along the supply curve*. However, the response of supply to changes in other supply-determining variables is shown graphically as a *shift of the supply curve itself*. To distinguish between these two graphical depictions of supply changes, economists often use the phrase *change in supply* to refer to shifts in the supply curve, while reserving the phrase *change in the quantity supplied* to apply to movements along the supply curve.

The Demand Curve

The **demand curve** shows how much of a good consumers are willing to buy as the price per unit changes. We can write this relationship between quantity demanded and price as an equation:

demand curve Relationship between the quantity of a good that consumers are willing to buy and the price of the good.

$$Q_D = Q_D(P)$$

or we can draw it graphically, as in Figure 2.2. Note that the demand curve in that figure, labeled D, slopes *downward*: Consumers are usually ready to buy more if the price is lower. For example, a lower price may encourage consumers who have already been buying the good to consume larger quantities. Likewise, it may allow other consumers who were previously unable to afford the good to begin buying it.

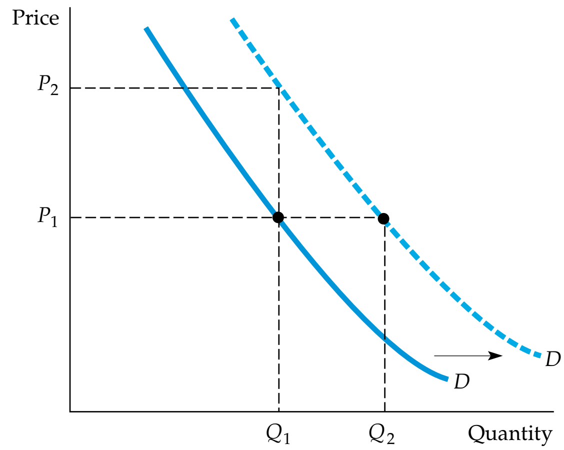

FIGURE 2.2 The Demand Curve

The demand curve, labeled *D*, shows how the quantity of a good demanded by consumers depends on its price. The demand curve is downward sloping; holding other things equal, consumers will want to purchase more of a good as its price goes down. The quantity demanded may also depend on other variables, such as income, the weather, and the prices of other goods. For most products, the quantity demanded increases when income rises. A higher income level shifts the demand curve to the right (from *D* to *D′*).

Of course the quantity of a good that consumers are willing to buy can depend on other things besides its price. *Income* is especially important. With greater incomes, consumers can spend more money on any good, and some consumers will do so for most goods.

Shifting the Demand Curve Let's see what happens to the demand curve if income levels increase. As you can see in Figure 2.2, if the market price were held constant at P_1, we would expect to see an increase in the quantity demanded—say, from Q_1 to Q_2, as a result of consumers' higher incomes. Because this increase would occur no matter what the market price, the result would be a *shift to the right of the entire demand curve*. In the figure, this is shown as a shift from *D* to *D′*. Alternatively, we can ask what price consumers would pay to purchase a given quantity Q_1. With greater income, they should be willing to pay a higher price—say, P_2 instead of P_1 in Figure 2.2. Again, *the demand curve will shift to the right*. As we did with supply, we will use the phrase *change in demand* to refer to shifts in the demand curve, and reserve the phrase *change in the quantity demanded* to apply to movements along the demand curve.[1]

substitutes Two goods for which an increase in the price of one leads to an increase in the quantity demanded of the other.

Substitute and Complementary Goods Changes in the prices of related goods also affect demand. Goods are **substitutes** when an increase in the price of one leads to an increase in the quantity demanded of the other. For example,

[1]Mathematically, we can write the demand curve as

$$Q_D = D(P,I)$$

where *I* is disposable income. When we draw a demand curve, we are keeping *I* fixed.

copper and aluminum are substitute goods. Because one can often be substituted for the other in industrial use, *the quantity of copper demanded will increase if the price of aluminum increases*. Likewise, beef and chicken are substitute goods because most consumers are willing to shift their purchases from one to the other when prices change.

Goods are **complements** when an increase in the price of one leads to a decrease in the quantity demanded of the other. For example, automobiles and gasoline are complementary goods. Because they tend to be used together, a decrease in the price of gasoline increases the quantity demanded for automobiles. Likewise, computers and computer software are complementary goods. The price of computers has dropped dramatically over the past decade, fueling an increase not only in purchases of computers, but also purchases of software packages.

complements Two goods for which an increase in the price of one leads to a decrease in the quantity demanded of the other.

We attributed the shift to the right of the demand curve in Figure 2.2 to an increase in income. However, this shift could also have resulted from either an increase in the price of a substitute good or a decrease in the price of a complementary good. Or it might have resulted from a change in some other variable, such as the weather. For example, demand curves for skis and snowboards will shift to the right when there are heavy snowfalls.

2.2 The Market Mechanism

The next step is to put the supply curve and the demand curve together. We have done this in Figure 2.3. The vertical axis shows the price of a good, P, again measured in dollars per unit. This is now the price that sellers receive for a given quantity supplied, and the price that buyers will pay for a given quantity demanded. The horizontal axis shows the total quantity demanded and supplied, Q, measured in number of units per period.

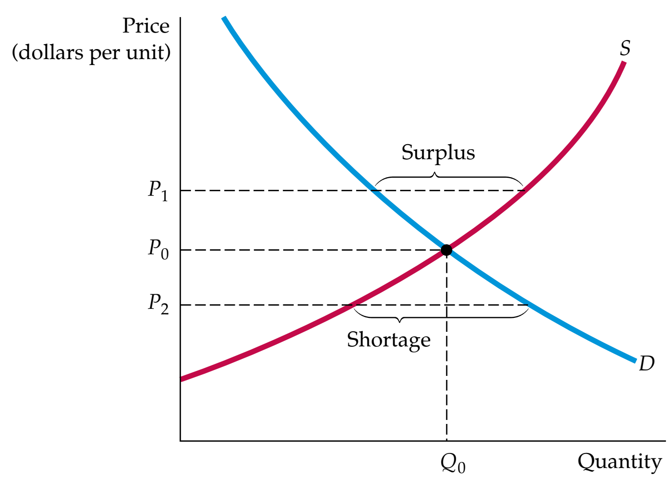

FIGURE 2.3 Supply and Demand

The market clears at price P_0 and quantity Q_0. At the higher price P_1, a surplus develops, so price falls. At the lower price P_2, there is a shortage, so price is bid up.

equilibrium (or market-clearing) price Price that equates the quantity supplied to the quantity demanded.

market mechanism Tendency in a free market for price to change until the market clears.

surplus Situation in which the quantity supplied exceeds the quantity demanded.

shortage Situation in which the quantity demanded exceeds the quantity supplied.

Equilibrium The two curves intersect at the **equilibrium**, or **market-clearing, price** and quantity. At this price (P_0 in Figure 2.3), the quantity supplied and the quantity demanded are just equal (to Q_0). The **market mechanism** is the tendency in a free market for the price to change until the market *clears*—i.e., until the quantity supplied and the quantity demanded are equal. At this point, because there is neither excess demand nor excess supply, there is no pressure for the price to change further. Supply and demand might not always be in equilibrium, and some markets might not clear quickly when conditions change suddenly. The *tendency*, however, is for markets to clear.

To understand why markets tend to clear, suppose the price were initially above the market-clearing level—say, P_1 in Figure 2.3. Producers will try to produce and sell more than consumers are willing to buy. A **surplus**—a situation in which the quantity supplied exceeds the quantity demanded—will result. To sell this surplus—or at least to prevent it from growing—producers would begin to lower prices. Eventually, as price fell, quantity demanded would increase, and quantity supplied would decrease until the equilibrium price P_0 was reached.

The opposite would happen if the price were initially below P_0—say, at P_2. A **shortage**—a situation in which the quantity demanded exceeds the quantity supplied—would develop, and consumers would be unable to purchase all they would like. This would put upward pressure on price as consumers tried to outbid one another for existing supplies and producers reacted by increasing price and expanding output. Again, the price would eventually reach P_0.

When Can We Use the Supply-Demand Model? When we draw and use supply and demand curves, we are assuming that at any given price, a given quantity will be produced and sold. This assumption makes sense only if a market is at least roughly *competitive*. By this we mean that both sellers and buyers should have little *market power*—i.e., little ability *individually* to affect the market price.

Suppose instead that supply were controlled by a single producer—a monopolist. In this case, there will no longer be a simple one-to-one relationship between price and the quantity supplied. Why? Because a monopolist's behavior depends on the shape and position of the demand curve. If the demand curve shifts in a particular way, it may be in the monopolist's interest to keep the quantity fixed but change the price, or to keep the price fixed and change the quantity. (How this could occur is explained in Chapter 10.) Thus when we work with supply and demand curves, we implicitly assume that we are referring to a competitive market.

2.3 Changes in Market Equilibrium

We have seen how supply and demand curves shift in response to changes in such variables as wage rates, capital costs, and income. We have also seen how the market mechanism results in an equilibrium in which the quantity supplied equals the quantity demanded. Now we will see how that equilibrium changes in response to shifts in the supply and demand curves.

Let's begin with a shift in the supply curve. In Figure 2.4, the supply curve has shifted from S to S' (as it did in Figure 2.1), perhaps as a result of a decrease in the price of raw materials. As a result, the market price drops (from P_1 to P_3), and the total quantity produced increases (from Q_1 to Q_3). This is what we would expect: Lower costs result in lower prices and increased sales. (Indeed, gradual decreases in costs resulting from technological progress and better management are an important driving force behind economic growth.)

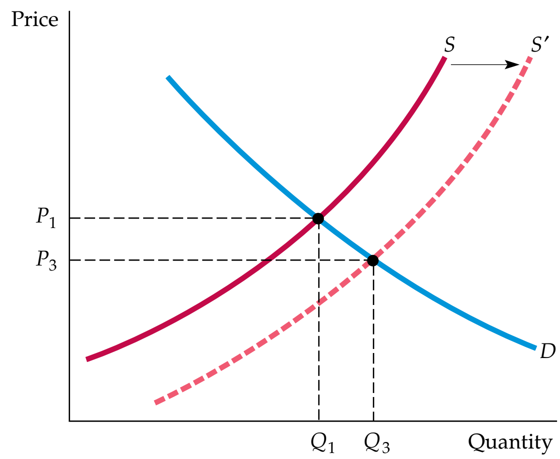

FIGURE 2.4 New Equilibrium Following Shift in Supply

When the supply curve shifts to the right, the market clears at a lower price P_3 and a larger quantity Q_3.

Figure 2.5 shows what happens following a rightward shift in the demand curve resulting from, say, an increase in income. A new price and quantity result after demand comes into equilibrium with supply. As shown in Figure 2.5, we would expect to see consumers pay a higher price, P_3, and firms produce a greater quantity, Q_3, as a result of an increase in income.

In most markets, both the demand and supply curves shift from time to time. Consumers' disposable incomes change as the economy grows (or contracts,

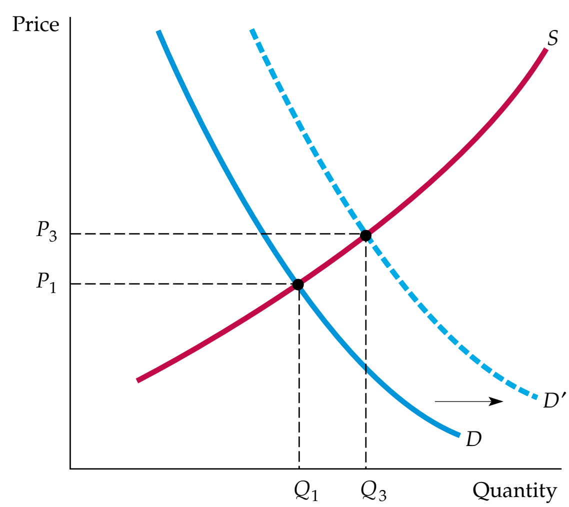

FIGURE 2.5 New Equilibrium Following Shift in Demand

When the demand curve shifts to the right, the market clears at a higher price P_3 and a larger quantity Q_3.

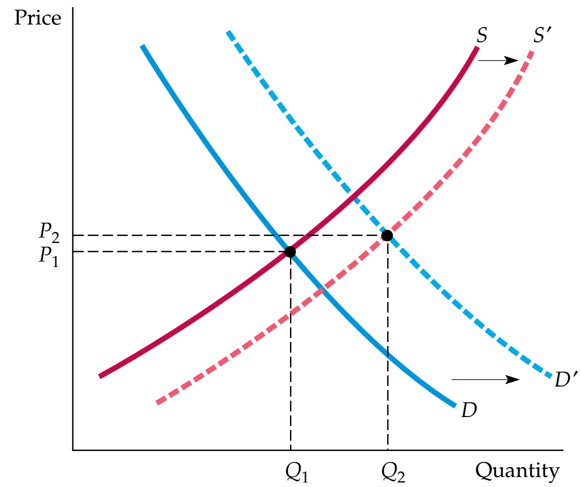

FIGURE 2.6 New Equilibrium Following Shifts in Supply and Demand

Supply and demand curves shift over time as market conditions change. In this example, rightward shifts of the supply and demand curves lead to a slightly higher price and a much larger quantity. In general, changes in price and quantity depend on the amount by which each curve shifts and the shape of each curve.

during economic recessions). The demands for some goods shift with the seasons (e.g., fuels, bathing suits, umbrellas), with changes in the prices of related goods (an increase in oil prices increases the demand for natural gas), or simply with changing tastes. Similarly, wage rates, capital costs, and the prices of raw materials also change from time to time, and these changes shift the supply curve.

Supply and demand curves can be used to trace the effects of these changes. In Figure 2.6, for example, shifts to the right of both supply and demand result in a slightly higher price (from P_1 to P_2) and a much larger quantity (from Q_1 to Q_2). In general, price and quantity will change depending both on how much the supply and demand curves shift and on the shapes of those curves. To predict the sizes and directions of such changes, we must be able to characterize quantitatively the dependence of supply and demand on price and other variables. We will turn to this task in the next section.

EXAMPLE 2.1 The Price of Eggs and the Price of a College Education Revisited

In Example 1.3, we saw that from 1970 to 2002, the real (constant-dollar) price of eggs fell by 74 percent, while the real price of a college education rose by 55 percent. What caused this large decline in egg prices and large increase in the price of college?

We can understand these price changes by examining the behavior of supply and demand for each good, as shown in Figure 2.7. For eggs, the mechanization of poultry farms sharply reduced the cost of producing eggs, shifting the supply curve downward. At the same time, the demand curve for eggs shifted to the left as a more health-conscious population changed its eating habits and tended to avoid eggs. As a result, the real price of eggs declined sharply, but total annual consumption increased only slightly (from 5300 million dozen to 5900 million dozen).

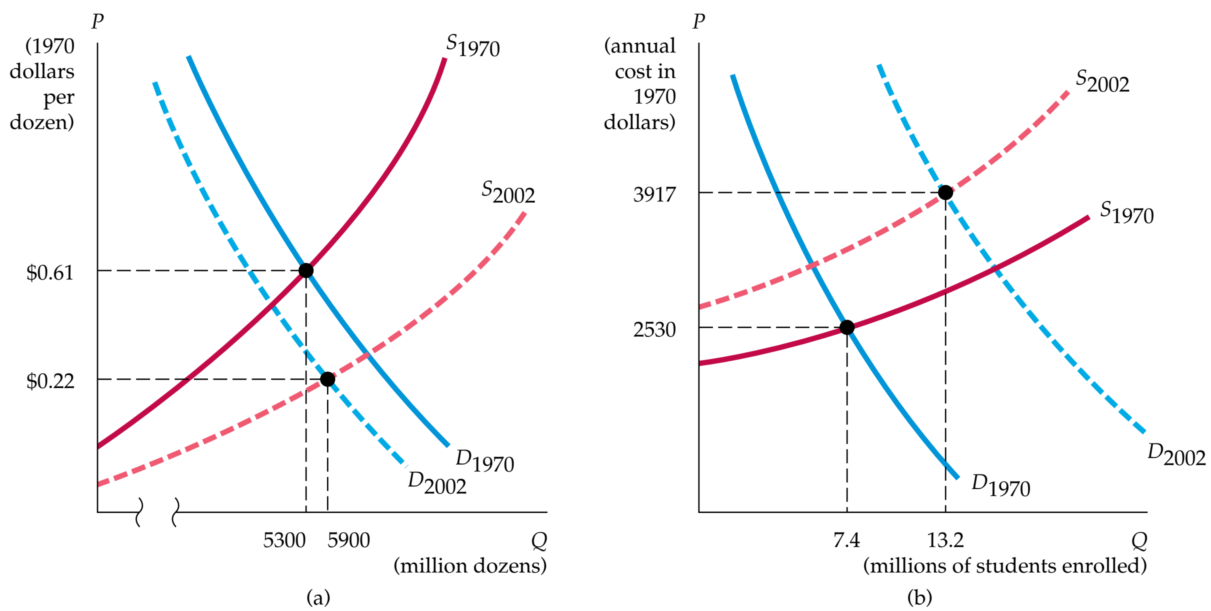

FIGURE 2.7 (a) Market for Eggs (b) Market for College Education

(a) The supply curve for eggs shifted downward as production costs fell; the demand curve shifted to the left as consumer preferences changed. As a result, the real price of eggs fell sharply and egg consumption rose slightly. **(b)** The supply curve for a college education shifted up as the costs of equipment, maintenance, and staffing rose. The demand curve shifted to the right as a growing number of high school graduates desired a college education. As a result, both price and enrollments rose sharply.

As for college, supply and demand shifted in the opposite directions. Increases in the costs of equipping and maintaining modern classrooms, laboratories, and libraries, along with increases in faculty salaries, pushed the supply curve up. At the same time, the demand curve shifted to the right as a larger percentage of a growing number of high school graduates decided that a college education was essential. Thus, despite the increase in price, 2002 found more than 13 million students enrolled in undergraduate college degree programs, compared with 7.4 million in 1970.

EXAMPLE 2.2 Wage Inequality in the United States

Although the U.S. economy has grown vigorously over the past two decades, the gains from this growth have not been shared equally by all. The wages of skilled high-income workers have grown substantially, while the wages of unskilled low-income workers have, in real terms, actually fallen slightly. Overall, there has been growing inequality in the distribution of earnings, a phenomenon which began around 1980 and has accelerated in recent years. For example, from 1978 to 2001, people in the top 20 percent of the income distribution experienced an increase in their average real (inflation-adjusted) pretax household income of 52 percent, while those in the bottom 20 percent saw their average real pretax income increase by only 8 percent.[2]

Why has income distribution become so much more unequal during the past two decades? The answer is in the supply and demand for workers. While the supply of unskilled workers—people with limited educations—has grown substantially, the demand for them has risen only slightly. This shift of the supply curve to the right, combined with little movement of the demand curve, has caused wages of unskilled workers to fall. On the other hand, while the supply of skilled workers—e.g., engineers, scientists, managers, and economists—has grown slowly, the demand has risen dramatically, pushing wages up. (We leave it to you as an exercise to draw supply and demand curves and show how they have shifted, as was done in Example 2.1.)

These trends are evident in the behavior of wages for different categories of employment. From 1980 to 2001, for example, the real (inflation-adjusted) weekly earnings of skilled workers (such as finance, insurance, and real estate workers) *rose* by more than 30 percent. Over the same period, the weekly real incomes of relatively unskilled workers (such as retail trade workers) *fell* by more than 8 percent.[3]

Most projections point to a continuation of this phenomenon during the coming decade. As the high-tech sectors of the American economy grow, the demand for highly skilled workers is likely to increase further. At the same time, the computerization of offices and factories will further reduce the demand for unskilled workers. (This trend is discussed further in Example 14.7.) These changes can only exacerbate wage inequality.

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[2]In *after-tax* terms, the growth of inequality has been even greater; the average real after-tax income of the bottom 20 percent of the distribution *fell* over this period. For historical data on income inequality in the United States, see the Historical Income Inequality Tables at the U.S. Census Bureau Web site: **http://www.census.gov/**.

[3]For detailed earnings data, visit the Detailed Statistics section of the Web site of the Bureau of Labor Statistics (BLS): **http://www.bls.gov/**. Select Employment, Hours, and Earnings from the Current Employment Statistics survey (National).

EXAMPLE 2.3 The Long-Run Behavior of Natural Resource Prices

Many people are concerned about the earth's natural resources. At issue is whether our energy and mineral resources are likely to be depleted in the near future, leading to sharp price increases that could bring an end to economic growth. An analysis of supply and demand can give us some perspective.

The earth does indeed have only a finite amount of mineral resources, such as copper, iron, coal, and oil. During the past century, however, the prices of these and most other natural resources have declined or remained roughly constant relative to overall prices. Figure 2.8, for example, shows the price of copper in real terms (adjusted for inflation), together with the quantity consumed from 1880 to 2002. (Both are shown as an index, with 1880 = 1.) Despite short-term variations in price, no significant long-term increase has occurred, even though annual consumption is now about 100 times greater than in 1880. Similar patterns hold for other mineral resources, such as iron, oil, and coal.[4]

As you can see from Figure 2.9, the demands for these resources grew along with the world economy. But as demand grew, production costs fell. The decline in costs was due, first, to the discovery of new and bigger deposits that were cheaper to mine, and then to technical progress and the economic

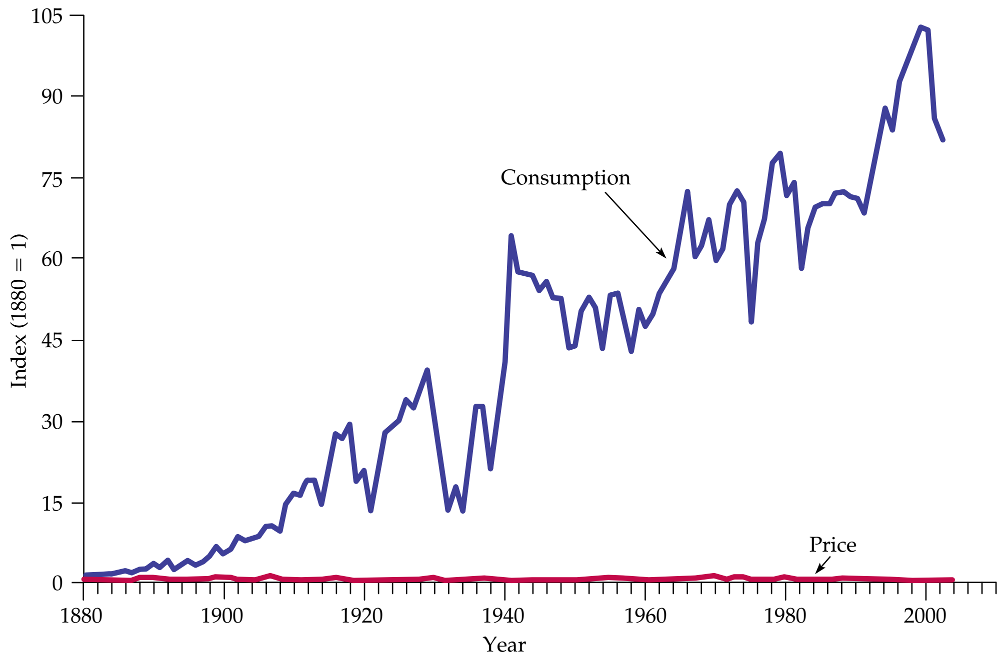

FIGURE 2.8 Consumption and Price of Copper, 1880–2002

Although annual consumption of copper has increased about a hundredfold, the real (inflation-adjusted) price has not changed much.

[4]The index of U.S. copper consumption was around 102 in 1999 and 2000 but then dropped off significantly due to the slowing economy in 2001 and 2002. Consumption data (1880–1899) and price data (1880–1969) in Figure 2.8 are from Robert S. Manthy, *Natural Resource Commodities—A Century of Statistics* (Baltimore: Johns Hopkins University Press, 1978). More recent price (1970–2002) and consumption data (1970–2002) are from the U.S. Geological Survey—Minerals Information, Copper Statistics and Information (**http://minerals.usgs.gov/**).

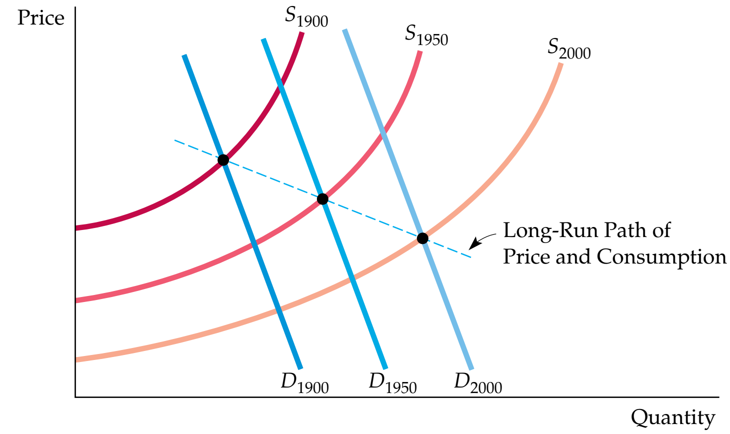

FIGURE 2.9 Long-Run Movements of Supply and Demand for Mineral Resources

Although demand for most resources has increased dramatically over the past century, prices have fallen or risen only slightly in real (inflation-adjusted) terms because cost reductions have shifted the supply curve to the right just as dramatically.

advantage of mining and refining on a large scale. As a result, the supply curve shifted over time to the right. Over the long term, because increases in supply were greater than increases in demand, price often fell, as shown in Figure 2.9.

This is not to say that the prices of copper, iron, and coal will decline or remain constant forever. After all, these resources are *finite*. But as prices begin to rise, consumption will likely shift, at least in part, to substitute materials. Copper, for example, has already been replaced in many applications by aluminum and, more recently, in electronic applications by fiber optics. (See Example 2.7 for a more detailed discussion of copper prices.)

EXAMPLE 2.4 The Effects of 9/11 on the Supply and Demand for New York City Office Space

The September 11, 2001, terrorist attack on the World Trade Center (WTC) complex damaged or destroyed 21 buildings, accounting for 31.2 million square feet (msf) of Manhattan office space—nearly 10 percent of the city's entire inventory. Just prior to the attack, the Manhattan office vacancy rate was 8.0 percent, and the average asking rent was $52.50 per square foot (psf). Given the huge unexpected reduction in the quantity of office space supplied, we might expect the equilibrium rental price of office space to increase and, as a result, the equilibrium quantity of rented office space to decrease. And because it takes time to construct new office buildings and restore damaged ones, we might also expect the vacancy rate to decline sharply.

Surprisingly, however, the vacancy rate in Manhattan *increased* from 8.0 percent in August 2001 to 9.3 percent in November 2001. Moreover, the average rental price *fell* from \$52.50 to \$50.75 per square foot. In downtown Manhattan, the location of the Trade Center, the changes were even more dramatic: The vacancy rate rose from 7.5 percent to 10.6 percent, and the average rental price fell nearly 8 percent, to \$41.81. What happened? Rental prices fell because the demand for office space fell.

Figure 2.10 describes the market for office space in downtown Manhattan. The supply and demand curves before 9/11 appear as S_{Aug} and D_{Aug}. The equilibrium price and quantity of downtown Manhattan office space were \$45.34 psf and 76.4 msf, respectively. The reduction in supply from August until November is indicated by a leftward shift in the supply curve (from S_{Aug} to S'_{Nov}); the result is a higher equilibrium price P' and a lower equilibrium quantity, Q'. This is the outcome that most forecasters predicted for the months following September 11.

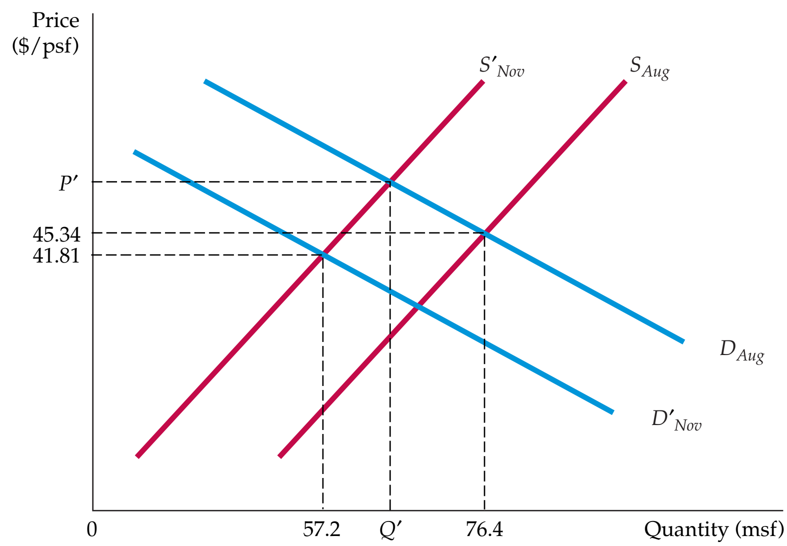

FIGURE 2.10 Supply and Demand for New York City Office Space

Following 9/11 the supply curve shifted to the left, but the demand curve also shifted to the left, so that the average rental price fell.

Many forecasters, however, failed to predict the significant *decrease* in demand for office space complementing the loss in supply. First, many firms, both displaced and non-displaced, chose not to relocate downtown because of quality-of-life concerns (i.e., the WTC ruins, pollution, disabled transportation, and aging inventory). Firms displaced by the attack were also forced to reevaluate their office-space needs, and they ultimately repurchased a little more than 50 percent of their original office space in Manhattan. Others left Manhattan but stayed in New York City; still others moved to New Jersey.[5] Furthermore, in late 2001, the U.S. economy was

[5]See Jason Bram, James Orr, and Carol Rapaport, "Measuring the Effects of the September 11 Attack on New York City," Federal Reserve Bank of New York, *Economic Policy Review*, November, 2002.

experiencing an economic slowdown (exacerbated by the events of September 11) that further reduced the demand for office space. Therefore, the cumulative decrease in demand (a shift from D_{Aug} to D'_{Nov}) actually caused the average rental price of downtown Manhattan office space to decrease rather than increase in the months following September 11. By November, even though the price had fallen to \$41.81, there were 57.2 msf on the market.

2.4 Elasticities of Supply and Demand

We have seen that the demand for a good depends not only on its price, but also on consumer income and on the prices of other goods. Likewise, supply depends both on price and on variables that affect production cost. For example, if the price of coffee increases, the quantity demanded will fall and the quantity supplied will rise. Often, however, we want to know *how much* the quantity supplied or demanded will rise or fall. How sensitive is the demand for coffee to its price? If price increases by 10 percent, how much will the quantity demanded change? How much will it change if income rises by 5 percent? We use *elasticities* to answer questions like these.

elasticity Percentage change in one variable resulting from a 1-percent increase in another.

An **elasticity** measures the sensitivity of one variable to another. Specifically, it is a number that tells us *the percentage change that will occur in one variable in response to a 1-percent increase in another variable*. For example, the *price elasticity of demand* measures the sensitivity of quantity demanded to price changes. It tells us what the percentage change in the quantity demanded for a good will be following a 1-percent increase in the price of that good.

price elasticity of demand Percentage change in quantity demanded of a good resulting from a 1-percent increase in its price.

Price Elasticity of Demand Let's look at this in more detail. Denoting quantity and price by Q and P, we write the **price elasticity of demand**, E_p, as

$$E_p = (\%\Delta Q)/(\%\Delta P)$$

where $\%\Delta Q$ simply means "percentage change in Q" and $\%\Delta P$ means "percentage change in P." (The symbol Δ is the Greek capital letter *delta*; it means "the change in." So ΔX means "the change in the variable X," say, from one year to the next.) The percentage change in a variable is just *the absolute change in the variable divided by the original level of the variable*. (If the Consumer Price Index were 200 at the beginning of the year and increased to 204 by the end of the year, the percentage change—or annual rate of inflation—would be 4/200 = .02, or 2 percent.) Thus we can also write the price elasticity of demand as follows:[6]

$$E_p = \frac{\Delta Q/Q}{\Delta P/P} = \frac{P}{Q}\frac{\Delta Q}{\Delta P} \qquad \textbf{(2.1)}$$

The price elasticity of demand is usually a negative number. When the price of a good increases, the quantity demanded usually falls. Thus $\Delta Q/\Delta P$ (the change in quantity for a change in price) is negative, as is E_p. Sometimes we refer to the *magnitude* of the price elasticity—i.e., its absolute size. For example, if $E_p = -2$, we say that the elasticity is 2 in magnitude.

[6]In terms of infinitesimal changes (letting the ΔP become very small), $E_p = (P/Q)(dQ/dP)$.

When the price elasticity is greater than 1 in magnitude, we say that demand is *price elastic* because the percentage decline in quantity demanded is greater than the percentage increase in price. If the price elasticity is less than 1 in magnitude, demand is said to be *price inelastic*. In general, the price elasticity of demand for a good depends on the availability of other goods that can be substituted for it. When there are close substitutes, a price increase will cause the consumer to buy less of the good and more of the substitute. Demand will then be highly price elastic. When there are no close substitutes, demand will tend to be price inelastic.

Linear Demand Curve Equation (2.1) says that the price elasticity of demand is the change in quantity associated with a change in price ($\Delta Q/\Delta P$) times the ratio of price to quantity (P/Q). But as we move down the demand curve, $\Delta Q/\Delta P$ may change, and the price and quantity will always change. Therefore, the price elasticity of demand must be measured *at a particular point on the demand curve* and will generally change as we move along the curve.

This principle is easiest to see for a **linear demand curve**—that is, a demand curve of the form

linear demand curve Demand curve that is a straight line.

$$Q = a - bP$$

As an example, consider the demand curve

$$Q = 8 - 2P$$

For this curve, $\Delta Q/\Delta P$ is constant and equal to –2 (a ΔP of 1 results in a ΔQ of –2). However, the curve does *not* have a constant elasticity. Observe from Figure 2.11 that as we move down the curve, the ratio P/Q falls; the elasticity therefore decreases in magnitude. Near the intersection of the curve with the price axis, Q is very small, so $E_p = -2(P/Q)$ is large in magnitude. When $P = 2$ and $Q = 4$, $E_p = -1$. At the intersection with the quantity axis, $P = 0$ so $E_p = 0$.

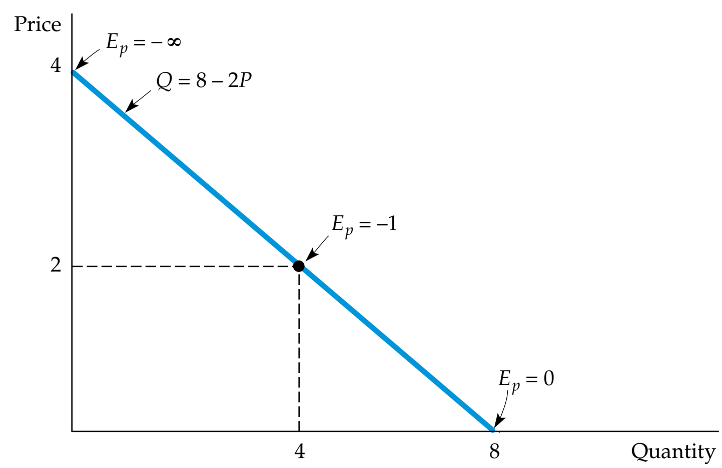

FIGURE 2.11 Linear Demand Curve

The price elasticity of demand depends not only on the slope of the demand curve but also on the price and quantity. The elasticity, therefore, varies along the curve as price and quantity change. Slope is constant for this linear demand curve. Near the top, because price is high and quantity is small, the elasticity is large in magnitude. The elasticity becomes smaller as we move down the curve.

infinitely elastic demand Consumers will buy as much of a good as they can get at a single price, but for any higher price the quantity demanded drops to zero, while for any lower price the quantity demanded increases without limit.

completely inelastic demand Consumers will buy a fixed quantity of a good regardless of its price.

income elasticity of demand Percentage change in the quantity demanded resulting from a 1-percent increase in income.

cross-price elasticity of demand Percentage change in the quantity demanded of one good resulting from a 1-percent increase in the price of another.

Because we draw demand (and supply) curves with price on the vertical axis and quantity on the horizontal axis, $\Delta Q/\Delta P$ = (1/slope of curve). As a result, for any price and quantity combination, the steeper the slope of the curve, the less elastic is demand. Figure 2.12 shows two special cases. Figure 2.12(a) shows a demand curve reflecting **infinitely elastic demand**: Consumers will buy as much as they can at a single price P^*. For even the smallest increase in price above this level, quantity demanded drops to zero, and for any decrease in price, quantity demanded increases without limit. The demand curve in Figure 2.12(b), on the other hand, reflects **completely inelastic demand**: Consumers will buy a fixed quantity Q^*, no matter what the price.

Other Demand Elasticities We will also be interested in elasticities of demand with respect to other variables besides price. For example, demand for most goods usually rises when aggregate income rises. The **income elasticity of demand** is the percentage change in the quantity demanded, Q, resulting from a 1-percent increase in income I:

$$E_I = \frac{\Delta Q/Q}{\Delta I/I} = \frac{I}{Q}\frac{\Delta Q}{\Delta I} \qquad (2.2)$$

The demand for some goods is also affected by the prices of other goods. For example, because butter and margarine can easily be substituted for each other, the demand for each depends on the price of the other. A **cross-price elasticity of demand** refers to the percentage change in the quantity demanded for a good that results from a 1-percent increase in the price of another good. So the elasticity of demand for butter with respect to the price of margarine would be written as

$$E_{Q_bP_m} = \frac{\Delta Q_b/Q_b}{\Delta P_m/P_m} = \frac{P_m}{Q_b}\frac{\Delta Q_b}{\Delta P_m} \qquad (2.3)$$

where Q_b is the quantity of butter and P_m is the price of margarine.

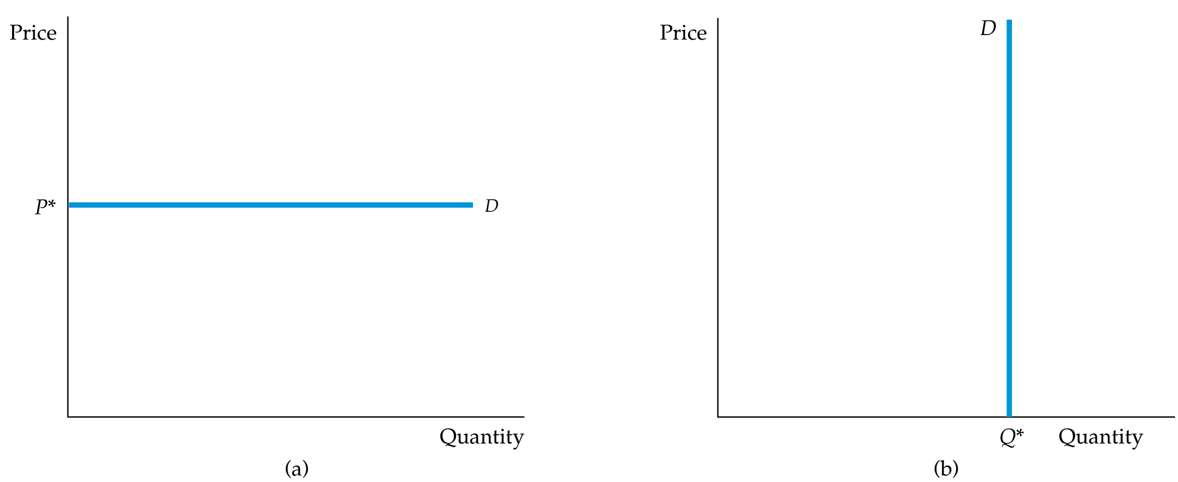

FIGURE 2.12 (a) Infinitely Elastic Demand (b) Completely Inelastic Demand

(a) For a horizontal demand curve, $\Delta Q/\Delta P$ is infinite. Because a tiny change in price leads to an enormous change in demand, the elasticity of demand is infinite. **(b)** For a vertical demand curve, $\Delta Q/\Delta P$ is zero. Because the quantity demanded is the same no matter what the price, the elasticity of demand is zero.

In this example, the cross-price elasticities will be positive because the goods are *substitutes*: Because they compete in the market, a rise in the price of margarine, which makes butter cheaper relative to margarine, leads to an increase in the quantity of butter demanded. (Because the demand curve for butter will shift to the right, the price of butter will rise.) But this is not always the case. Some goods are *complements*: Because they tend to be used together, an increase in the price of one tends to push down the consumption of the other. Take gasoline and motor oil. If the price of gasoline goes up, the quantity of gasoline demanded falls—motorists will drive less. And because people are driving less, the demand for motor oil also falls. (The entire demand curve for motor oil shifts to the left.) Thus, the cross-price elasticity of motor oil with respect to gasoline is negative.

Elasticities of Supply Elasticities of supply are defined in a similar manner. The **price elasticity of supply** is the percentage change in the quantity supplied resulting from a 1-percent increase in price. This elasticity is usually positive because a higher price gives producers an incentive to increase output.

price elasticity of supply Percentage change in quantity supplied resulting from a 1-percent increase in price.

We can also refer to elasticities of supply with respect to such variables as interest rates, wage rates, and the prices of raw materials and other intermediate goods used to manufacture the product in question. For example, for most manufactured goods, the elasticities of supply with respect to the prices of raw materials are negative. An increase in the price of a raw material input means higher costs for the firm; other things being equal, therefore, the quantity supplied will fall.

Point versus Arc Elasticities

So far, we have considered elasticities at a particular point on the demand curve or the supply curve. These are called *point elasticities*. The **point elasticity of demand**, for example, is *the price elasticity of demand at a particular point on the demand curve* and is defined by Equation (2.1). As we demonstrated in Figure 2.11 using a linear demand curve, the point elasticity of demand can vary depending on where it is measured along the demand curve.

point elasticity of demand Price elasticity at a particular point on the demand curve.

There are times, however, when we want to calculate a price elasticity over some portion of the demand curve (or supply curve) rather than at a single point. Suppose, for example, that we are contemplating an increase in the price of a product from \$8.00 to \$10.00 and expect the quantity demanded to fall from 6 units to 4. How should we calculate the price elasticity of demand? Is the price increase 25 percent (a \$2 increase divided by the original price of \$8), or is it 20 percent (a \$2 increase divided by the new price of \$10)? Is the percentage decrease in quantity demanded 33 1/3 percent (2/6) or 50 percent (2/4)?

There is no correct answer to such questions. We could calculate the price elasticity using the original price and quantity. If so, we would find that E_p = (–33 1/3 percent/25 percent) = –1.33. Or we could use the new price and quantity, in which case we would find that E_p = (–50 percent/20 percent) = –2.5. The difference between these two calculated elasticities is large, and neither seems preferable to the other.

Arc Elasticity of Demand We can resolve this problem by using the **arc elasticity of demand**: *the elasticity calculated over a range of prices*. Rather than choose either the initial or the final price, we use an average of the two, $\overline{P}$; for the quantity demanded, we use $\overline{Q}$. Thus the arc elasticity of demand is given by

arc elasticity of demand Price elasticity calculated over a range of prices.

$$\text{Arc elasticity:} \quad E_p = (\Delta Q/\Delta P)(\overline{P}/\overline{Q}) \qquad \textbf{(2.4)}$$

In our example, the average price is \$9 and the average quantity 5 units. Thus the arc elasticity is

$$E_p = (-2/\$2)(\$9/5) = -1.8$$

The arc elasticity will always lie somewhere (but not necessarily halfway) between the point elasticities calculated at the lower and the higher prices.

Although the arc elasticity of demand is sometimes useful, economists generally use the word "elasticity" to refer to a *point* elasticity. Throughout the rest of this book, we will do the same, unless noted otherwise.

EXAMPLE 2.5 The Market for Wheat

Wheat is an important agricultural commodity, and the wheat market has been studied extensively by agricultural economists. During the 1980s and 1990s, changes in the wheat market had major implications for both American farmers and U.S. agricultural policy. To understand what happened, let's examine the behavior of supply and demand over this period.

From statistical studies, we know that for 1981 the supply curve for wheat was approximately as follows:[7]

$$\textit{Supply:} \quad Q_S = 1800 + 240P$$

where price is measured in nominal dollars per bushel and quantities in millions of bushels per year. These studies also indicate that in 1981, the demand curve for wheat was

$$\textit{Demand:} \quad Q_D = 3550 - 266P$$

By setting the quantity supplied equal to the quantity demanded, we can determine the market-clearing price of wheat for 1981:

$$Q_S = Q_D$$
$$1800 + 240P = 3550 - 266P$$
$$506P = 1750$$
$$P = \$3.46 \text{ per bushel}$$

To find the market-clearing quantity, substitute this price of \$3.46 into either the supply curve equation or the demand curve equation. Substituting into the supply curve equation, we get

$$Q = 1800 + (240)(3.46) = 2630 \text{ million bushels}$$

[7] For a survey of statistical studies of the demand and supply of wheat and an analysis of evolving market conditions, see Larry Salathe and Sudchada Langley, "An Empirical Analysis of Alternative Export Subsidy Programs for U.S. Wheat," *Agricultural Economics Research* 38, No. 1 (Winter 1986). The supply and demand curves in this example are based on the studies they survey.

What are the price elasticities of demand and supply at this price and quantity? We use the demand curve to find the price elasticity of demand:

$$E_P^D = \frac{P}{Q}\frac{\Delta Q_D}{\Delta P} = \frac{3.46}{2630}(-266) = -0.35$$

Thus demand is inelastic. We can likewise calculate the price elasticity of supply:

$$E_P^S = \frac{P}{Q}\frac{\Delta Q_S}{\Delta P} = \frac{3.46}{2630}(240) = 0.32$$

Because these supply and demand curves are linear, the price elasticities will vary as we move along the curves. For example, suppose that a drought caused the supply curve to shift far enough to the left to push the price up to $4.00 per bushel. In this case, the quantity demanded would fall to 3550 – (266)(4.00) = 2486 million bushels. At this price and quantity, the elasticity of demand would be

$$E_P^D = \frac{4.00}{2486}(-266) = -0.43$$

The wheat market has evolved over the years, in part because of changes in demand. The demand for wheat has two components: domestic (demand by U.S. consumers) and export (demand by foreign consumers). During the 1980s and 1990s, domestic demand for wheat rose only slightly (due to modest increases in population and income). Export demand, however, fell sharply. There were several reasons. First and foremost was the success of the Green Revolution in agriculture: Developing countries like India, which had been large importers of wheat, became increasingly self-sufficient. In addition, European countries adopted protectionist policies that subsidized their own production and imposed tariff barriers against imported wheat.

In 2002, demand and supply were

$$\textit{Demand:}\quad Q_D = 2809 - 226P$$
$$\textit{Supply:}\quad Q_S = 1439 + 267P$$

Once again, equating quantity supplied and quantity demanded yields the market-clearing (nominal) price and quantity:

$$1439 + 267P = 2809 - 226P$$
$$P = \$2.78 \text{ per bushel}$$
$$Q = 2809 - (226)(2.78) = 2181 \text{ million bushels}$$

Thus the price of wheat fell even in nominal terms. (You can check to see that at this price and quantity, the price elasticity of demand was –0.29 and the price elasticity of supply was 0.34).[8]

[8]These are short-run elasticity estimates from Economics Research Service (ERS) of the U.S. Department of Agriculture (USDA). For more information, consult the following publications: William Lin, Paul C. Westcott, Robert Skinner, Scott Sanford, and Daniel G. De La Torre Ugarte, *Supply Response Under the 1996 Farm Act and Implications for the U.S. Field Crops Sector* (Technical Bulletin No. 1888, ERS, USDA, July 2000, **http://www.ers.usda.gov/**); and James Barnes and Dennis Shields, *The Growth in U.S. Wheat Food Demand* (Wheat Situation and Outlook Yearbook, WHS-1998, **http://www.ers.usda.gov/**).

The price of wheat was actually greater than $3.46 in 1981 because the U.S. government bought wheat through its price-support program. In addition, throughout the 1980s and 1990s, farmers received direct subsidies for the wheat they produced. In 1996, Congress passed the Freedom to Farm bill designed to eliminate crop subsidies and acreage limitations for wheat and other agricultural products. Since that time, however, emergency aid to farmers and direct loan payments have effectively maintained the price subsidies originally "phased out" by the 1996 bill. In May 2002, Congress passed another bill subsidizing farmers over the next 10 years; the cost to taxpayers will be $190 billion.

We discuss how such agricultural policies work and evaluate the costs and benefits for consumers, farmers, and the federal budget in Chapter 9.

2.5 Short-Run versus Long-Run Elasticities

When analyzing demand and supply, we must distinguish between the short run and the long run. In other words, if we ask how much demand or supply changes in response to a change in price, we must be clear about *how much time is allowed to pass before we measure the changes in the quantity demanded or supplied*. If we allow only a short time to pass—say, one year or less—then we are dealing with the *short run*. When we refer to the *long run* we mean that enough time is allowed for consumers or producers to *adjust fully* to the price change. In general, short-run demand and supply curves look very different from their long-run counterparts.

Demand

For many goods, demand is much more price elastic in the long run than in the short run. For one thing, it takes time for people to change their consumption habits. For example, even if the price of coffee rises sharply, the quantity demanded will fall only gradually as consumers begin to drink less. In addition, the demand for a good might be linked to the stock of another good that changes only slowly. For example, the demand for gasoline is much more elastic in the long run than in the short run. A sharply higher price of gasoline reduces the quantity demanded in the short run by causing motorists to drive less, but it has its greatest impact on demand by inducing consumers to buy smaller and more fuel-efficient cars. But because the stock of cars changes only slowly, the quantity of gasoline demanded falls only slowly. Figure 2.13(a) shows short-run and long-run demand curves for goods such as these.

Demand and Durability On the other hand, for some goods just the opposite is true—demand is more elastic in the short run than in the long run. Because these goods (automobiles, refrigerators, televisions, or the capital equipment purchased by industry) are *durable*, the total stock of each good owned by consumers is large relative to annual production. As a result, a small change in the total stock that consumers want to hold can result in a large percentage change in the level of purchases.

Suppose, for example, that the price of refrigerators goes up 10 percent, causing the total stock of refrigerators that consumers want to hold to drop 5 percent. Initially, this will cause purchases of new refrigerators to drop much more than

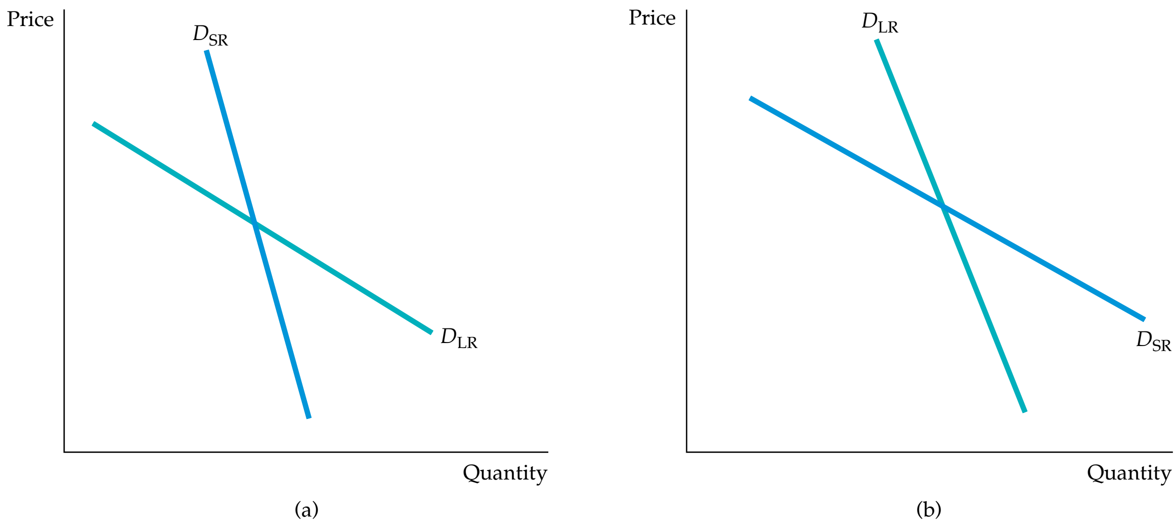

FIGURE 2.13 (a) Gasoline: Short-Run and Long-Run Demand Curves
(b) Automobiles: Short-Run and Long-Run Demand Curves

(a) In the short run, an increase in price has only a small effect on the quantity of gasoline demanded. Motorists may drive less, but they will not change the kinds of cars they are driving overnight. In the longer run, however, because they will shift to smaller and more fuel-efficient cars, the effect of the price increase will be larger. Demand, therefore, is more elastic in the long run than in the short run. **(b)** The opposite is true for automobile demand. If price increases, consumers initially defer buying new cars; thus annual quantity demanded falls sharply. In the longer run, however, old cars wear out and must be replaced; thus annual quantity demanded picks up. Demand, therefore, is less elastic in the long run than in the short run.

5 percent. But eventually, as consumers' refrigerators depreciate (and units must be replaced), the quantity demanded will increase again. In the long run, the total stock of refrigerators owned by consumers will be about 5 percent less than before the price increase. In this case, while the long-run price elasticity of demand for refrigerators would be $-.05/.10 = -0.5$, the short-run elasticity would be much larger in magnitude.

Or consider automobiles. Although annual U.S. demand—new car purchases—is about 8 to 11 million, the stock of cars that people own is around 130 million. If automobile prices rise, many people will delay buying new cars. The quantity demanded will fall sharply, even though the total stock of cars that consumers might want to own at these higher prices falls only a small amount. Eventually, however, because old cars wear out and must be replaced, the quantity of new cars demanded picks up again. As a result, the long-run change in the quantity demanded is much smaller than the short-run change. Figure 2.13(b) shows demand curves for a durable good like automobiles.

Income Elasticities Income elasticities also differ from the short run to the long run. For most goods and services—foods, beverages, fuel, entertainment, etc.—the income elasticity of demand is larger in the long run than in the short run. Consider the behavior of gasoline consumption during a period of strong economic growth during which aggregate income rises by 10 percent. Eventually people will increase gasoline consumption because they can afford to take more trips and perhaps own larger cars. But this change in consumption takes time, and demand initially increases only by a small amount. Thus, the long-run elasticity will be larger than the short-run elasticity.

For a durable good, the opposite is true. Again, consider automobiles. If aggregate income rises by 10 percent, the total stock of cars that consumers will want to own will also rise—say, by 5 percent. But this change means a much larger increase in *current purchases* of cars. (If the stock is 130 million, a 5-percent increase is 6.5 million, which might be about 60 to 70 percent of normal demand in a single year.) Eventually consumers succeed in increasing the total number of cars owned; after the stock has been rebuilt, new purchases are made largely to replace old cars. (These new purchases will still be greater than before because a larger stock of cars outstanding means that more cars need to be replaced each year.) Clearly, the short-run income elasticity of demand will be much larger than the long-run elasticity.

Cyclical Industries Because the demands for durable goods fluctuate so sharply in response to short-run changes in income, the industries that produce these goods are quite vulnerable to changing macroeconomic conditions, and in particular to the business cycle—recessions and booms. Thus, these industries are often called **cyclical industries**—their sales patterns tend to magnify cyclical changes in gross domestic product (GDP) and national income.

cyclical industries Industries in which sales tend to magnify cyclical changes in gross domestic product and national income.

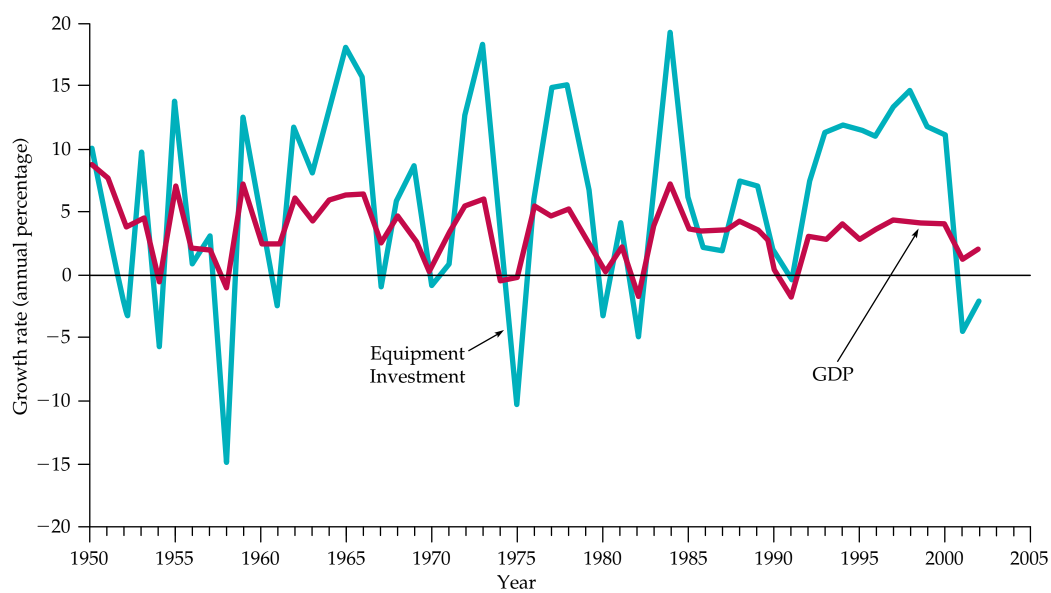

FIGURE 2.14 GDP and Investment in Durable Equipment

Annual growth rates are compared for GDP and investment in durable equipment. Because the short-run GDP elasticity of demand is larger than the long-run elasticity for long-lived capital equipment, changes in investment in equipment magnify changes in GDP. Thus capital goods industries are considered "cyclical."

Figures 2.14 and 2.15 illustrate this principle. Figure 2.14 plots two variables over time: the annual real (inflation-adjusted) rate of growth of GDP and the annual real rate of growth of investment in producers' durable equipment (i.e., machinery and other equipment purchased by firms). Note that although the durable equipment series follows the same pattern as the GDP series, the changes in GDP are magnified. For example, in 1961–1966 GDP grew by at least 4 percent each year. Purchases of durable equipment also grew, but by much more (over 10 percent in 1963–1966). Equipment investment likewise grew much more quickly than GDP during 1993–1998. On the other hand, during the recessions of 1974–1975, 1982, 1991, and 2001, equipment purchases fell by much more than GDP.

Figure 2.15 also shows the real rate of growth of GDP, along with the annual real rates of growth of spending by consumers on durable goods (automobiles, appliances, etc.) and nondurable goods (food, fuel, clothing, etc.). Note that while both consumption series follow GDP, only the durable goods series tends to magnify changes in GDP. Changes in consumption of nondurables are roughly the same as changes in GDP, but changes in consumption of durables are usually several times larger. This is why companies such as General Motors and General Electric are considered "cyclical": Sales of cars and electrical appliances are strongly affected by changing macroeconomic conditions.

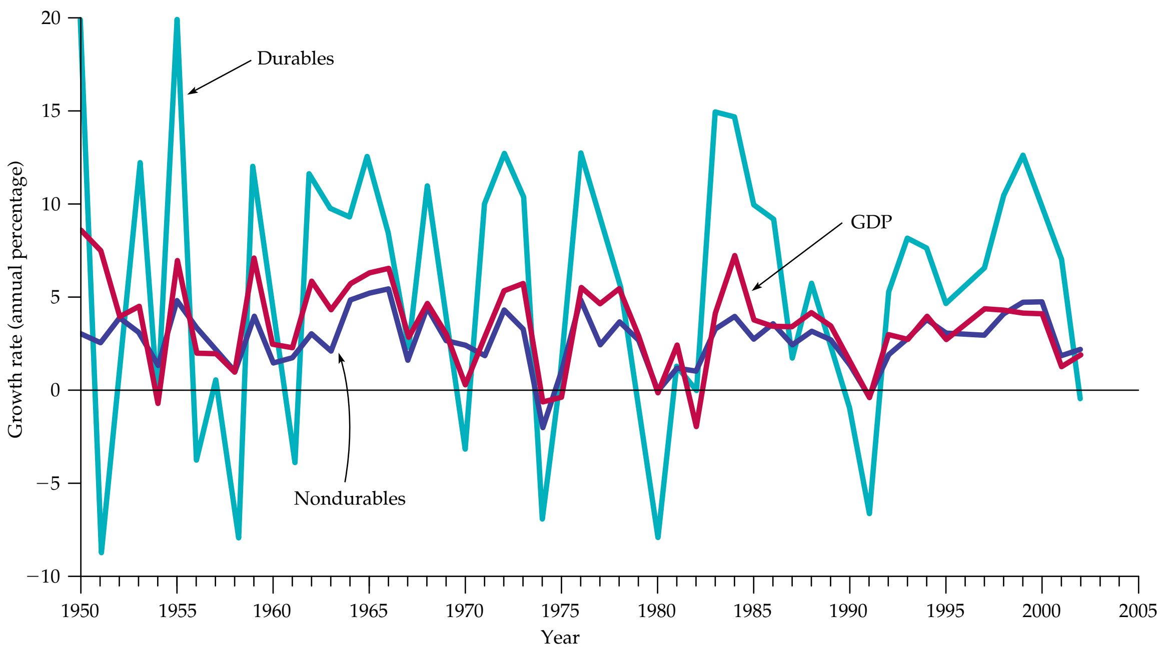

FIGURE 2.15 Consumption of Durables versus Nondurables

Annual growth rates are compared for GDP, consumer expenditures on durable goods (automobiles, appliances, furniture, etc.), and consumer expenditures on nondurable goods (food, clothing, services, etc.). Because the stock of durables is large compared with annual demand, short-run demand elasticities are larger than long-run elasticities. Like capital equipment, industries that produce consumer durables are "cyclical" (i.e., changes in GDP are magnified). This is not true for producers of nondurables.

EXAMPLE 2.6 The Demand for Gasoline and Automobiles

Gasoline and automobiles exemplify some of the different characteristics of demand discussed above. They are complementary goods—an increase in the price of one tends to reduce the demand for the other. In addition, their respective dynamic behaviors (long-run versus short-run elasticities) are just the opposite from each other. For gasoline, the long-run price and income elasticities are larger than the short-run elasticities; for automobiles, the reverse is true.

There have been a number of statistical studies of the demands for gasoline and automobiles. Here we report elasticity estimates from a study that emphasizes the dynamic response of demand.[9] Table 2.1 shows price and income elasticities of demand for gasoline in the United States for the short run, the long run, and just about everything in between.

TABLE 2.1 Demand for Gasoline

	Number of Years Allowed to Pass Following a Price or Income Change					
Elasticity	*1*	*2*	*3*	*5*	*10*	*20*
Price	–0.11	–0.22	–0.32	–0.49	–0.82	–1.17
Income	0.07	0.13	0.20	0.32	0.54	0.78

Note the large differences between the long-run and the short-run elasticities. Following the sharp increases that occurred in the price of gasoline with the rise of the OPEC oil cartel in 1974, many people (including executives in the automobile and oil industries) claimed that the quantity of gasoline demanded would not change much—that demand was not very elastic. Indeed, for the first year after the price rise, they were right. But demand did eventually change. It just took time for people to alter their driving habits and to replace large cars with smaller and more fuel-efficient ones. This response continued after the second sharp increase in oil prices that occurred in 1979–1980. It was partly because of this response that OPEC could not maintain oil prices above $30 per barrel, and prices fell.

Table 2.2 shows price and income elasticities of demand for automobiles. Note that the short-run elasticities are much larger than the long-run elasticities. It should be clear from the income elasticities why the automobile industry is so highly cyclical. For example, GDP fell by nearly 3 percent in real (inflation-adjusted) terms during the 1982 recession, but automobile sales fell by about 8 percent in real terms.[10] Auto sales recovered, however, during

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[9]Elasticity estimates are from R. S. Pindyck, *The Structure of World Energy Demand* (Cambridge, MA: MIT Press, 1979). For related demand studies and elasticity estimates, see Carol Dahl and Thomas Sterner, "Analyzing Gasoline Demand Elasticities: A Survey," *Energy Economics* (July 1991); Molly Espey, "Watching the Fuel Gauge: An International Model of Automobile Fuel Economy," *Energy Economics* (April 1996); and David L. Greene, James R. Kahn, and Robert C. Gibson, "Fuel Economy Rebound Effects for U.S. Household Vehicles," *The Energy Journal* 20, No. 3 (1999).

[10]This figure includes imports, which were capturing a growing share of the U.S. market. Domestic auto sales fell by even more.

TABLE 2.2 Demand for Automobiles

	Number of Years Allowed to Pass Following a Price or Income Change					
Elasticity	***1***	***2***	***3***	***5***	***10***	***20***
Price	–1.20	–0.93	–0.75	–0.55	–0.42	–0.40
Income	3.00	2.33	1.88	1.38	1.02	1.00

1983–1985. They also fell by about 8 percent during the 1991 recession (when GDP fell 2 percent), but began to recover in 1993, and rose sharply during 1995–1999.

Supply

Elasticities of supply also differ from the long run to the short run. For most products, long-run supply is much more price elastic than short-run supply: Firms face *capacity constraints* in the short run and need time to expand capacity by building new production facilities and hiring workers to staff them. This is not to say that the quantity supplied will not increase in the short run if price goes up sharply. Even in the short run, firms can increase output by using their existing facilities for more hours per week, paying workers to work overtime, and hiring some new workers immediately. But firms will be able to expand output much more when they have the time to expand their facilities and hire larger permanent workforces.

For some goods and services, short-run supply is completely inelastic. Rental housing in most cities is an example. In the very short run, there is only a fixed number of rental units. Thus an increase in demand only pushes rents up. In the longer run, and without rent controls, higher rents provide an incentive to renovate existing buildings and construct new ones. As a result, the quantity supplied increases.

For most goods, however, firms can find ways to increase output even in the short run—if the price incentive is strong enough. However, because various constraints make it costly to increase output rapidly, it may require large price increases to elicit small short-run increases in the quantity supplied. We discuss these characteristics of supply in more detail in Chapter 8.

Supply and Durability For some goods, supply is more elastic in the short run than in the long run. Such goods are durable and can be recycled as part of supply if price goes up. An example is the *secondary supply* of metals: the supply from *scrap metal*, which is often melted down and refabricated. When the price of copper goes up, it increases the incentive to convert scrap copper into new supply, so that, initially, secondary supply increases sharply. Eventually, however, the stock of good-quality scrap falls, making the melting, purifying, and refabricating more costly. Secondary supply then contracts. Thus the long-run price elasticity of secondary supply is smaller than the short-run elasticity.

FIGURE 2.16 Copper: Short-Run and Long-Run Supply Curves

Like that of most goods, the supply of primary copper, shown in part (a), is more elastic in the long run. If price increases, firms would like to produce more but are limited by capacity constraints in the short run. In the longer run, they can add to capacity and produce more. Part (b) shows supply curves for secondary copper. If the price increases, there is a greater incentive to convert scrap copper into new supply. Initially, therefore, secondary supply (i.e., supply from scrap) increases sharply. But later, as the stock of scrap falls, secondary supply contracts. Secondary supply is therefore less elastic in the long run than in the short run.

Figures 2.16(a) and 2.16(b) show short-run and long-run supply curves for primary (production from the mining and smelting of ore) and secondary copper production. Table 2.3 shows estimates of the elasticities for each component of supply and for total supply, based on a weighted average of the component elasticities.[11] Because secondary supply is only about 20 percent of total supply, the price elasticity of total supply is larger in the long run than in the short run.

TABLE 2.3 Supply of Copper

Price Elasticity of:	*Short-Run*	*Long-Run*
Primary supply	0.20	1.60
Secondary supply	0.43	0.31
Total supply	0.25	1.50

[11]These estimates were obtained by aggregating the regional estimates reported in Franklin M. Fisher, Paul H. Cootner, and Martin N. Baily, "An Econometric Model of the World Copper Industry," *Bell Journal of Economics* 3 (Autumn 1972): 568–609.

EXAMPLE 2.7 The Weather in Brazil and the Price of Coffee in New York

Droughts or subfreezing weather occasionally destroy or damage many of Brazil's coffee trees. Because Brazil produces much of the world's coffee, the result is a decrease in the supply of coffee and a sharp run-up in its price.

In July 1975, for example, a frost destroyed most of Brazil's 1976–1977 coffee crop. (Remember that it is winter in Brazil when it is summer in the northern hemisphere.) As Figure 2.17 shows, the price of a pound of coffee in New York went from 68 cents in 1975 to $1.23 in 1976 and $2.70 in 1977. Prices fell but then jumped again in 1986, after a seven-month drought in 1985 ruined much of Brazil's crop. Finally, starting in June 1994, freezing weather followed by a drought destroyed nearly half of Brazil's crop. As a result, the price of coffee in 1994–1995 was about double its 1993 level. By 1999, however, the price had dropped considerably and continued to decline through 2001.

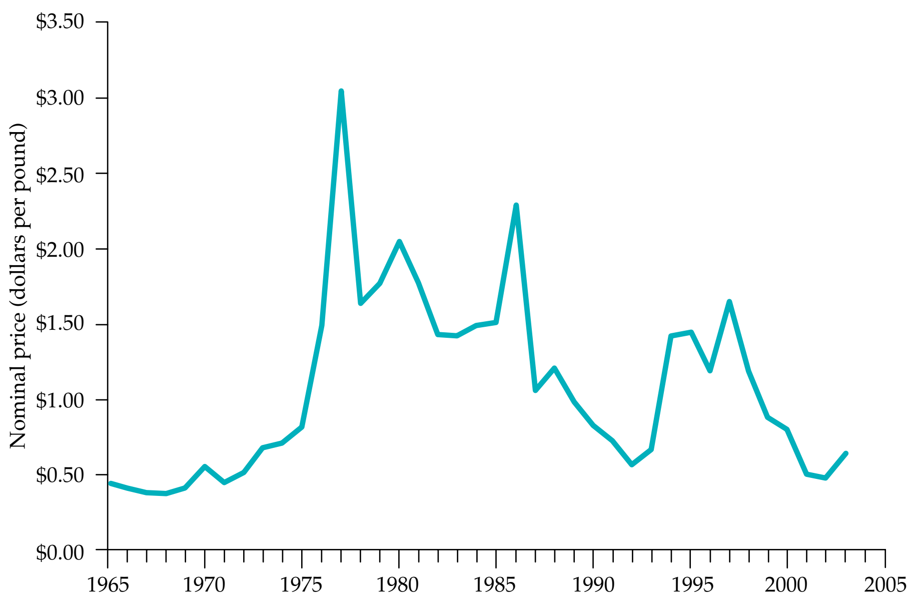

FIGURE 2.17 Price of Brazilian Coffee

When droughts or freezes damage Brazil's coffee trees, the price of coffee can soar. The price usually falls again after a few years, as demand and supply adjust.

The run-up price following a freeze or drought is usually short-lived, however. Within a year, price begins to fall; within three or four years, it returns to its earlier levels. In 1978, for example, the price of coffee in New York fell to $1.48 per pound, and by 1983, it had fallen in real (inflation-adjusted) terms to within a few cents of its prefreeze 1975 price.[12] Likewise, in 1987 the price of coffee fell to below its predrought 1984 level, and then continued declining until the 1994 freeze.

[12]During 1980, however, prices temporarily went just above $2.00 per pound as a result of export quotas imposed under the International Coffee Agreement (ICA). The ICA is essentially a cartel agreement implemented by the coffee-producing countries in 1968. It has been largely ineffective and has seldom had an effect on the price. We discuss cartel pricing in detail in Chapter 12.

Coffee prices behave this way because both demand and supply (especially supply) are much more elastic in the long run than in the short run. Figure 2.18 illustrates this fact. Note from part (a) of the figure that in the very short run (within one or two months after a freeze), supply is completely inelastic: There are simply a fixed number of coffee beans, some of which have been damaged by the frost. Demand is also relatively inelastic. As a result of the frost, the supply curve shifts to the left, and price increases sharply, from P_0 to P_1.

In the intermediate run—say, one year after the freeze—both supply and demand are more elastic, supply because existing trees can be harvested more intensively (with some decrease in quality), and demand because consumers have had time to change their buying habits. As part (b) shows, although the intermediate-run supply curve also shifts to the left, price has come down from P_1 to P_2. The quantity supplied has also increased somewhat from the short run, from Q_1 to Q_2. In the long run shown in part (c), price returns to its normal level because growers have had time to replace trees damaged by the freeze. The long-run supply curve, then, simply reflects the cost of producing coffee, including the costs of land, of planting and caring for the trees, and of a competitive rate of profit.[13]

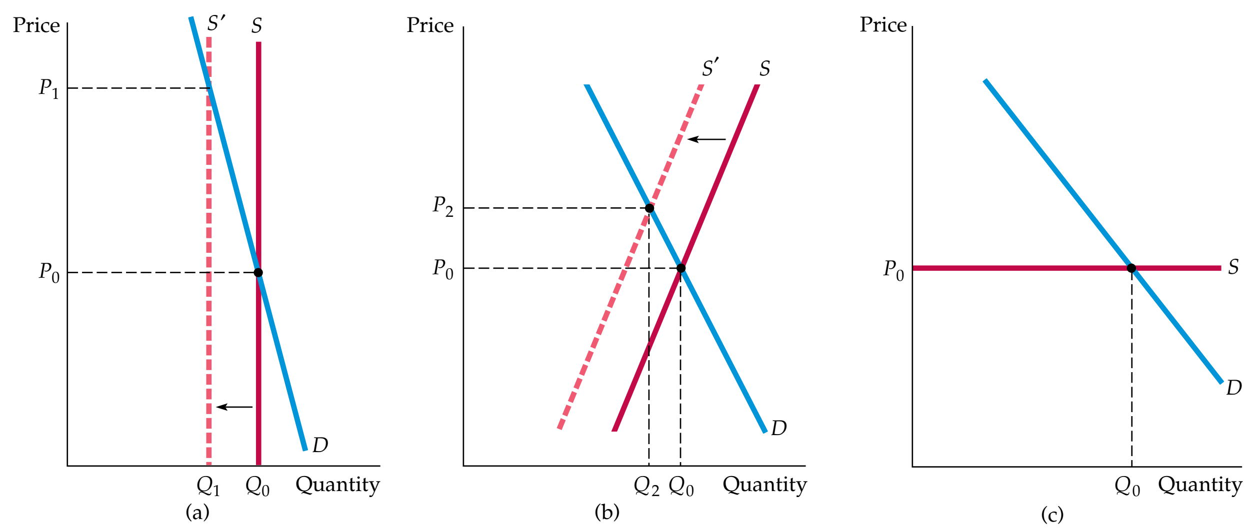

FIGURE 2.18 Supply and Demand for Coffee

(a) A freeze or drought in Brazil causes the supply curve to shift to the left. In the short run, supply is completely inelastic; only a fixed number of coffee beans can be harvested. Demand is also relatively inelastic; consumers change their habits only slowly. As a result, the initial effect of the freeze is a sharp increase in price, from P_0 to P_1. **(b)** In the intermediate run, supply and demand are both more elastic; thus price falls part of the way back, to P_2. **(c)** In the long run, supply is extremely elastic; because new coffee trees will have had time to mature, the effect of the freeze will have disappeared. Price returns to P_0.

[13] You can learn more about the world coffee market from the Foreign Agriculture Service of the U.S. Department of Agriculture by visiting their Web site at **http://www.fas.usda.gov/htp/tropical/coffee.html**.

*2.6 Understanding and Predicting the Effects of Changing Market Conditions

So far, our discussion of supply and demand has been largely qualitative. To use supply and demand curves to analyze and predict the effects of changing market conditions, we must begin attaching numbers to them. For example, to see how a 50-percent reduction in the supply of Brazilian coffee may affect the world price of coffee, we must determine actual supply and demand curves and then calculate the shifts in those curves and the resulting changes in price.

In this section, we will see how to do simple "back of the envelope" calculations with linear supply and demand curves. Although they are often approximations of more complex curves, we use linear curves because they are easier to work with. It may come as a surprise, but one can do some informative economic analyses on the back of a small envelope with a pencil and a pocket calculator.

First, we must learn how to "fit" linear demand and supply curves to market data. (By this we do not mean *statistical fitting* in the sense of linear regression or other statistical techniques, which we will discuss later in the book.) Suppose we have two sets of numbers for a particular market: The first set consists of the price and quantity that generally prevail in the market (i.e., the price and quantity that prevail "on average," when the market is in equilibrium or when market conditions are "normal"). We call these numbers the *equilibrium price* and *quantity* and denote them by P^* and Q^*. The second set consists of the price elasticities of supply and demand for the market (at or near the equilibrium), which we denote by E_S and E_D, as before.

These numbers may come from a statistical study done by someone else; they may be numbers that we simply think are reasonable; or they may be numbers that we want to try out on a "what if" basis. Our goal is to *write down the supply and demand curves that fit (i.e., are consistent with) these numbers*. We can then determine numerically how a change in a variable such as GDP, the price of another good, or some cost of production will cause supply or demand to shift and thereby affect market price and quantity.

Let's begin with the linear curves shown in Figure 2.19. We can write these curves algebraically as follows:

$$\textit{Demand:}\quad Q = a - bP \tag{2.5a}$$

$$\textit{Supply:}\quad Q = c + dP \tag{2.5b}$$

Our problem is to choose numbers for the constants a, b, c, and d. This is done, for supply and for demand, in a two-step procedure:

- ***Step 1:*** Recall that each price elasticity, whether of supply or demand, can be written as

$$E = (P/Q)(\Delta Q/\Delta P),$$

where $\Delta Q/\Delta P$ is the change in quantity demanded or supplied resulting from a small change in price. For linear curves, $\Delta Q/\Delta P$ is constant. From equations (2.5a) and (2.5b), we see that $\Delta Q/\Delta P = d$ for supply and $\Delta Q/\Delta P = -b$ for demand. Now, let's substitute these values for $\Delta Q/\Delta P$ into the elasticity formula:

$$\textit{Demand:}\quad E_D = -b(P^*/Q^*) \tag{2.6a}$$

$$\textit{Supply:}\quad E_S = d(P^*/Q^*), \tag{2.6b}$$

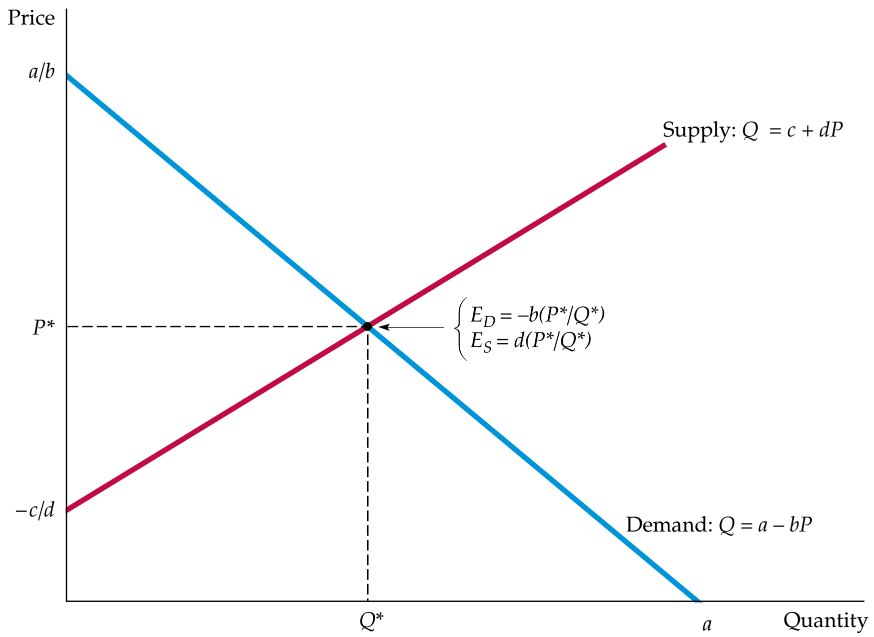

FIGURE 2.19 Fitting Linear Supply and Demand Curves to Data

Linear supply and demand curves provide a convenient tool for analysis. Given data for the equilibrium price and quantity P^* and Q^*, as well as estimates of the elasticities of demand and supply E_D and E_S, we can calculate the parameters c and d for the supply curve and a and b for the demand curve. (In the case drawn here, $c < 0$.) The curves can then be used to analyze the behavior of the market quantitatively.

where P^* and Q^* are the equilibrium price and quantity for which we have data and to which we want to fit the curves. Because we have numbers for E_S, E_D, P^*, and Q^*, we can substitute these numbers in equations (2.6a) and (2.6b) and solve for b and d.

- ***Step 2:*** Since we now know b and d, we can substitute these numbers, as well as P^* and Q^*, into equations (2.5a) and (2.5b) and solve for the remaining constants a and c. For example, we can rewrite equation (2.5a) as

$$a = Q^* + bP^*$$

and then use our data for Q^* and P^*, together with the number we calculated in Step 1 for b, to obtain a.

Let's apply this procedure to a specific example: long-run supply and demand for the world copper market. The relevant numbers for this market are as follows:

Quantity $Q^* = 7.5$ million metric tons per year (mmt/yr)

Price $P^* = \$0.75$ per pound

Elasticity of supply $E_S = 1.6$

Elasticity of demand $E_D = -0.8$

(The price of copper has fluctuated during the past few decades between \$0.60 and more than \$1.30, but \$0.75 is a reasonable average price for 1980–2000.)

We begin with the supply curve equation (2.5b) and use our two-step procedure to calculate numbers for c and d. The long-run price elasticity of supply is 1.6, $P^* = .75$, and $Q^* = 7.5$.

- ***Step 1:*** Substitute these numbers in equation (2.6b) to determine d:

$$1.6 = d(0.75/7.5) = 0.1d,$$

so that $d = 1.6/0.1 = 16$.

- ***Step 2:*** Substitute this number for d, together with the numbers for P^* and Q^*, into equation (2.5b) to determine c:

$$7.5 = c + (16)(0.75) = c + 12,$$

so that $c = 7.5 - 12 = -4.5$. We now know c and d, so we can write our supply curve:

$$\textit{Supply:} \quad Q = -4.5 + 16P$$

We can now follow the same steps for the demand curve equation (2.5a). An estimate for the long-run elasticity of demand is –0.8. First, substitute this number, as well as the values for P^* and Q^*, into equation (2.6a) to determine b:

$$-0.8 = -b(0.75/7.5) = -0.1b,$$

so that $b = 0.8/0.1 = 8$. Second, substitute this value for b and the values for P^* and Q^* in equation (2.5a) to determine a:

$$7.5 = a - (8)(0.75) = a - 6,$$

so that $a = 7.5 + 6 = 13.5$. Thus, our demand curve is

$$\textit{Demand:} \quad Q = 13.5 - 8P$$

To check that we have not made a mistake, let's set the quantity supplied equal to the quantity demanded and calculate the resulting equilibrium price:

$$\textit{Supply} = -4.5 + 16P = 13.5 - 8P = \textit{Demand}$$
$$16P + 8P = 13.5 + 4.5$$

or $P = 18/24 = 0.75$, which is indeed the equilibrium price with which we began.

Although we have written supply and demand so that they depend only on price, they could easily depend on other variables as well. Demand, for example, might depend on income as well as price. We would then write demand as

$$Q = a - bP + fI, \qquad \textbf{(2.7)}$$

where I is an index of aggregate income or GDP. For example, I might equal 1.0 in a base year and then rise or fall to reflect percentage increases or decreases in aggregate income.

For our copper market example, a reasonable estimate for the long-run income elasticity of demand is 1.3. For the linear demand curve (2.7), we can then calculate f by using the formula for the income elasticity of demand: $E = (I/Q)(\Delta Q/\Delta I)$. Taking the base value of I as 1.0, we have

$$1.3 = (1.0/7.5)(f)$$

Thus $f = (1.3)(7.5)/(1.0) = 9.75$. Finally, substituting the values $b = 8$, $f = 9.75$, $P^* = 0.75$, and $Q^* = 7.5$ into equation (2.7), we can calculate that a must equal 3.75.

We have seen how to fit linear supply and demand curves to data. Now, to see how these curves can be used to analyze markets, let's look at Example 2.8, which deals with the behavior of copper prices, and Example 2.9, which concerns the world oil market.

EXAMPLE 2.8 Declining Demand and the Behavior of Copper Prices

After reaching a level of about $1.00 per pound in 1980, the price of copper fell sharply to about 60 cents per pound in 1986. In real (inflation-adjusted) terms, this price was even lower than during the Great Depression 50 years earlier. Prices increased in 1988–1989 and in 1995, largely as a result of strikes by miners in Peru and Canada that disrupted supplies, but then fell again from 1996 onwards. Figure 2.20 shows the behavior of copper prices during 1965–2002 in both real and nominal terms.

Worldwide recessions in 1980 and 1982 contributed to the decline of copper prices; as mentioned above, the income elasticity of copper demand is about 1.3. But copper demand did not pick up as the industrial economies recovered during the mid-1980s. Instead, the 1980s saw a steep decline in demand.

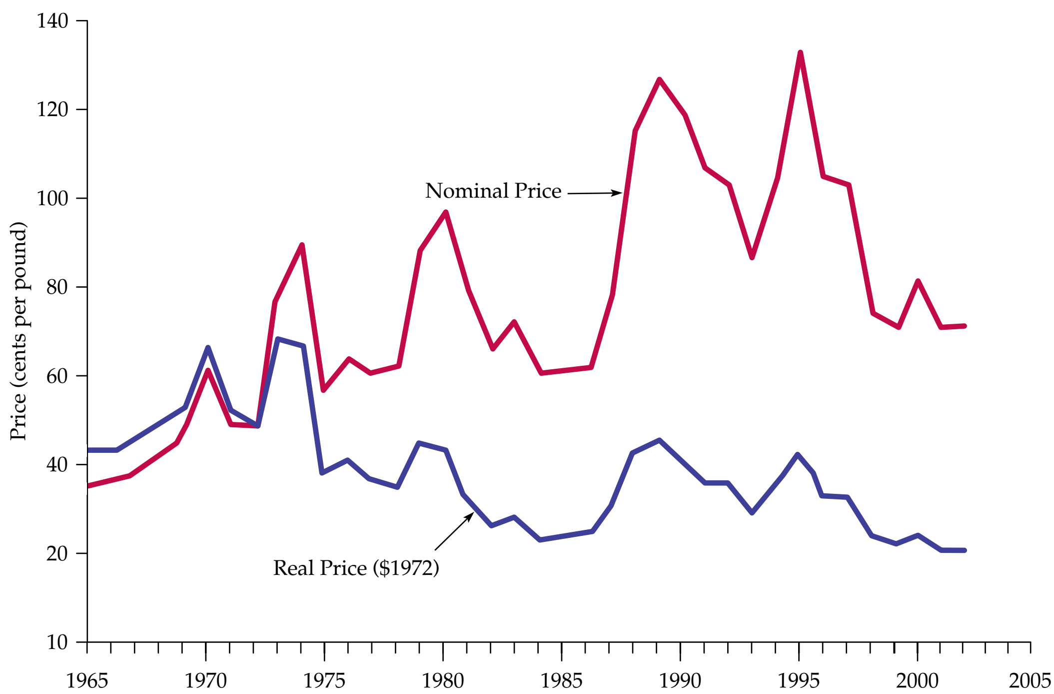

FIGURE 2.20 Copper Prices, 1965–2002

Copper prices are shown in both nominal (no adjustment for inflation) and real (inflation-adjusted) terms. In real terms, copper prices declined steeply from the early 1970s through the mid-1980s as demand fell. In 1988–1990, copper prices rose in response to supply disruptions caused by strikes in Peru and Canada but later fell after the strikes ended. Prices declined sharply during the 1996–2002 period.

This decline occurred for two reasons. First, a large part of copper consumption is for the construction of equipment for electric power generation and transmission. But by the late 1970s, the growth rate of electric power generation had fallen dramatically in most industrialized countries. In the United States, for example, the growth rate fell from over 6 percent per annum in the 1960s and early 1970s to less than 2 percent in the late 1970s and 1980s. This decline meant a big drop in what had been a major source of copper demand. Second, in the 1980s, other materials, such as aluminum and fiber optics, were increasingly substituted for copper.

Copper producers are concerned about the possible effects of further declines in demand, particularly as strikes end and supplies increase. Declining demand, of course, will depress prices. To find out how much, we can use the linear supply and demand curves that we just derived. Let's calculate the effect on price of a 20-percent decline in demand. Because we are not concerned here with the effects of GDP growth, we can leave the income term fI out of demand.

We want to shift the demand curve to the left by 20 percent. In other words, we want the quantity demanded to be 80 percent of what it would be otherwise for every value of price. For our linear demand curve, we simply multiply the right-hand side by 0.8:

$$Q = (0.8)(13.5 - 8P) = 10.8 - 6.4P$$

Supply is again $Q = -4.5 + 16P$. Now we can equate the quantity supplied and the quantity demanded and solve for price:

$$16P + 6.4P = 10.8 + 4.5,$$

or $P = 15.3/22.4 = 68.3$ cents per pound. A decline in demand of 20 percent, therefore, entails a drop in price of roughly 7 cents per pound, or 10 percent.[14]

EXAMPLE 2.9 Upheaval in the World Oil Market

Since the early 1970s, the world oil market has been buffeted by the OPEC cartel and by political turmoil in the Persian Gulf. In 1974, by collectively restraining output, OPEC (the Organization of Petroleum Exporting Countries) pushed world oil prices well above what they would have been in a competitive market. OPEC could do this because it accounted for much of world oil production. During 1979–1980, oil prices shot up again, as the Iranian revolution and the outbreak of the Iran-Iraq war sharply reduced Iranian and Iraqi production. During the 1980s, the price gradually declined, as demand fell and competitive (i.e., non-OPEC) supply rose in response to price. Prices remained relatively stable during 1988–2001, except for a temporary spike in 1990 following the Iraqi invasion of Kuwait. Prices spiked again in 2002–2003 as a result of a strike in Venezuela and then the war with Iraq in the spring of 2003. Figure 2.21 shows the world price of oil from 1970 to 2003, in both nominal and real terms.

[14]You can obtain recent data and learn more about the behavior of copper prices by accessing the Web site of the U.S. Geological Survey at **http://minerals.usgs.gov/.**

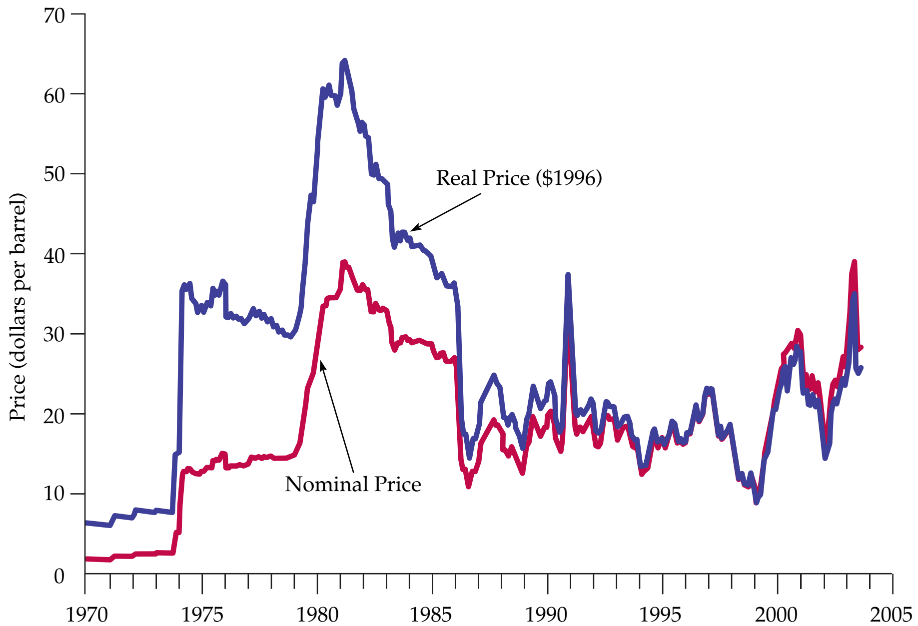

FIGURE 2.21 Price of Crude Oil

The OPEC cartel and political events caused the price of oil to rise sharply at times. It later fell as supply and demand adjusted.

The Persian Gulf is one of the less stable regions of the world—a fact that has led to concern over the possibility of new oil supply disruptions and sharp increases in oil prices. What would happen to oil prices—in both the short run and longer run—if a war or revolution in the Persian Gulf caused a sharp cutback in oil production? Let's see how simple supply and demand curves can be used to predict the outcome of such an event.

Because this example is set in 1997, all prices are measured in 1997 dollars. Here are some rough figures:

- 1997 world price = $18 per barrel
- World demand and total supply = 23 billion barrels per year (bb/yr)
- 1997 OPEC supply = 10 bb/yr
- Competitive (non-OPEC) supply = 13 bb/yr[15]

The following table gives price elasticity estimates for oil supply and demand:[16]

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[15]Non-OPEC supply includes the production of China and the former Soviet republics.

[16]For the sources of these numbers and a more detailed discussion of OPEC oil pricing, see Robert S. Pindyck, "Gains to Producers from the Cartelization of Exhaustible Resources," *Review of Economics and Statistics* 60 (May 1978): 238–51; James M. Griffin and David J. Teece, *OPEC Behavior and World Oil Prices* (London: Allen and Unwin, 1982); and Hillard G. Huntington, "Inferred Demand and Supply Elasticities from a Comparison of World Oil Models," in T. Sterner, ed., *International Energy Economics* (London: Chapman and Hall, 1992).

	Short-Run	***Long-Run***
World demand:	–0.05	–0.40
Competitive supply:	0.10	0.40

You should verify that these numbers imply the following for demand and competitive supply in the *short run*:

Short-run demand: $D = 24.08 - 0.06P$

Short-run competitive supply: $S_C = 11.74 + 0.07P$

Of course, *total* supply is competitive supply *plus* OPEC supply, which we take as constant at 10 bb/yr. Adding this 10 bb/yr to the competitive supply curve above, we obtain the following for the total short-run supply:

Short-run total supply: $S_T = 21.74 + 0.07P$

You should verify that the quantity demanded and the total quantity supplied are equal at an equilibrium price of $18 per barrel.

You should also verify that the corresponding demand and supply curves for the *long run* are as follows:

Long-run demand: $D = 32.18 - 0.51P$

Long-run competitive supply: $S_C = 7.78 + 0.29P$

Long-run total supply: $S_T = 17.78 + 0.29P$

Again, you can check that the quantities supplied and demanded equate at a price of $18.

Saudi Arabia is one of the world's largest oil producers, accounting for roughly 3 bb/yr, which is nearly one third of OPEC production and about 13 percent of total world production. What would happen to the price of oil if, because of war or political upheaval, Saudi Arabia stopped producing oil? We can use our supply and demand curves to find out.

For the *short run*, simply subtract 3 from total supply:

Short-run demand: $D = 24.08 - 0.06P$

Short-run total supply: $S_T = 18.74 + 0.07P$

By equating this total quantity supplied with the quantity demanded, we can see that in the short run, the price will more than double to $41.08 per barrel. Figure 2.22 shows this supply shift and the resulting short-run increase in price. The initial equilibrium is at the intersection of S_T and D. After the drop in Saudi production, the equilibrium occurs where S'_T and D cross.

In the *long run*, however, things will be different. Because both demand and competitive supply are more elastic in the long run, the 3 bb/yr cut in oil production will no longer support such a high price. Subtracting 3 from long-run total supply and equating with long-run demand, we can see that the price will fall to $21.75, only $3.75 above the initial $18 price.

Thus, if Saudi Arabia suddenly stops producing oil, we should expect to see more than a doubling in price. However, we should also expect to see the price gradually decline afterward, as demand falls and competitive supply rises.

This is indeed what happened following the sharp decline in Iranian and Iraqi production in 1979–1980. History may or may not repeat itself, but if it does, we can at least predict the impact on oil prices.[17]

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[17]You can obtain recent data and learn more about the world oil market by accessing the Web sites of the American Petroleum Institute at **www.api.org** or the U.S. Energy Information Administration at **www.eia.doe.gov**.

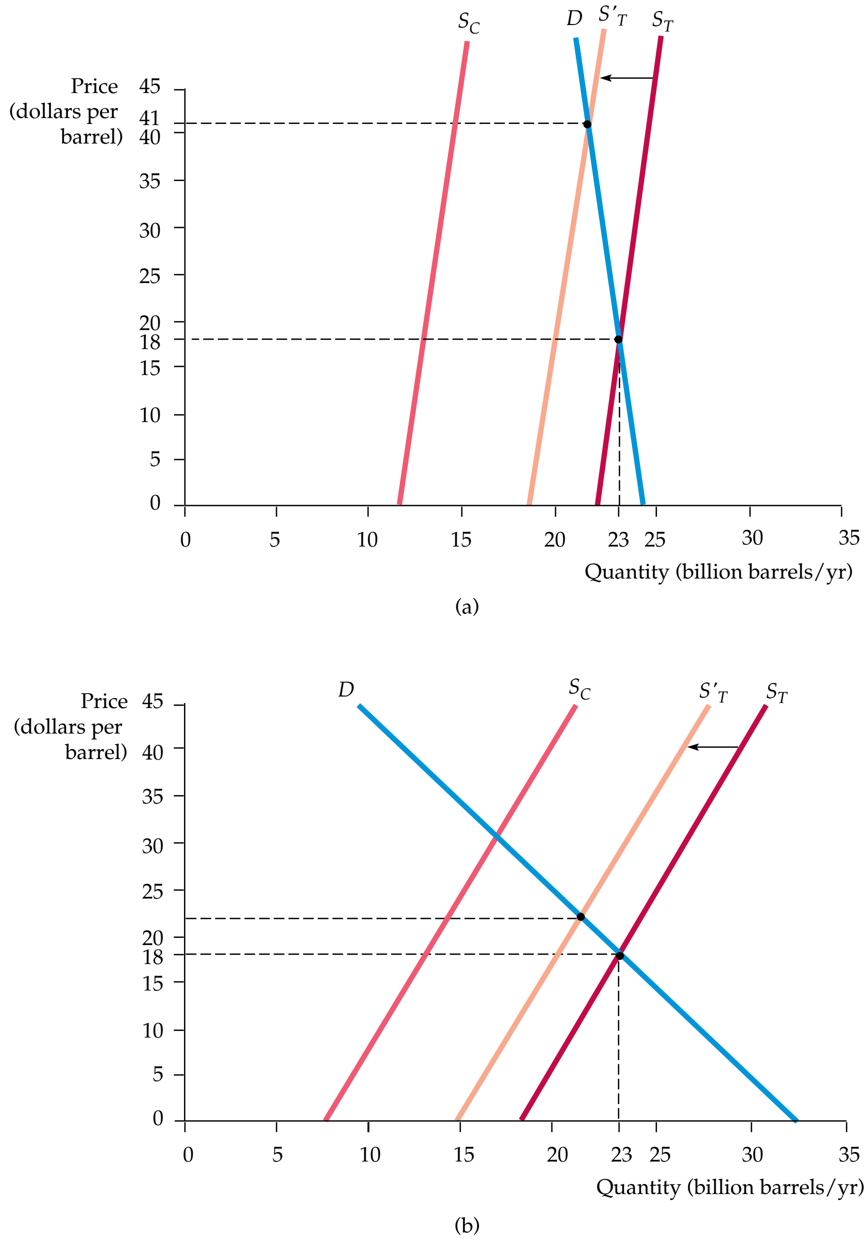

FIGURE 2.22 Impact of Saudi Production Cut

The total supply is the sum of competitive (non-OPEC) supply and the 10 bb/yr of OPEC supply. Part **(a)** shows the short-run supply and demand curves. If Saudi Arabia stops producing, the supply curve will shift to the left by 3 bb/yr. In the short-run, price will increase sharply. Part **(b)** shows long-run curves. In the long run, because demand and competitive supply are much more elastic, the impact on price will be much smaller.

2.7 Effects of Government Intervention—Price Controls

In the United States and most other industrial countries, markets are rarely free of government intervention. Besides imposing taxes and granting subsidies, governments often regulate markets (even competitive markets) in a variety of ways. In this section, we will see how to use supply and demand curves to analyze the effects of one common form of government intervention: price controls. Later, in Chapter 9, we will examine the effects of price controls and other forms of government intervention and regulation in more detail.

Figure 2.23 illustrates the effects of price controls. Here, P_0 and Q_0 are the equilibrium price and quantity that would prevail without government regulation. The government, however, has decided that P_0 is too high and mandated that the price can be no higher than a maximum allowable *ceiling price*, denoted by P_{max}. What is the result? At this lower price, producers (particularly those with higher costs) will produce less, and the quantity supplied will drop to Q_1. Consumers, on the other hand, will demand more at this low price; they would like to purchase the quantity Q_2. Demand therefore exceeds supply, and a shortage develops—i.e., there is *excess demand*. The amount of excess demand is $Q_2 - Q_1$.

This excess demand sometimes takes the form of queues, as when drivers lined up to buy gasoline during the winter of 1974 and the summer of 1979. In both instances, the lines were the result of price controls; the government prevented

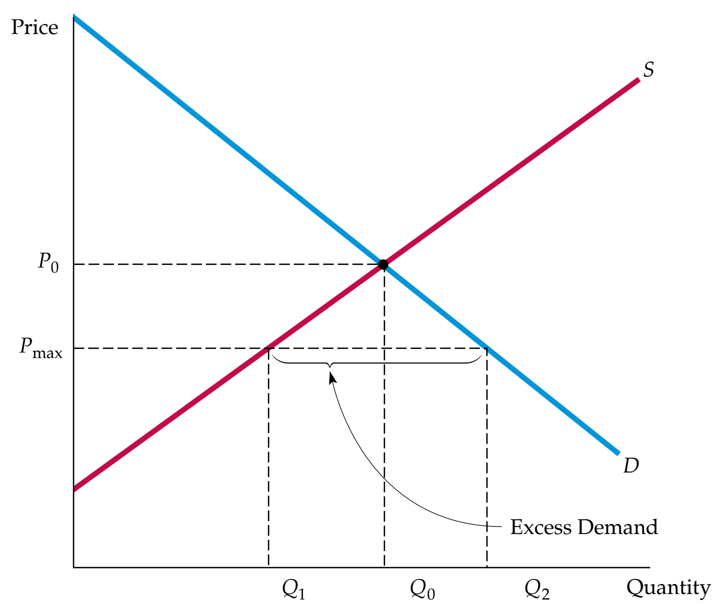

FIGURE 2.23 Effects of Price Controls

Without price controls, the market clears at the equilibrium price and quantity P_0 and Q_0. If price is regulated to be no higher than P_{max}, the quantity supplied falls to Q_1, the quantity demanded increases to Q_2, and a shortage develops.

domestic oil and gasoline prices from rising along with world oil prices. Sometimes excess demand results in curtailments and supply rationing, as with natural gas price controls and the resulting gas shortages of the mid-1970s, when industrial consumers closed factories because gas supplies were cut off. Sometimes it spills over into other markets, where it artificially increases demand. For example, natural gas price controls caused potential buyers of gas to use oil instead.

Some people gain and some lose from price controls. As Figure 2.23 suggests, producers lose: They receive lower prices, and some leave the industry. Some but not all consumers gain. While those who can purchase the good at a lower price are better off, those who have been "rationed out" and cannot buy the good at all are worse off. How large are the gains to the winners and how large are the losses to the losers? Do total gains exceed total losses? To answer these questions, we need a method to measure the gains and losses from price controls and other forms of government intervention. We discuss such a method in Chapter 9.

EXAMPLE 2.10 Price Controls and Natural Gas Shortages

In 1954, the federal government began regulating the wellhead price of natural gas. Initially the controls were not binding; the ceiling prices were above those that cleared the market. But in about 1962, when these ceiling prices did become binding, excess demand for natural gas developed and slowly began to grow. In the 1970s, this excess demand, spurred by higher oil prices, became severe and led to widespread curtailments. Soon ceiling prices were far below prices that would have prevailed in a free market.[18]

Today, producers and industrial consumers of natural gas, oil, and other commodities are concerned that the government might respond, once again, with price controls if prices rise sharply. To understand the likely impact of such price controls, we will go back to the year 1975 and calculate the impact of natural gas price controls at that time.

Based on econometric studies of natural gas markets and the behavior of those markets as controls were gradually lifted during the 1980s, the following data describe the market in 1975.

- The free-market price of natural gas would have been about $2.00 per mcf (thousand cubic feet);
- Production and consumption would have been about 20 Tcf (trillion cubic feet);
- The average price of oil (including both imports and domestic production), which affects both supply and demand for natural gas, was about $8/barrel.

A reasonable estimate for the price elasticity of supply is 0.2. Higher oil prices also lead to more natural gas production because oil and gas are often discovered and produced together; an estimate of the cross-price elasticity of supply is 0.1. As for demand, the price elasticity is about –0.5, and the cross-price elasticity

[18]This regulation began with the Supreme Court's 1954 decision requiring the then Federal Power Commission to regulate wellhead prices on natural gas sold to interstate pipeline companies. These price controls were largely removed during the 1980s, under the mandate of the Natural Gas Policy Act of 1978. For a detailed discussion of natural gas regulation and its effects, see Paul W. MacAvoy and Robert S. Pindyck, *The Economics of the Natural Gas Shortage* (Amsterdam: North-Holland, 1975); R. S. Pindyck, "Higher Energy Prices and the Supply of Natural Gas," *Energy Systems and Policy* 2 (1978): 177–209; and Arlon R. Tussing and Connie C. Barlow, *The Natural Gas Industry* (Cambridge, MA: Ballinger, 1984).

with respect to oil price is about 1.5. You can verify that the following linear supply and demand curves fit these numbers:

$$\text{Supply:} \quad Q = 14 + 2P_G + .25P_O$$
$$\text{Demand:} \quad Q = -5P_G + 3.75P_O$$

where Q is the quantity of natural gas (in Tcf), P_G is the price of natural gas (in dollars per mcf), and P_O is the price of oil (in dollars per barrel). You can also verify, by equating the quantities supplied and demanded and substituting \$8.00 for P_O, that these supply and demand curves imply an equilibrium free-market price of \$2.00 for natural gas.

The regulated price of gas in 1975 was about \$1.00 per mcf. Substituting this price for P_G in the supply function gives a quantity supplied (Q_1 in Figure 2.23) of 18 Tcf. Substituting for P_G in the demand function gives a quantity demanded (Q_2 in Figure 2.23) of 25 Tcf. Price controls thus created an excess demand of 25 – 18 = 7 Tcf, which manifested itself in the form of widespread curtailments.

Price regulation was a major component of U.S. energy policy during the 1970s and continued to influence the evolution of natural gas markets in the 1980s. In Example 9.1 of Chapter 9, we show how to measure the gains and losses that result from price controls.

SUMMARY

1. Supply-demand analysis is a basic tool of microeconomics. In competitive markets, supply and demand curves tell us how much will be produced by firms and how much will be demanded by consumers as a function of price.
2. The market mechanism is the tendency for supply and demand to equilibrate (i.e., for price to move to the market-clearing level), so that there is neither excess demand nor excess supply.
3. Elasticities describe the responsiveness of supply and demand to changes in price, income, or other variables. For example, the price elasticity of demand measures the percentage change in the quantity demanded resulting from a 1-percent increase in price.
4. Elasticities pertain to a time frame, and for most goods it is important to distinguish between short-run and long-run elasticities.
5. If we can estimate, at least roughly, the supply and demand curves for a particular market, we can calculate the market-clearing price by equating the quantity supplied with the quantity demanded. Also, if we know how supply and demand depend on other economic variables, such as income or the prices of other goods, we can calculate how the market-clearing price and quantity will change as these other variables change. This is a means of explaining or predicting market behavior.
6. Simple numerical analyses can often be done by fitting linear supply and demand curves to data on price and quantity and to estimates of elasticities. For many markets, such data and estimates are available, and simple "back of the envelope" calculations can help us understand the characteristics and behavior of the market.

QUESTIONS FOR REVIEW

1. Suppose that unusually hot weather causes the demand curve for ice cream to shift to the right. Why will the price of ice cream rise to a new market-clearing level?
2. Use supply and demand curves to illustrate how each of the following events would affect the price of butter and the quantity of butter bought and sold: (a) an increase in the price of margarine; (b) an increase in the price of milk; (c) a decrease in average income levels.
3. If a 3-percent increase in the price of corn flakes causes a 6-percent decline in the quantity demanded, what is the elasticity of demand?
4. Explain the difference between a shift in the supply curve and a movement along the supply curve.

5. Explain why for many goods, the long-run price elasticity of supply is larger than the short-run elasticity.

6. Why do long-run elasticities of demand differ from short-run elasticities? Consider two goods: paper towels and televisions. Which is a durable good? Would you expect the price elasticity of demand for paper towels to be larger in the short run or in the long run? Why? What about the price elasticity of demand for televisions?

7. Are the following statements true or false? Explain your answers.
 a. The elasticity of demand is the same as the slope of the demand curve.
 b. The cross-price elasticity will always be positive.
 c. The supply of apartments is more inelastic in the short run than the long run.

8. Suppose the government regulates the prices of beef and chicken and sets them below their market-clearing levels. Explain why shortages of these goods will develop and what factors will determine the sizes of the shortages. What will happen to the price of pork? Explain briefly.

9. The city council of a small college town decides to regulate rents in order to reduce student living expenses. Suppose the average annual market-clearing rent for a two-bedroom apartment had been $700 per month and that rents were expected to increase to $900 within a year. The city council limits rents to their current $700-per-month level.
 a. Draw a supply and demand graph to illustrate what will happen to the rental price of an apartment after the imposition of rent controls.
 b. Do you think this policy will benefit all students? Why or why not?

10. In a discussion of tuition rates, a university official argues that the demand for admission is completely price inelastic. As evidence, she notes that while the university has doubled its tuition (in real terms) over the past 15 years, neither the number nor quality of students applying has decreased. Would you accept this argument? Explain briefly. (*Hint*: The official makes an assertion about the demand for admission, but does she actually observe a demand curve? What else could be going on?)

11. Suppose the demand curve for a product is given by

$$Q = 10 - 2P + P_S$$

where P is the price of the product and P_S is the price of a substitute good. The price of the substitute good is $2.00.
 a. Suppose P = $1.00. What is the price elasticity of demand? What is the cross-price elasticity of demand?
 b. Suppose the price of the good, P, goes to $2.00. Now what is the price elasticity of demand? What is the cross-price elasticity of demand?

12. Suppose that rather than the declining demand assumed in Example 2.8, a decrease in the cost of copper production causes the supply curve to shift to the right by 40 percent. How will the price of copper change?

13. Suppose the demand for natural gas is perfectly inelastic. What would be the effect, if any, of natural gas price controls?

EXERCISES

1. Suppose the demand curve for a product is given by $Q = 300 - 2P + 4I$, where I is average income measured in thousands of dollars. The supply curve is $Q = 3P - 50$.
 a. If $I = 25$, find the market-clearing price and quantity for the product.
 b. If $I = 50$, find the market-clearing price and quantity for the product.
 c. Draw a graph to illustrate your answers.

2. Consider a competitive market for which the quantities demanded and supplied (per year) at various prices are given as follows:

Price (Dollars)	Demand (Millions)	Supply (Millions)
60	22	14
80	20	16
100	18	18
120	16	20

 a. Calculate the price elasticity of demand when the price is $80 and when the price is $100.
 b. Calculate the price elasticity of supply when the price is $80 and when the price is $100.
 c. What are the equilibrium price and quantity?
 d. Suppose the government sets a price ceiling of $80. Will there be a shortage, and if so, how large will it be?

3. Refer to Example 2.5 on the market for wheat. At the end of 1998, both Brazil and Indonesia opened their wheat markets to U.S. farmers. Suppose that these new markets add 200 million bushels to U.S. wheat demand. What will be the free-market price of wheat and what quantity will be produced and sold by U.S. farmers?

4. A vegetable fiber is traded in a competitive world market, and the world price is $9 per pound. Unlimited quantities are available for import into the United States at this price. The U.S. domestic supply and demand for various price levels are shown as follows:

Price	U.S. Supply (Million Lbs)	U.S. Demand (Million Lbs)
3	2	34
6	4	28
9	6	22
12	8	16
15	10	10
18	12	4

a. What is the equation for demand? What is the equation for supply?
b. At a price of \$9, what is the price elasticity of demand? What is it at a price of \$12?
c. What is the price elasticity of supply at \$9? At \$12?
d. In a free market, what will be the U.S. price and level of fiber imports?

***5.** Much of the demand for U.S. agricultural output has come from other countries. In 1998, the total demand for wheat was $Q = 3244 - 283P$. Of this, total domestic demand was $Q_D = 1700 - 107P$, and domestic supply was $Q_S = 1944 + 207P$. Suppose the export demand for wheat falls by 40 percent.
a. U.S. farmers are concerned about this drop in export demand. What happens to the free-market price of wheat in the United States? Do farmers have much reason to worry?
b. Now suppose the U.S. government wants to buy enough wheat to raise the price to \$3.50 per bushel. With the drop in export demand, how much wheat would the government have to buy? How much would this cost the government?

6. The rent control agency of New York City has found that aggregate demand is $Q_D = 160 - 8P$. Quantity is measured in tens of thousands of apartments. Price, the average monthly rental rate, is measured in hundreds of dollars. The agency also noted that the increase in Q at lower P results from more three-person families coming into the city from Long Island and demanding apartments. The city's board of realtors acknowledges that this is a good demand estimate and has shown that supply is $Q_S = 70 + 7P$.
a. If both the agency and the board are right about demand and supply, what is the free-market price? What is the change in city population if the agency sets a maximum average monthly rent of \$300 and all those who cannot find an apartment leave the city?
b. Suppose the agency bows to the wishes of the board and sets a rental of \$900 per month on all apartments to allow landlords a "fair" rate of return. If 50 percent of any long-run increases in apartment offerings comes from new construction, how many apartments are constructed?

7. In 1998, Americans smoked 470 billion cigarettes, or 23.5 billion packs of cigarettes. The average retail price was \$2 per pack. Statistical studies have shown that the price elasticity of demand is –0.4, and the price elasticity of supply is 0.5. Using this information, derive linear demand and supply curves for the cigarette market.

8. In Example 2.8 we examined the effect of a 20-percent decline in copper demand on the price of copper, using the linear supply and demand curves developed in Section 2.6. Suppose the long-run price elasticity of copper demand were –0.4 instead of –0.8.
a. Assuming, as before, that the equilibrium price and quantity are $P^* = 75$ cents per pound and $Q^* = 7.5$ million metric tons per year, derive the linear demand curve consistent with the smaller elasticity.
b. Using this demand curve, recalculate the effect of a 20-percent decline in copper demand on the price of copper.

9. Example 2.9 analyzes the world oil market. Using the data given in that example:
a. Show that the short-run demand and competitive supply curves are indeed given by

$$D = 24.08 - 0.06P$$
$$S_C = 11.74 + 0.07P$$

b. Show that the long-run demand and competitive supply curves are indeed given by

$$D = 32.18 - 0.51P$$
$$S_C = 7.78 + 0.29P$$

c. In 2002, Saudi Arabia accounted for 3 billion barrels per year of OPEC's production. Suppose that war or revolution caused Saudi Arabia to stop producing oil. Use the model above to calculate what would happen to the price of oil in the short run *and* the long run if OPEC's production were to drop by 3 billion barrels per year.

10. Refer to Example 2.10, which analyzes the effects of price controls on natural gas.
a. Using the data in the example, show that the following supply and demand curves did indeed describe the market in 1975:

Supply: $Q = 14 + 2P_G + 0.25P_O$
Demand: $Q = -5P_G + 3.75P_O$

where P_G and P_O are the prices of natural gas and oil, respectively. Also verify that if the price of oil is \$8.00, these curves imply a free-market price of \$2.00 for natural gas.
b. Suppose the regulated price of gas in 1975 had been \$1.50 per thousand cubic feet instead of \$1.00. How much excess demand would there have been?
c. Suppose that the market for natural gas had *not* been regulated. If the price of oil had increased from \$8.00 to \$16.00, what would have happened to the free-market price of natural gas?

*11. The table below shows the retail price and sales for instant coffee and roasted coffee for 1997 and 1998.

a. Using this data alone, estimate the short-run price elasticity of demand for roasted coffee. Derive a linear demand curve for roasted coffee.

b. Now estimate the short-run price elasticity of demand for instant coffee. Derive a linear demand curve for instant coffee.

c. Which coffee has the higher short-run price elasticity of demand? Why do you think this is the case?

Year	*Retail Price of Instant Coffee ($/Lb)*	*Sales of Instant Coffee (Million Lbs)*	*Retail Price of Roasted Coffee ($/Lb)*	*Sales of Roasted Coffee (Million Lbs)*
1997	10.35	75	4.11	820
1998	10.48	70	3.76	850