# 2 Supply and Demand

*Talk is cheap because supply exceeds demand.*

## Challenge

### Quantities and Prices of Genetically Modified Foods

Countries around the globe are debating whether to permit firms to grow or sell genetically modified (GM) foods, which have their DNA altered through genetic engineering rather than through conventional breeding.[1] The introduction of GM techniques can affect both the quantity of a crop that farmers supply and whether consumers want to buy that crop.

At least 29 countries grow GM food crops, which are mostly herbicide-resistant varieties of corn (maize), soybean, and canola (oilseed rape). Developing countries grow more GM crops than developed countries, though the United States plants 40% of worldwide GM acreage. As of 2015, the largest GM-producing countries are (in order) the United States, Brazil, Argentina, India, Canada, and China. European farmers produce virtually none of the world's GM crops, growing them on only 0.1% of their cultivatable land.

According to some polls, 70% of consumers in Europe object to GM foods. Fears cause some consumers to refuse to buy a GM crop (or the entire crop if consumers cannot distinguish non-GM from GM products). Consumers in other countries, such as the United States, are less concerned about GM foods. However, even in the United States, a 2015 poll found that 57% of U.S. consumers believe that GM foods are generally unsafe to eat, whereas 88% of scientists believe they are generally safe. The U.S. National Academy of Science reported in 2016 that they could find no evidence to support claims that genetically modified organisms are dangerous for either the environment or human health.

As of 2016, 65 nations require labeling of GM foods, including European Union countries, Japan, Australia, Brazil, Russia, China, and the United States. Consumers are unlikely to avoid GM crops if products are unlabeled.

Will the use of GM seeds lead to lower prices and more food sold? What happens to prices and quantities sold if many consumers refuse to buy GM crops? We will use the models in this chapter to answer these questions at the end of the chapter.

To analyze questions concerning the price and quantity responses to the introduction of new products or technologies, new government regulations or taxes, or other events, economists may use the *supply-and-demand model*. When asked, "What is the most important thing you know about economics?" a common reply is, "Supply equals demand." This statement is a shorthand description of one of the simplest yet most powerful models of economics. The supply-and-demand model describes how consumers and suppliers interact to determine the quantity and price of a good or

[1]Sources for Challenges, which appear at the beginning of chapters, and Applications, which appear throughout the chapters, are listed at the end of the book.

service. To use the model, you need to determine three things: buyers' behavior, sellers' behavior, and how they interact.

After reading this chapter, you should be adept enough at using the supply-and-demand model to analyze some of the most important policy questions facing your country today, such as those concerning international trade, minimum wages, and price controls on health care.

After reading that grandiose claim, you may ask, "Is that all there is to economics? Can I become an expert economist that fast?" The answer to both these questions is no, of course not. In addition, you need to learn the limits of this model and what other models to use when this one does not apply. (You must also learn the economists' secret handshake.)

Even with its limitations, the supply-and-demand model is the most widely used economic model. It provides a good description of how competitive markets function. *Competitive markets* are those with many buyers and sellers, such as most agriculture markets, labor markets, and stock and commodity markets. Like all good theories, the supply-and-demand theory can be tested—and possibly shown to be false. But in competitive markets, where it works well, it allows us to make accurate predictions easily.

In this chapter, we examine six main topics

1. **Demand.** The quantity of a good or service that consumers demand depends on price and other factors, such as consumers' incomes and the price of related goods.
2. **Supply.** The quantity of a good or service that firms supply depends on price and other factors, such as the cost of inputs firms use to produce the good or service.
3. **Market Equilibrium.** The interaction between consumers' demand and firms' supply determines the market price and quantity of a good or service that is bought and sold.
4. **Shocking the Equilibrium.** Changes in a factor that affect demand (such as consumers' incomes), supply (such as a rise in the price of inputs), or a new government policy (such as a new tax) alter the market price and quantity of a good.
5. **Effects of Government Interventions.** Government policies may alter the equilibrium and cause the quantity supplied to differ from the quantity demanded.
6. **When to Use the Supply-and-Demand Model.** The supply-and-demand model applies only to competitive markets.

## 2.1 Demand

Potential consumers decide how much of a good or service to buy on the basis of its price and many other factors, including consumers' tastes, information, prices of other goods, income, and government actions. Before concentrating on the role of price in determining demand, let's look briefly at some of the other factors.

Consumers' *tastes* determine what they buy. Consumers do not purchase foods they dislike, artwork they hate, or clothes they view as unfashionable or uncomfortable. Advertising may influence people's tastes.

Similarly, *information* (or misinformation) about the characteristics of a good affects consumers' decisions. A number of years ago when many consumers were convinced that oatmeal could lower their cholesterol level, they rushed to grocery stores and bought large quantities of oatmeal. (They even ate some of it until they remembered that they couldn't stand how it tastes.)

The *prices of other goods* also affect consumers' purchase decisions. Before deciding to buy Levi's jeans, you might check the prices of other brands. If the price of a close *substitute*—a product that you view as similar or identical to the one you are

considering purchasing—is much lower than the price of Levi's jeans, you may buy that brand instead. Similarly, the price of a *complement*—a good that you like to consume at the same time as the product you are considering buying—may affect your decision. If you eat pie only with ice cream, the higher the price of ice cream, the less likely you are to buy pie.

*Income* plays a major role in determining what and how much to purchase. People who suddenly inherit great wealth may purchase a Rolls-Royce or other luxury items and would probably no longer buy do-it-yourself repair kits.

*Government rules and regulations* affect purchase decisions. Sales taxes increase the price that a consumer must pay for a good, and government-imposed limits on the use of a good may affect demand. In the nineteenth century, one could buy Bayer heroin, a variety of products containing cocaine, and other drug-related products that most countries ban today. When a city's government bans the use of skateboards on its streets, skateboard sales fall.[2]

*Other factors* may also affect the demand for specific goods. Consumers are more likely to use a particular smart phone app (application) if their friends use that one. The demand for small, dead evergreen trees is substantially higher in December than in other months.

Although many factors influence demand, economists usually concentrate on how price affects the quantity demanded. The relationship between price and quantity demanded plays a critical role in determining the market price and quantity in a supply-and-demand analysis. To determine how a change in price affects the quantity demanded, economists must hold constant other factors that affect demand, such as income and tastes.

**quantity demanded**
the amount of a good that consumers are willing to buy at a given price, holding constant the other factors that influence purchases

**demand curve**
the *quantity demanded* at each possible price, holding constant the other factors that influence purchases

## The Demand Curve

The amount of a good that consumers are *willing* to buy at a given price, holding constant other factors that influence purchases, is the **quantity demanded**. The quantity demanded of a good or service can exceed the quantity *actually* sold.

For example, as a promotion, a local store might sell Ghirardelli 4.12 oz. dark chocolate bars for $1 each today only. At that low price, you might want to buy 10 chocolate bars, but because the store has only 5 remaining, you can buy at most 5 chocolate bars at this price. The quantity you demand at this price is 10 chocolate bars—it's the amount you want—even though the amount you actually buy is only 5.

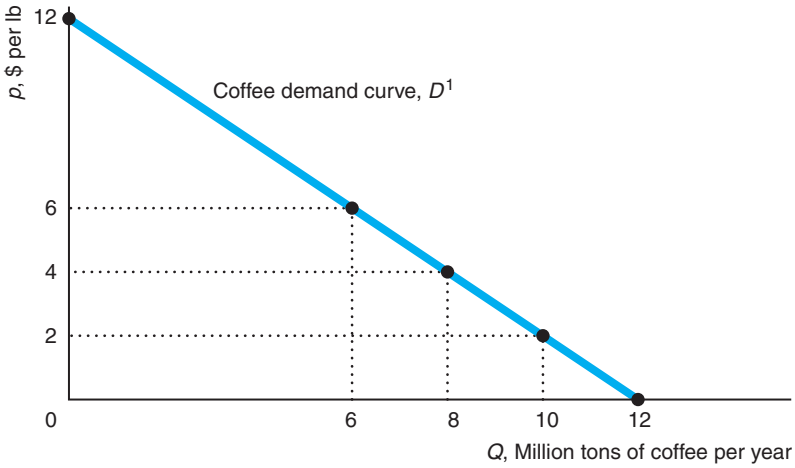
We can show the relationship between price and the quantity demanded graphically. A **demand curve** shows the quantity demanded at each possible price, holding constant other factors that influence purchases. Figure 2.1 shows the estimated annual demand curve, $D^1$, for green (unroasted) coffee beans.[3] (Although this demand curve is a straight line,

[2]When a Mississippi woman attempted to sell her granddaughter in exchange for $2,000 and a car, state legislators were horrified to discover that they had no law on the books prohibiting the sale of children and quickly passed such a law. (Mac Gordon, "Legislators Make Child-Selling Illegal," *Jackson Free Press*, March 16, 2009.)

[3]Because prices, quantities, and other factors change simultaneously over time, economists use statistical techniques to hold the effects of factors other than the price of the good constant so that they can determine how price affects the quantity demanded (see Appendix 2A at the back of the book). I estimated this model using data from the Food and Agriculture Organization, *Commodity Review and Outlook*; International Coffee Organization, **www.ico.org/new_historical.asp**; International Cocoa Organization, *The World Cocoa Economy: Past and Present* (July 2012); and World Bank, *World Development Indicators*.

**Figure 2.1** A Demand Curve

The estimated global demand curve, $D^1$, for coffee shows the relationship between the annual quantity demanded and the price per lb. The downward slope of the demand curve shows that, holding other factors that influence demand constant, consumers demand a smaller quantity of this good when its price is high and a larger quantity when the price is low. A change in price causes a *movement along the demand curve*. For example, an increase in the price of coffee causes consumers to demand a smaller quantity of coffee.




demand curves may also be smooth curves or wavy lines.) By convention, the vertical axis of the graph measures the price, $p$, per unit of the good. Here, we measure the price of coffee in dollars per pound (abbreviated "lb"). The horizontal axis measures the quantity, $Q$, of the good in a *physical measure per period*. Here, we measure the quantity of coffee demanded in millions of tons per year.

The demand curve hits the vertical axis at \$12, indicating that the quantity demanded is zero when the price is \$12 per lb or higher. The demand curve hits the horizontal quantity axis at 12 million tons per year, which is the quantity of coffee that consumers would want if the price were zero. To find out what quantity is demanded at a price between zero and \$4, we pick that price—say, \$2—on the vertical axis, draw a horizontal line across until we hit the demand curve, and then draw a vertical line down to the horizontal quantity axis. As the figure shows, the quantity demanded at a price of \$2 per lb is 10 million tons per year.

One of the most important things to know about the graph of a demand curve is what it does *not* show. All relevant economic variables that are not explicitly included in the demand curve graph—income, prices of other goods (such as other fruits or vegetables), tastes, information, and so on—are held constant. Thus, the demand curve shows how quantity varies with price but not how quantity varies with income, the price of substitute goods, tastes, information, or other variables. The demand curve is a concise summary of the answer to the question "What happens to the quantity demanded as the price changes, when all other factors are held constant?"

**Law of Demand** consumers demand more of a good the lower its price, holding constant tastes, the prices of other goods, and other factors that influence consumption

**Effect of Prices on the Quantity Demanded** Many economists claim that the most important *empirical* finding in economics is the **Law of Demand:** Consumers demand more of a good the lower its price, holding constant other factors that influence the amount they consume. According to the Law of Demand, *demand curves slope downward*, as in Figure 2.1.[4]

A downward-sloping demand curve illustrates that consumers demand a large quantity of this good at a low price and a small quantity at a high price. What happens to the quantity of coffee demanded if the price of coffee drops and all other

[4]Theoretically, a demand curve could slope upward (see Chapter 5); however, available empirical evidence strongly supports the Law of Demand.


variables remain constant? The quantity demanded increases. For example, the demand curve in Figure 2.1 shows that if the price decreases from \$6 to \$4 per lb, the quantity consumers demand increases by 2 million tons, from 6 to 8 million tons.[5] These changes in the quantity demanded in response to changes in price are *movements along the demand curve*.

**Effects of Other Factors on Demand** If a demand curve measures the effects of price changes when we hold constant all other factors that affect demand, how can we use demand curves to show the effects of a change in one of these other factors, such as household income? One solution is to draw the demand curve in a three-dimensional diagram with the price of coffee on one axis, the income on a second axis, and the quantity of coffee on the third axis. Just thinking about drawing such a diagram probably makes your head hurt. Moreover, what would you do if the demand curve depended on one more factor?

Economists use a simpler approach to show how quantity demanded is affected by a change in a factor other than price. A change in any factor other than the price of the good itself results in a *shift of the demand curve* rather than a *movement along the demand curve*.

If the average household income rises and the price of coffee remains constant, people buy more coffee. Suppose that the average income rises from \$35,000 per year to \$50,000, an increase of \$15,000. Figure 2.2 shows that the higher income causes the coffee demand curve to shift 1.5 units (million tons) to the right from $D^1$, where the average income is \$35,000, to $D^2$, where average income is \$50,000.

A change in other factors, such as the prices of *substitutes* and *complements*, may also cause a demand curve to shift. A **substitute** is a good or service that may be consumed instead of another good or service. For many people, tea is a substitute for coffee, so a decrease in the price of tea may cause their demand curve to shift to the left—less coffee is demanded at any given price of coffee. A **complement** is a good or service that is jointly consumed with another good or service. For example, many people drink coffee with sugar. An increase in the price of sugar would cause their demand curves to shift to the left.

Other factors also affect demand curves. For example, if cigarettes become more addictive, the demand curve of existing smokers shifts to the right.[6]

In summary, to properly analyze the effects of a change in a factor on the quantity demanded, we must distinguish between a *movement along a demand curve* and a *shift of a demand curve*. A change in the *price of a good* causes a *movement along a demand curve*. A change in *any other factor besides the price of the good* causes a *shift of the demand curve*.

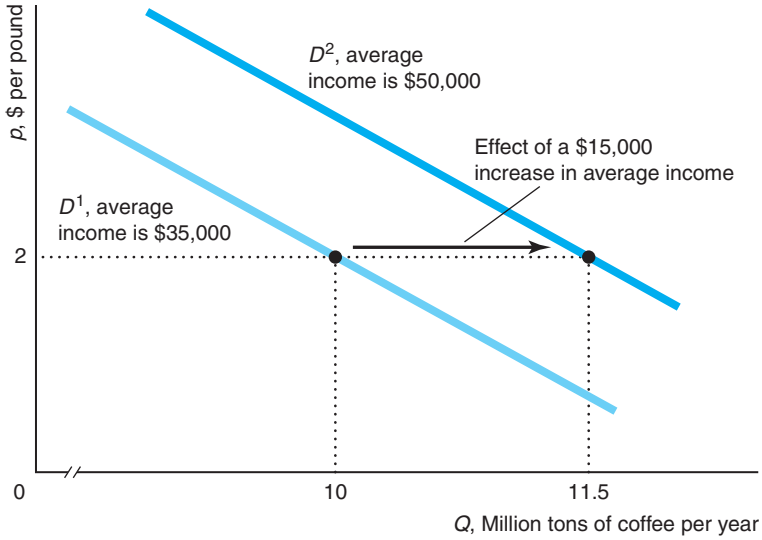
---

[5]Economists typically do not state the relevant physical and period measures unless they are particularly useful. They refer to *quantity* rather than something useful such as "metric tons per year" and *price* rather than "cents per pound." I'll generally follow this convention, usually referring to the price as \$4 (with the "per lb" understood) and the quantity as 8 (with the "million tons per year" understood).

[6]A Harvard School of Public Health study concluded that cigarette manufacturers raised nicotine levels in cigarettes by 11% from 1998 to 2005 to make them more addictive. Gardiner Harris, "Study Showing Boosted Nicotine Levels Spurs Calls for Controls," *San Francisco Chronicle*, January 19, 2007, A-4.

**Figure 2.2** A Shift of the Demand Curve

The global coffee demand curve shifts rightward from $D^1$ to $D^2$ as average annual household income in high-income countries rises by $15,000, from $35,000 to $50,000. At the higher income, a larger quantity of coffee is demanded at any given price.




## Application

Calorie Counting

Information can also affect demand curves. New York City started requiring mandatory posting of calories on menus in chain restaurants in mid-2008. Bollinger, Leslie, and Sorensen (2011) found that New York City's calorie posting requirement caused average calories per transaction at Starbucks to fall by 6% due to reduced consumption of high-calorie foods. They found larger responses to information among wealthier and better-educated consumers and among those who prior to the law consumed relatively more calories.

Some other studies found less of a response to such information. Dingman et al. (2015) posted calorie information on vending machines selling food and sent email to residents of some college residence halls. In other halls, they provided no information. Comparing vending machine sales in the four weeks before and after they provided information, they found no change in behavior from the information. However, U.S. Department of Agriculture studies found that people who already have healthy diets habits—apparently unlike college students—*do* pay attention to this information (Stewart and Mentzer Morrison, 2015).

A U.S. Food and Drug Administration (FDA) rule requires that large restaurant chains include calorie information on their menus. In 2016, the FDA also set new calorie, nutritional, and serving size labeling requirements for packaged food, which becomes mandatory as of July 2018.

**substitute**
a good or service that may be consumed instead of another good or service

**complement**
a good or service that is jointly consumed with another good or service

**demand function**
the relationship between the quantity demanded, price, and other factors that influence purchases

## The Demand Function

The **demand function** shows the relationship between the quantity demanded, price, and other factors that influence purchases. Other factors that may influence the quantity demanded include income, substitutes, complements, tastes, and consumer

information. Graphically, we illustrate the effect of a change in one of these other relevant factors by shifting the demand curve. We can represent the same information mathematically—information about how price, income, and other variables affect quantity demanded—using a *demand function*. The demand function shows the effect of *all* the relevant factors on the quantity demanded.

We examine a demand function for coffee. The quantity of coffee demanded, $Q$, varies with the price of coffee, $p$, the price of sugar, $p_s$, and consumers' income, $Y$, so the coffee demand function, $D$, is

$$Q = D(p, p_s, Y). \tag{2.1}$$

We assume that any other factors that we do not explicitly list in the demand function are irrelevant (such as the price of llamas in Peru) or constant (such as the prices of substitutes and complements, tastes, and consumer information).

Equation 2.1 is a general functional form—it does not specify exactly how $Q$ varies with the explanatory variables, $p$, $p_s$, and $Y$. The estimated demand function that corresponds to the demand curve $D$ in Figure 2.1 and $D^1$ in Figure 2.2 has a specific (linear) form. Our estimated world demand function for green coffee beans is

$$Q = 8.56 - p - 0.3p_s + 0.1Y, \tag{2.2}$$

where $Q$ is the quantity of coffee demanded in millions of tons per year, $p$ is the price of coffee in dollars per pound (lb), $p_s$ is the price of sugar in dollars per pound, and $Y$ is the average annual household income in high-income countries in thousands of dollars.

When we draw the demand curve in Figures 2.1 and 2.2, we hold $p_s$ and $Y$ at specific values. In these figures, we use the average values of $p_s$, \$0.20 per lb, and $Y$, \$35 thousand per year. Substituting those values into Equation 2.2, we can write the quantity demanded as a function of only the price of coffee:

$$\begin{aligned} Q &= 8.56 - p - 0.3p_s + 0.1Y \\ &= 8.56 - p - (0.3 \times 0.2) + (0.1 \times 35) \\ &= 12 - p. \end{aligned} \tag{2.3}$$

The linear demand function in Equation 2.3 corresponds to the straight-line demand curve $D$ in Figure 2.1. The constant term, 12, in Equation 2.3 is the quantity demanded (in millions of tons per year) if the price of coffee is zero. Setting the price equal to zero in Equation 2.3, we find that the quantity demanded is $Q = 12 - (1 \times 0) = 12$. Figure 2.1 shows that $Q = 12$ where $D$ hits the quantity axis—where price is zero.

By plugging any particular value for $p$ into Equation 2.3, we can determine the corresponding quantities. For example, if $p = \$2$, then $Q = 12 - 2 = 10$, as Figure 2.1 shows.

We can also use Equation 2.3 to determine how the quantity demanded varies with a change in price: a movement *along* the demand curve. If the price falls from $p_1$ to $p_2$, the change in price, $\Delta p$, equals $p_2 - p_1$. (The $\Delta$ symbol, the Greek letter delta, means "change in" the variable following the delta, so $\Delta p$ means "change in price.") If the price of coffee falls from $p_1 = \$4$ to $p_2 = \$2$, then $\Delta p = p_2 - p_1 = \$2 - \$4 = -\$2$. The quantity demanded changes from $Q_1 = 8$ at a price of \$4 to $Q_2 = 10$ at a price of \$2, so $\Delta Q = Q_2 - Q_1 = 10 - 8 = 2$. That is, as price falls by \$2 per pound, the quantity demanded rises by 2 million tons per year.

More generally, the quantity demanded at $p_1$ is $Q_1 = D(p_1)$, and the quantity demanded at $p_2$ is $Q_2 = D(p_2)$. The change in the quantity demanded, $\Delta Q = Q_2 - Q_1$, in response to the price change (using Equation 2.3) is

$$\begin{aligned}\Delta Q &= Q_2 - Q_1 \\ &= D(p_2) - D(p_1) \\ &= (12 - p_2) - (12 - p_1) \\ &= -(p_2 - p_1) \\ &= -\Delta p.\end{aligned}$$

Thus, the change in the quantity demanded, $\Delta Q$, is $-40$ times the change in the price, $\Delta p$. For example, if $\Delta p = -\$2$, then $\Delta Q = -\Delta p = -(-2) = 2$ million tons per year.

This effect is consistent with the Law of Demand. A \$2 decrease in price causes an increase in quantity demanded of 2 million tons per year. Similarly, raising the price would cause the quantity demanded to fall.

The slope of a demand curve is $\Delta p/\Delta Q$—the "rise" ($\Delta p$, the change along the vertical axis) divided by the "run" ($\Delta Q$, the change along the horizontal axis). The slope of the demand curve $D^1$ in Figures 2.1 and 2.2 is

$$\text{Slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta p}{\Delta Q} = \frac{\$1 \text{ per lb}}{-1 \text{ million tons per year}} = -\$1 \text{ per million tons per year}.$$

The negative sign of this slope is consistent with the Law of Demand. The slope says that the price rises by \$1 per lb as the quantity demanded falls by 1 million tons per year.

Thus, we can use the demand curve to answer questions about how a change in price affects the quantity demanded and how a change in the quantity demanded affects price. We can also answer these questions using demand functions.

## Solved Problem 2.1

MyLab Economics Solved Problem

How much would the price have to fall for consumers to be willing to buy 1 million more tons of coffee per month?

### Answer

1. *Express the price that consumers are willing to pay as a function of quantity.* We use algebra to rewrite the demand function as an *inverse demand function*, where price depends on the quantity demanded. Subtracting $Q$ from both sides of Equation 2.3, $Q = 12 - p$, and adding $p$ to both sides, we obtain the inverse demand function:

$$p = 4 - Q \tag{2.4}$$

2. *Use the inverse demand curve to determine how much the price must change for consumers to buy 1 million more tons of coffee per year.* We want the new quantity, $Q_2$, to equal the original quantity, $Q_1$, plus one: $Q_2 = Q_1 + 1$. Using the inverse demand function, Equation 2.4, we can determine by how much the price must change:

$$\begin{aligned}\Delta p &= p_2 - p_1 \\ &= (1 - Q_2) - (1 - Q_1) \\ &= -(Q_2 - Q_1) \\ &= -\Delta Q.\end{aligned}$$

The change in quantity is $\Delta Q = Q_2 - Q_1 = (Q_1 + 1) - Q_1 = 1$, so the change in price is $\Delta p = -1$. That is, for consumers to demand 1 million more tons of coffee per year, the price must fall by \$1 per pound, which is a *movement along the demand curve*.

## Summing Demand Curves

If we know the demand curve for each of two consumers, how do we determine the total demand curve for the two consumers combined? The total quantity demanded *at a given price* is the sum of the quantity each consumer demands at that price.

We can use the demand functions to determine the total demand of several consumers. Suppose that the demand function for Consumer 1 is

$$Q_1 = D^1(p)$$

and the demand function for Consumer 2 is

$$Q_2 = D^2(p).$$

At price $p$, Consumer 1 demands $Q_1$ units, Consumer 2 demands $Q_2$ units, and the total demand of both consumers is the sum of the quantities each demands separately:

$$Q = Q_1 + Q_2 = D^1(p) + D^2(p).$$

We can generalize this approach to look at the total demand for three or more consumers.

It makes sense to add the quantities demanded only when all consumers face the same price. Adding the quantity Consumer 1 demands at one price to the quantity Consumer 2 demands at another price would be like adding apples and oranges.

## Application

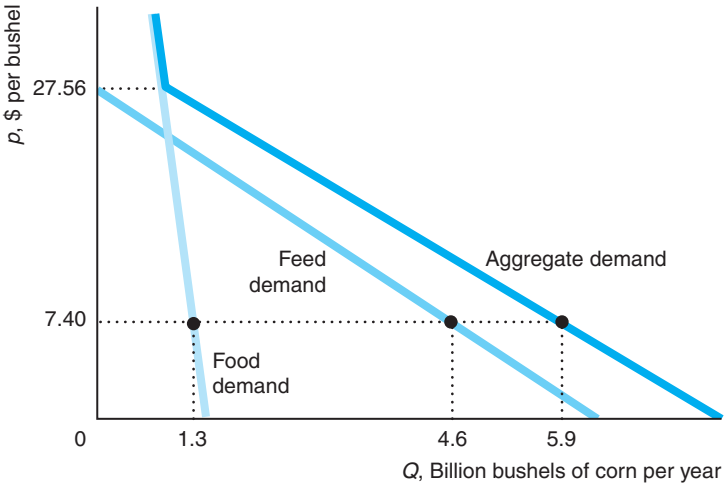
Aggregating Corn Demand Curves

We illustrate how to sum individual demand curves to get an aggregate demand curve using estimated demand curves for corn (McPhail and Babcock, 2012). The figure shows the U.S. feed demand (the use of corn to feed animals) curve, the U.S. food demand curve, and the aggregate demand curve from these two uses.[7]

To derive the sum of the quantity demanded for these two uses at a given price, we add the quantities from the individual demand curves at that price. That is, we add the demand curves horizontally. At a price for corn of \$7.40, the quantity demanded for food is 1.3 billion bushels per year and the quantity demanded for feed is 4.6 billion bushels. Thus, the total quantity demanded at that price is $Q = 1.3 + 4.6 = 5.9$ billion bushels.

When the price of corn exceeds \$27.56 per bushel, farmers stop using corn for animal feed, so the quantity demanded for this use equals zero. Thus, the total demand curve is the same as the food demand curve at prices above \$27.56.

[7]For graphical simplicity, we do not show the other major U.S. demand curves for export, storage, and use in biofuels (ethanol). Thus, this aggregate demand curve is not the total demand curve for corn.




## 2.2 Supply

Knowing how much consumers want is not enough by itself for us to determine the market price and quantity. We also need to know how much firms want to supply at any given price.

Firms determine how much of a good to supply based on the price of that good and other factors, including the costs of production and government rules and regulations. Usually, we expect firms to supply more at a higher price. Before concentrating on the role of price in determining supply, we'll briefly describe the role of some of the other factors.

*Costs of production* affect how much firms want to sell of a good. As a firm's cost falls, it is willing to supply more, all else the same. If the firm's cost exceeds what it can earn from selling the good, the firm sells nothing. Thus, factors that affect costs also affect supply. A technological advance that allows a firm to produce a good at lower cost leads the firm to supply more of that good, all else the same.

*Government rules and regulations* affect how much firms want to sell or whether they may sell a product. Taxes and many government regulations—such as those covering pollution, sanitation, and health insurance—alter the cost of production. Other regulations affect when and how suppliers may sell their products. In some countries, retailers may not sell most goods and services on days of particular religious significance. U.S. city and state governments prohibit the sale of cigarettes and liquor to children.

**quantity supplied**
the amount of a good that firms *want* to sell at a given price, holding constant other factors that influence firms' supply decisions, such as costs and government actions

### The Supply Curve

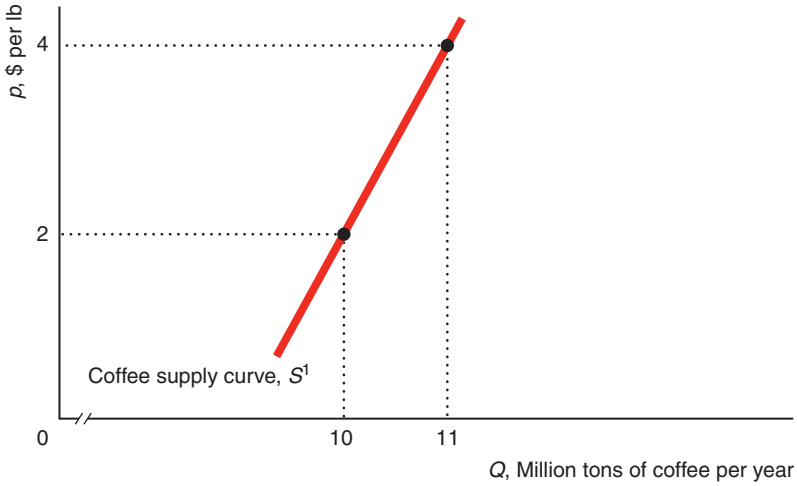
The **quantity supplied** is the amount of a good that firms *want* to sell at a given price, holding constant other factors that influence firms' supply decisions, such as costs and government actions. We can show the relationship between price and the quantity supplied graphically. A **supply curve** shows the quantity supplied at each possible price, holding constant the other factors that influence firms' supply decisions.

**supply curve**
the *quantity supplied* at each possible price, holding constant the other factors that influence firms' supply decisions

Figure 2.3 shows the estimated supply curve, $S^1$, for coffee. As with the demand curve, the price on the vertical axis is measured in dollars per physical unit (dollars per lb), and the quantity on the horizontal axis is measured in physical units per period (millions of tons per year). Because we hold fixed other variables that may

**Figure 2.3** A Supply Curve

The estimated global supply curve, $S^1$, for coffee shows the relationship between the quantity supplied per year and the price per lb, holding constant cost and other factors that influence supply. The upward slope of this supply curve indicates that firms supply more coffee when its price is high and less when the price is low. An increase in the price of coffee causes firms to supply a larger quantity of coffee; any change in price results in a *movement along the supply curve*.




affect the supply, such as costs and government rules, the supply curve concisely answers the question "What happens to the quantity supplied as the price changes, holding all other factors constant?"

**Effects of Price on Supply** We illustrate how price affects the quantity supplied using the coffee supply curve in Figure 2.3. The supply curve is upward sloping. As the price increases, firms supply more. If the price is \$2 per lb, the quantity supplied by the market is 10 million tons per year. If the price rises to \$4, the quantity supplied rises to 11 million tons. An increase in the price of coffee causes a *movement along the supply curve*—firms supply more coffee.

Although the Law of Demand states that the demand curve slope downward, we have *no* "Law of Supply" that requires the market supply curve to have a particular slope. The market supply curve can be upward sloping, vertical, horizontal, or downward sloping. Many supply curves slope upward, such as the one for coffee. Along such supply curves, the higher the price, the more firms are willing to sell, holding costs and government regulations fixed.

**Effects of Other Variables on Supply** A change in a factor other than a product's price causes a *shift of the supply curve*. Suppose the price of cocoa (which is a key input in making chocolate) increases by \$3 from \$3 to \$6 per lb. The land on which coffee is grown is also suitable to grow cocoa. When the price of cocoa rises, some coffee farmers switch to producing cocoa. Therefore, when the price of cocoa rises, the amount of coffee produced at any given coffee price falls.

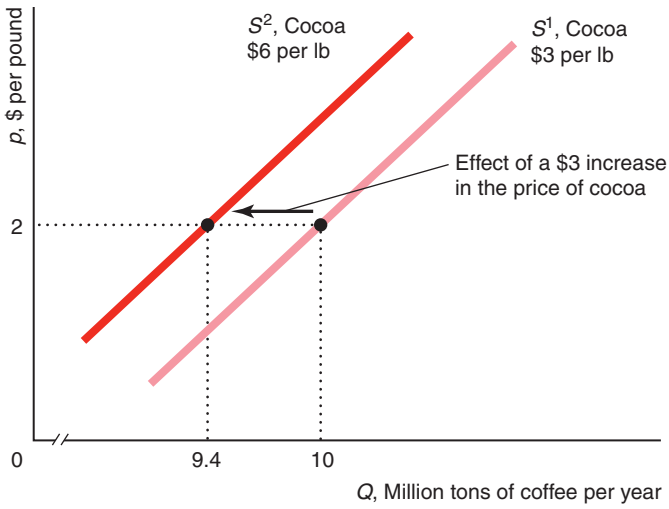
In Figure 2.4, $S^1$ is the supply curve of coffee before the price of cocoa increases, and $S^2$ is the supply curve after the price of cocoa rises. The increase in the price of cocoa causes the coffee supply curve to shift to the *left*, from $S^1$ to $S^2$.[8] That is, firms want to supply less coffee at any given price than before the increase in the price of cocoa. At a coffee price of \$2 per lb, the quantity of coffee supplied falls from 12 million tons on $S^1$ to 9.4 million on $S^2$.

Again, it is important to distinguish between a *movement along a supply curve* and a *shift of the supply curve*. When the coffee price changes, the change in the quantity

[8]Alternatively, we may say that the supply curve shifts *up* because firms will supply a given quantity only at a higher price.

**Figure 2.4** A Shift of a Supply Curve

A $3 per lb increase in the price of cocoa, which farmers can grow instead of coffee, causes the supply curve for coffee to shift left from $S^1$ to $S^2$. At a price for coffee of $2 per lb, the quantity supplied falls from 10 million tons on $S^1$ to 9.4 million tons on $S^2$.




supplied reflects a *movement along the supply curve*. When costs, government rules, or other variables that affect supply change, the entire *supply curve shifts*.

## The Supply Function

**supply function** shows the correspondence between the quantity supplied, price, and other factors that influence the number of units offered for sale

The **supply function** shows the relationship between the quantity supplied, price, and other factors that influence the number of units offered for sale. Written generally (without specifying the functional form), the coffee supply function is

$$Q = S(p, p_c), \tag{2.5}$$

where $Q$ is the quantity of coffee supplied, $p$ is the price of coffee, and $p_c$ is the price of cocoa.

The supply function, Equation 2.5, might also incorporate other factors such as wages, transportation costs, and the state of technology. By leaving them out, we are implicitly holding them constant.

Our estimate of the coffee supply function is

$$Q = 9.6 + 0.5p - 0.2p_c, \tag{2.6}$$

where $Q$ is the quantity of coffee in millions of tons per year, $p$ is the price of coffee in dollars per lb, and $p_c$ is the price of cocoa in dollars per lb.

If we fix the cocoa price at $3 per lb, we can rewrite the supply function in Equation 2.6 as a function solely of the coffee price. Substituting $p_c = \$3$ into Equation 2.6, we find that

$$Q = 9.6 + 0.5p - (0.2 \times 3) = 9 + 0.5p. \tag{2.7}$$

Because we hold fixed other variables that may affect the quantity supplied, such as costs and government rules, this supply function concisely answers the question "What happens to the quantity supplied as the price changes, holding all other factors constant?"

What happens to the quantity supplied if the price of coffee increases by $\Delta p = p_2 - p_1$? As the price increases from $p_1$ to $p_2$, the quantity supplied goes from $Q_1$ to $Q_2$, so the change in quantity supplied is

$$\Delta Q = Q_2 - Q_1 = (9.6 + 0.5p_2) - (9.6 + 0.5p_1) = 0.5(p_2 - p_1) = 0.5\Delta p.$$

Thus, a \$1 increase in price ($\Delta p = 1$) causes the quantity supplied to increase by $\Delta Q = 0.5$ million tons per year. This change in the quantity of coffee supplied as $p$ increases is a *movement along the supply curve*.

## Summing Supply Curves

The total supply curve shows the total quantity produced by all suppliers at each possible price. For example, the total supply of rice in Japan is the sum of the domestic and foreign supply curves of rice.

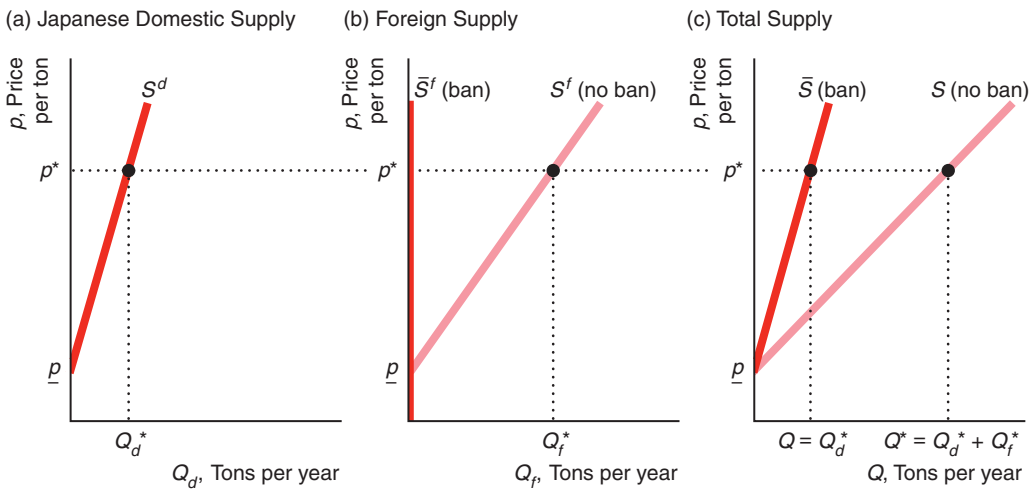
Suppose that the domestic supply curve (panel a) and foreign supply curve (panel b) of rice in Japan are as Figure 2.5 shows. The total supply curve, $S$ in panel c, is the horizontal sum of the Japanese *domestic* supply curve, $S^d$, and the *foreign* supply curve, $S^f$. In the figure, the Japanese and foreign supplies are zero at any price equal to or less than $\underline{p}$, so the total supply is zero. At prices above $\underline{p}$, the Japanese and foreign supplies are positive, so the total supply is positive. For example, when price is $p^*$, the quantity supplied by Japanese firms is $Q_d^*$ (panel a), the quantity supplied by foreign firms is $Q_f^*$ (panel b), and the total quantity supplied is $Q^* = Q_d^* + Q_f^*$ (panel c). Because the total supply curve is the horizontal sum of the domestic and foreign supply curves, the total supply curve is flatter than the other two supply curves.

## How Government Import Policies Affect Supply Curves

We can use this approach for deriving the total supply curve to analyze the effect of government policies on the total supply curve. Traditionally, the Japanese government has banned the importation of foreign rice. We want to determine how the ban affects the supply curve in the Japanese market.

**Figure 2.5** Total Supply: The Sum of Domestic and Foreign Supply

If foreigners may sell their rice in Japan, the total Japanese supply of rice, $S$, is the horizontal sum of the domestic Japanese supply, $S^d$, and the imported foreign supply, $S^f$. With a ban on foreign imports, the foreign supply curve, $\overline{S}^f$, is zero at every price, so the total supply curve, $\overline{S}$, is the same as the domestic supply curve, $S^d$.



Without a ban, the foreign supply curve is $S^f$ in panel b of Figure 2.5. A ban on imports eliminates the foreign supply, so the foreign supply curve after the ban is imposed, $\overline{S}^f$, is a vertical line at $Q_f = 0$. The import ban had no effect on the domestic supply curve, $S^d$, so the supply curve remains the same as in panel a.

Because the foreign supply with a ban, $\overline{S}^f$, is zero at every price, the total supply with a ban, $\overline{S}$ in panel c is the same as the Japanese domestic supply, $S^d$, at any given price. The total supply curve under the ban lies to the left of the total supply curve without a ban, $S$. Thus, the effect of the import ban is to rotate the total supply curve toward the vertical axis.

**quota**
the limit that a government sets on the quantity of a foreign-produced good that may be imported

The limit that a government sets on the quantity that may be imported of a foreign-produced good is called a **quota**. By absolutely banning the importation of rice, the Japanese government set a quota of zero on rice imports. Sometimes governments set positive quotas, $\overline{Q} > 0$. Foreign firms may supply as much as they want, $Q_f$, as long as they supply no more than the quota: $Q_f \leq \overline{Q}$.

We investigate the effect of such a quota in Solved Problem 2.2. In most of the solved problems in this book, you are asked to determine how a *change* in a variable or policy *affects* one or more variables. In this problem, the policy *changes* from no quota to a quota, which *affects* the total supply curve.

## Solved Problem 2.2

MyLab Economics Solved Problem

How does the quota, $\overline{Q}$, set by the United States on foreign sugar imports affect the total American supply curve for sugar given the domestic supply curve, $S^d$ in panel a of the graph, and the foreign supply curve, $S^f$ in panel b?

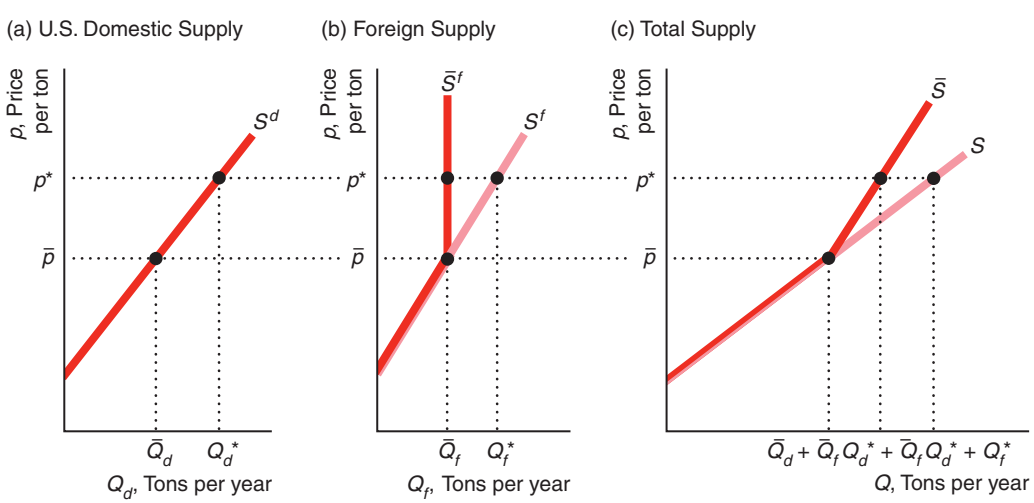
### Answer

1. *Determine the American supply curve without the quota*. The *no-quota* total supply curve, $S$ in panel c, is the horizontal sum of the U.S. domestic supply curve, $S^d$, and the no-quota foreign supply curve, $S^f$.

2. *Show the effect of the quota on foreign supply*. At prices less than $\overline{p}$, foreign suppliers want to supply quantities less than the quota, $\overline{Q}$. As a result, the foreign supply curve under the quota, $\overline{S}^f$, is the same as the no-quota foreign supply curve, $S^f$, for prices less than $\overline{p}$. At prices above $\overline{p}$, foreign suppliers want to supply more but are limited to $\overline{Q}$. Thus, the foreign supply curve with a quota, $\overline{S}^f$, is vertical at $\overline{Q}$ for prices above $\overline{p}$.

3. *Determine the American total supply curve with the quota*. The total supply curve with the quota, $\overline{S}$, is the horizontal sum of $S^d$ and $\overline{S}^f$. At any price above $\overline{p}$, the total supply equals the quota plus the domestic supply. For example, at $p^*$, the domestic supply is $Q_d^*$ and the foreign supply is $\overline{Q}_f$, so the total supply is $Q_d^* + \overline{Q}_f$. Above $\overline{p}$, $\overline{S}$ is the domestic supply curve shifted $\overline{Q}$ units to the right. As a result, the portion of $\overline{S}$ above $\overline{p}$ has the same slope as $S^d$.

4. *Compare the American total supply curves with and without the quota*. At prices less than or equal to $\overline{p}$, the same quantity is supplied with and without the quota, so $\overline{S}$ is the same as $S$. At prices above $\overline{p}$, less is supplied with the quota than without one, so $\overline{S}$ is steeper than $S$, indicating that a given increase in price raises the quantity supplied less with a quota than without one.




## 2.3 Market Equilibrium

The supply and demand curves determine the price and quantity of goods and services in a market. The demand curve shows the quantity consumers want to buy at various prices, and the supply curve shows the quantity firms want to sell at various prices. Unless the price is set so that consumers want to buy exactly the same amount that suppliers want to sell, either some buyers cannot buy as much as they want or some sellers cannot sell as much as they want.

When all traders are able to buy or sell as much as they want, we say that the market is in **equilibrium**: a situation in which no one wants to change his or her behavior. The *equilibrium price* is the price at which consumers can buy as much as they want and sellers can sell as much as they want. The *equilibrium quantity* is the amount that consumers buy and suppliers sell at the equilibrium price.

**equilibrium**
a situation in which no one wants to change his or her behavior

### Using a Graph to Determine the Equilibrium

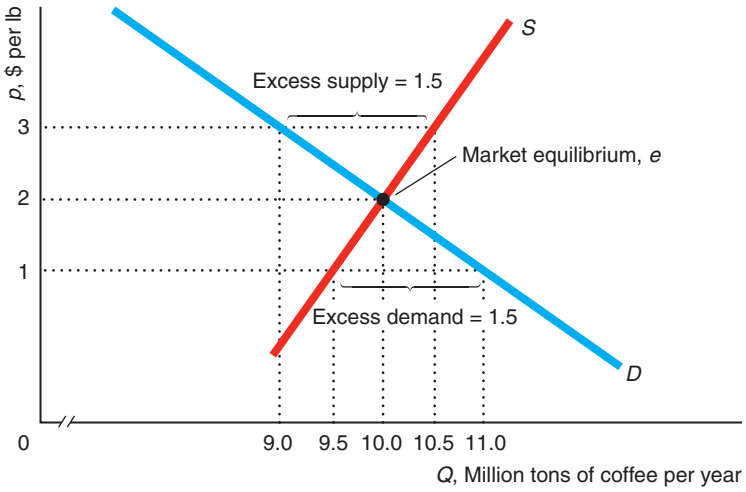
To illustrate how supply and demand curves determine the equilibrium price and quantity, we return to our old friend, the coffee example. Figure 2.6 shows the supply, *S*, and demand, *D*, curves for coffee. The supply and demand curves intersect at point *e*, the market equilibrium. The equilibrium price is $2 per lb, and the equilibrium quantity is 10 million tons per year, which is the quantity firms want to sell and consumers want to buy at the equilibrium price.

### Using Math to Determine the Equilibrium

We can determine the equilibrium mathematically, using algebraic representations of the supply and demand curves. We use these two equations to solve for the equilibrium price at which the quantity demanded equals the quantity supplied

**Figure 2.6** Market Equilibrium

The intersection of the supply curve, $S$, and the demand curve, $D$, for coffee determines the market equilibrium point, $e$, where the equilibrium price is $p = \$2$ per lb and the equilibrium quantity is $Q = 10$ million tons per year. At a price of $p = \$1$, which is below the equilibrium price, the quantity demanded is 11, but the quantity supplied is only 9.5, so the excess demand is 1.5. At $p = \$3$, a price that exceeds the equilibrium price, the market has an excess supply of 1.5 because the quantity demanded, 9, is less than the quantity supplied, 10.5. With either excess demand or excess supply, market forces drive the price back to the equilibrium price of $2.




(the equilibrium quantity). The demand curve, Equation 2.3, shows the relationship between the quantity demanded, $Q_d$, and the price:[9]

$$Q_d = 12 - p.$$

The supply curve, Equation 2.7, tells us the relationship between the quantity supplied, $Q_s$, and the price:

$$Q_s = 9 + 0.5p.$$

We want to find the equilibrium price, $p$, at which $Q_d = Q_s = Q$, the equilibrium quantity. Thus, we set the right sides of these two equations equal,

$$9 + 0.5p = 12 - p,$$

and solve for the equilibrium price. Adding $p$ to both sides of this expression and subtracting 9 from both sides, we find that $1.5p = 3$. Dividing both sides of this last expression by 1.5, we learn that the equilibrium price is $p = \$2$.

We can determine the equilibrium quantity by substituting this equilibrium price, $p = \$2$, into either the supply or the demand equation:

$$\begin{aligned} Q_d &= Q_s \\ 12 - (1 \times 2) &= 9 + (0.5 \times 2) \\ 10 &= 10. \end{aligned}$$

Thus, the equilibrium quantity, $Q = Q_d = Q_s$, is 10 million tons per year.

[9]Usually, we use $Q$ to represent both the quantity demanded and the quantity supplied. However, for clarity in this discussion, we use $Q_d$ and $Q_s$.

## Forces That Drive the Market to Equilibrium

A market equilibrium is not just an abstract concept or a theoretical possibility.[10] We observe markets in equilibrium. The ability to buy as much as you want of a good at the market price is indirect evidence that a market is in equilibrium. You can almost always buy as much as you want of milk, ballpoint pens, and many other goods.

Amazingly, a market equilibrium occurs without any explicit coordination between consumers and firms. In a competitive market such as that for agricultural goods, millions of consumers and thousands of firms make their buying and selling decisions independently. Yet each firm can sell as much as it wants, and each consumer can buy as much as he or she wants. It is as though an unseen market force, like an *invisible hand*, directs people to coordinate their activities to achieve market equilibrium.

What really causes the market to be in equilibrium? If the price were not at the equilibrium level, consumers or firms would have an incentive to change their behavior in a way that would drive the price to the equilibrium level.

If the price were initially lower than the equilibrium price, consumers would want to buy more than suppliers would want to sell. For example, if the coffee price were \$1 in Figure 2.6, which is less than the equilibrium price, consumers would demand 11 million tons per year, but firms would be willing to supply only 9.5 million tons. At this price, the market would be in *disequilibrium*, meaning that the quantity demanded would not equal the quantity supplied. The market would have **excess demand**—the amount by which the quantity demanded exceeds the quantity supplied at a specified price—of $11 - 9.5 = 1.5$ million tons per year.

**excess demand**
the amount by which the *quantity demanded* exceeds the *quantity supplied* at a specified price

Some consumers would be lucky enough to be able to buy coffee at \$1. Other consumers would not find anyone willing to sell them coffee at that price. What could they do? Some frustrated consumers might offer to pay suppliers more than \$1. Alternatively, suppliers, noticing these disappointed consumers, might raise their prices. Such actions by consumers and producers would cause the market price to rise. At higher prices, the quantity that firms want to supply increases and the quantity that consumers want to buy decreases. The upward pressure on the price would continue until it reached the equilibrium price, \$2, where the market has no excess demand.

If, instead, the price is initially above the equilibrium level, suppliers want to sell more than consumers want to buy. For example, at a price for coffee of \$3, suppliers would want to sell 10.5 million tons per year, but consumers would want to buy only 9 million, as Figure 2.6 shows. Thus, at a price of \$3, the market would be in disequilibrium. The market would have **excess supply**—the amount by which the quantity supplied is greater than the quantity demanded at a specified price—of $10.5 - 9 = 1.5$ million tons. Not all firms could sell as much as they wanted. Rather than incur storage costs (and possibly have their unsold coffee spoil), firms might lower their price to attract additional customers. As long as the price remained above the equilibrium price, some firms would have unsold coffee and would want to lower the price further. The price would fall until it reached the equilibrium level, \$2, without excess supply and hence no pressure to lower the price further.[11]

**excess supply**
the amount by which the *quantity supplied* is greater than the *quantity demanded* at a specified price

[10] MyLab Economics has games (called *experiments*) for your course. These online games allow you to play against the computer. The *Market Experiment* illustrates the operation of the supply-and-demand model, allowing you to participate in a simulated market. To play, go to MyLab Economics Multimedia Library, Single Player Experiment, and set the Chapter field to "All Chapters."

[11] Not all markets reach equilibrium through the independent actions of many buyers or sellers. In institutionalized or formal markets, such as the Chicago Mercantile Exchange—where agricultural commodities, financial instruments, energy, and metals are traded—buyers and sellers meet at a single location (or on a single website). In these markets, certain individuals or firms, sometimes referred to as *market makers*, act to adjust the price and bring the market into equilibrium very quickly.

In summary, at any price other than the equilibrium price, either consumers or suppliers are unable to trade as much as they want. These disappointed buyers or suppliers act to change the price, driving the price to the equilibrium level. The equilibrium price is called the *market clearing price* because it removes from the market all frustrated buyers and sellers: The market has no excess demand or excess supply at the equilibrium price.

## 2.4 Shocking the Equilibrium

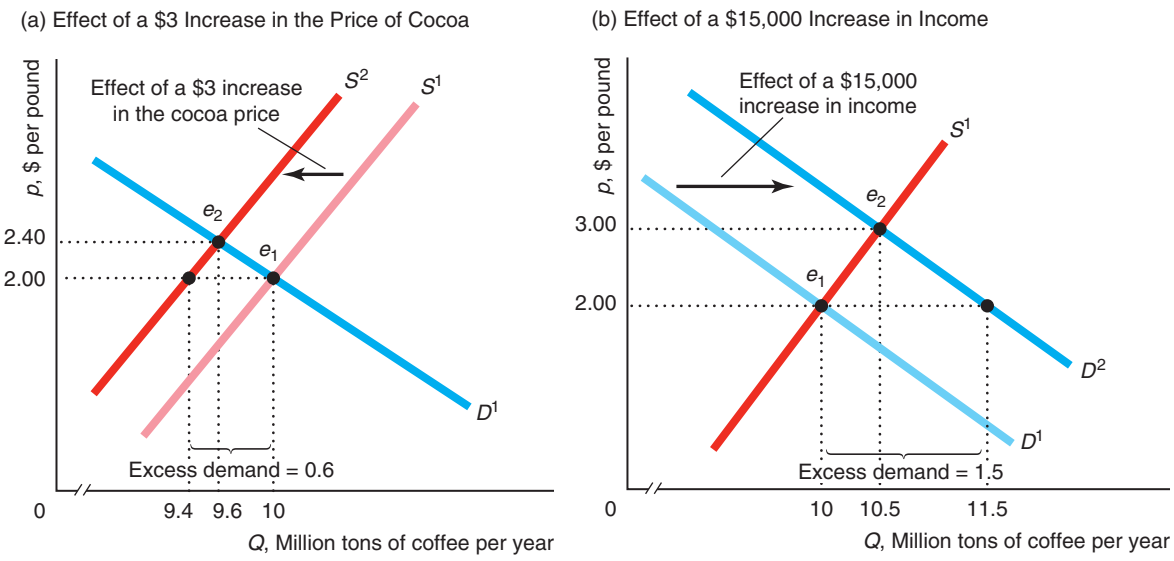
If the variables we hold constant in the demand and supply curves do not change, an equilibrium would persist indefinitely because none of the participants in the market would apply pressure to change the price. The equilibrium changes only if a shock occurs that shifts the demand curve or the supply curve. These curves shift if one of the variables we are holding constant changes. If tastes, income, government policies, or costs of production change, the demand curve or the supply curve or both shift, and the equilibrium changes.

### Effects of a Shock to the Supply Curve

Suppose only one variable changes: The price of cocoa increases by $3 per pound. However, as panel a of Figure 2.7 shows, the increase in the price of cocoa causes the coffee supply curve to shift 0.6 units to the left from $S^1$ to $S^2$ at every possible price of

**Figure 2.7** Equilibrium Effects of a Shift of a Demand or Supply Curve MyLab Economics Video

(a) A $3 per pound increase in the price of cocoa causes some farmers to shift from coffee production to cocoa production, reducing the quantity of coffee supplied at every price. The supply curve shifts to the left from $S^1$ to $S^2$. At the original equilibrium price of $2, the market has excess demand of 0.6 million tons per year. Market pressures drive the market equilibrium from $e_1$ to $e_2$, where the new equilibrium price is $2.40. (b) A $15,000 increase in average annual household income causes the demand curve for coffee to shift to the right from $D^1$ to $D^2$. At the original equilibrium, $e_1$, price, the market has excess demand of 1.5 million tons per year. Market pressures drive up the price to $3. The new equilibrium is $e_2$.



*Well, there goes the price of lobsters!*

coffee. Because the price of cocoa is not included in the demand function, the demand curve, $D^1$, does not shift.

At the original equilibrium price of coffee, \$2, consumers still want to buy 10 million tons, but suppliers are now willing to supply only 9.4 million tons at that price, so the market has an excess demand of $10 - 9.4 = 0.6$. Market pressure forces the coffee price upward until it reaches the new equilibrium, $e_2$.

At $e_2$, the new equilibrium price is \$2.40, and the new equilibrium quantity is 9.6 million tons. Thus, the increase in the price of cocoa causes the equilibrium price of coffee to rise by 40¢ per lb, and the equilibrium quantity to fall by 0.4 million tons. In this case, the increase in the price of cocoa causes a *shift of the supply curve* and a *movement along the demand curve*.

## Solved Problem 2.3

Using algebra, determine how the equilibrium price and quantity of coffee change from the initial levels, $p = \$2$ and $Q = 10$, if the price of cocoa increases from its original price of $p_c = \$3$ by \$3 to \$6 per lb.

### Answer

1. *Show how the demand and supply functions change due to the increase in the price of cocoa.* Because the demand function does not depend on $p_c$, it remains unchanged: $Q = 12 - p$ (Equation 2.3). Substituting the new $p_c = \$6$ into the supply function, Equation 2.6, $Q = 9.6 + 0.5p - 0.2p_c$, we find that the new supply function is $Q = 9.6 + 0.5p - (0.2 \times 6) = 8.4 + 0.5p$.

2. *Equate the supply and demand functions to determine the new equilibrium.* The equilibrium price is determined by equating the right sides of these demand and supply functions:

$$12 - p = 8.4 + 0.5p.$$

   Solving this equation for $p$, we find that the equilibrium price is $p = \$2.40$. We calculate the equilibrium quantity by substituting this price into the demand or supply functions: $Q = 12 - 2.40 = 8.4 + (0.5 \times 2.40) = 9.6$ million tons per year.

3. *Show how the equilibrium price and quantity of coffee changes by subtracting the original price and quantity from the new ones.* The change in the equilibrium price is $\Delta p = \$2.40 - \$2 = \$0.40$. The change in the equilibrium quantity is $\Delta Q = 9.6 - 10 = -0.4$ million tons per year. Figure 2.7 illustrates these changes.

### Effects of a Shock to the Demand Curve

Now suppose that the price of cocoa stays constant at its original level but annual household income rises from $35,000 to $50,000. This change causes the coffee demand curve to shift to the right but does not affect the supply curve, as panel b of Figure 2.7 shows.

At the original equilibrium coffee price, the market has excess demand of 1.5 million tons per year. The excess demand causes upward pressure on the price. In the new equilibrium, $e_2$, the equilibrium price is $3 and the equilibrium quantity is 10.5 million tons per year. Here a *shift of the demand curve* results in a *movement along the supply curve*.

In summary, a change in an underlying factor shifts the demand curve or the supply curve, causing the equilibrium to change. To describe the effect of this change, we compare the original equilibrium price and quantity to the new equilibrium values.

## 2.5 Effects of Government Interventions

A government can affect a market equilibrium in many ways. Sometimes government actions shift the supply curve, the demand curve, or both curves, affecting the equilibrium. However, other government interventions can cause the quantity demanded to differ from the quantity supplied.

### Policies That Shift Supply Curves

We concentrate on government policies that affect the supply curve because they are more common than policies that affect the demand curve. We discuss two government supply policies: licensing laws and quotas.

**Licensing Laws** A government *licensing law* limits the number of firms that may sell goods in a market. For example, many local governments around the world limit the number of taxicabs (see Chapter 9). Governments use zoning laws to limit the number of bars, bookstores, hotel chains, as well as firms in many other markets. In developed countries, early entrants or those people who pass an exam receive licenses. In some developing countries, licenses go to relatives of government officials or to whomever offers those officials the largest bribe.

### Application

Occupational Licensing

In the United States, in many occupations, working without a license is illegal. Local, state, or federal governments license more than 800 occupations, including animal masseuse, animal trainers, dietitians and nutritionists, doctors, electricians, embalmers, funeral directors, hairdressers, librarians, nurses, psychologists, real estate brokers, respiratory therapists, salespeople, teachers, tree trimmers, and truck drivers (but not economists).

During the early 1950s, fewer than 5% of U.S. workers were in occupations covered by licensing laws at the state level. Since then, the share of licensed employed workers has grown, reaching nearly 18% by the 1980s, at least 20% in 2000, and 26% in 2015. Licensing is more common in occupations that require extensive education: More than 40% of workers with post-college education are required to have a license compared to only 15% of those with less than a high school education. More than three-fourths of workers in healthcare and technical occupations have licenses.

A worker must pass a test to get a license in some occupations. Frequently, licensed members of the occupation design these tests. By making the exam difficult, current workers can limit entry. For example, only 47% of people taking the California State Bar Examination in July 2015 passed it, although all of them had law degrees. (The national rate for lawyers passing state bar exams in July 2015 was higher, but still only 63%.) To braid hair professionally in South Dakota requires 2,100 hours of education and a cosmetology license; whereas, South Carolina mandates only a six-hour course.

To the degree that testing is objective, licensing may raise the average quality of the workforce. However, its primary effect is to restrict the number of workers in an occupation. To analyze the effects of licensing, one can use a graph similar to panel b of Figure 2.7, where the wage is on the vertical axis and the number of workers per year is on the horizontal axis.

Licensing shifts the occupational supply curve to the left, reducing the equilibrium number of workers and raising the wage. Kleiner and Krueger (2013) found that licensing raises occupational wages by 18%. According to the U.S. Labor Department in 2016, the median worker with a license earned just over $1,000 a week compared to a little under $800 for those without. A license is worth $108 more per week for a worker with a high-school degree, but did not raise earnings for those with bachelor's or advanced degrees. Kleiner (2015) claims that occupational licensing costs consumers $203 billion annually.

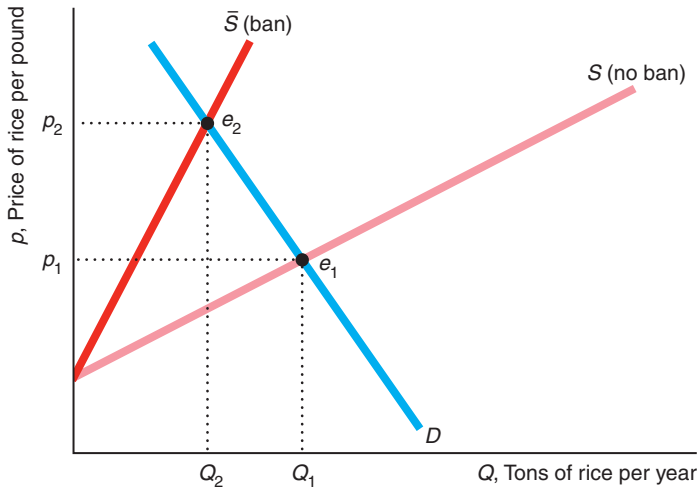
In 2016, the Obama White House announced that it would provide $7.5 million in grants to organizations that would work with states to reduce overly burdensome licensing and make it easier for licensed practitioners to work across state lines.

**Quotas** Quotas typically limit the amount of a good that firms may sell (rather than the number of firms that sell it). Governments commonly use quotas to limit imports. As we saw earlier, quotas on imports affect the supply curve.

We illustrate the effect of quotas on market equilibrium using our previous example of the ban on rice imports in Japan. The Japanese government's ban (the quota was set to zero) on rice imports raised the price of rice in Japan substantially. Figure 2.8 shows the Japanese demand curve for rice, $D$, and the total supply curve

**Figure 2.8** A Ban on Rice Imports Raises the Price in Japan

A ban on rice imports shifts the total supply curve of rice in Japan without a ban, $S$, to $\bar{S}$, which equals the domestic supply alone. As a result, the equilibrium changes from $e_1$ to $e_2$. The ban causes the price to rise from $p_1$ to $p_2$ and the equilibrium quantity to fall to $Q_1$ from $Q_2$.



without a ban, $S$. The intersection of $S$ and $D$ determines the equilibrium, $e_1$, if the Japanese government permits rice imports.

What is the effect of a ban on foreign rice on Japanese supply and demand? The ban does not affect the demand curve if Japanese consumers do not care whether they eat domestic or foreign rice. The ban causes the total supply curve to rotate toward the origin from $S$ (total supply is the horizontal sum of domestic and foreign supply) to $\overline{S}$ (total supply equals the domestic supply).

The intersection of $\overline{S}$ and $D$ determines the new equilibrium, $e_2$, which lies above and to the left of $e_1$. The ban causes a shift of the supply curve and a movement along the demand curve. It causes the equilibrium quantity to fall from $Q_1$ to $Q_2$ and the equilibrium price to increase from $p_1$ to $p_2$. Because of a near total ban on imported rice in 2001, the price of rice in Japan was 10.5 times higher than the price in the rest of the world. This markup has decreased in recent years.

A quota of $\overline{Q}$ may have a similar effect to an outright ban; however, a quota may have no effect on the equilibrium if the quota is set so high that it does not limit imports. We investigate this possibility in Solved Problem 2.4.

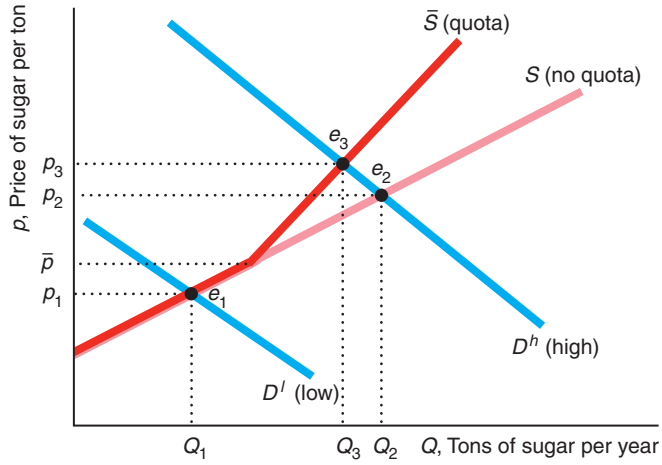
## Solved Problem 2.4

MyLab Economics Solved Problem

What is the effect of a United States quota on sugar of $\overline{Q}$ on the equilibrium in the U.S. sugar market? *Hint*: The answer depends on whether the quota *binds* (is low enough to affect the equilibrium).

### Answer

1. *Show how a quota, $\overline{Q}$, affects the total supply of sugar in the United States.* The graph reproduces the no-quota total American supply curve of sugar, $S$, and the total supply curve under the quota, $\overline{S}$ (which we derived in Solved Problem 2.2). At a price below $\overline{p}$, the two supply curves are identical because the quota is not binding: It is greater than the quantity foreign firms want to supply. Above $\overline{p}$, $\overline{S}$ lies to the left of $S$.




2. *Show the effect of the quota if the original equilibrium quantity is less than the quota so that the quota does not bind.* Suppose that the American demand is relatively *low* at any given price so that the demand curve, $D^l$, intersects both the supply curves at a price below $\overline{p}$. The equilibria both before and after the quota is imposed are at $e_1$, where the equilibrium price, $p_1$, is less than $\overline{p}$. Thus if the demand curve lies near enough to the origin that the quota is not binding, the quota has no effect on the equilibrium.

3. *Show the effect of the quota if the quota binds*. With a relatively *high* demand curve, $D^h$, the quota affects the equilibrium. The no-quota equilibrium is $e_2$, where $D^h$ intersects the no-quota total supply curve, $S$. After the quota is imposed, the equilibrium is $e_3$, where $D^h$ intersects the total supply curve with the quota, $\overline{S}$. The quota raises the price of sugar in the United States from $p_2$ to $p_3$ and reduces the quantity from $Q_2$ to $Q_3$.

*Comment*: Currently, 76% of the sugar Americans consume is produced domestically, while the rest is imported from about 40 countries under a quota system. In a typical year, the U.S. price of sugar is 24% higher than the price in the rest of the world. (This increase in price is applauded by nutritionists who deplore the amount of sugar consumed in the typical U.S. diet.)

## Policies That Cause the Quantity Demanded to Differ from the Quantity Supplied

Some government policies do more than merely shift the supply or demand curve. For example, governments may control prices directly, a policy that leads to either excess supply or excess demand if the price the government sets differs from the equilibrium price. We illustrate this result with two types of price control programs: price ceilings and price floors. When the government sets a *price ceiling* at $\overline{p}$, the price at which goods are sold may be no higher than $\overline{p}$. When the government sets a *price floor* at $\underline{p}$, the price at which goods are sold may not fall below $\underline{p}$.


**Price Ceilings** Price ceilings have no effect if they are set above the equilibrium price that would be observed in the absence of the price controls. If the government says that firms may charge no more than $\overline{p} = \$5$ per gallon of gas and firms are actually charging $p = \$1$, the government's price control policy is irrelevant. However, if the equilibrium price, $p$, was above the price ceiling $\overline{p}$, the price actually observed in the market would be the price ceiling.

The United States used price controls during both world wars, the Korean War, and in 1971–1973 during the Nixon administration, among other times. The U.S. experience with gasoline illustrates the effects of price controls. In the 1970s, the Organization of Petroleum Exporting Countries (OPEC) reduced supplies of oil (which is converted into gasoline) to Western countries. As a result, the total supply curve for gasoline in the United States—the horizontal sum of domestic and OPEC supply curves—shifted to the left, from $S^1$ to $S^2$, in Figure 2.9. Because of this shift, the equilibrium price of gasoline would have risen substantially, from $p_1$ to $p_2$. In an attempt to protect consumers by keeping gasoline prices from rising, the U.S. government set price ceilings on gasoline in 1973 and 1979.

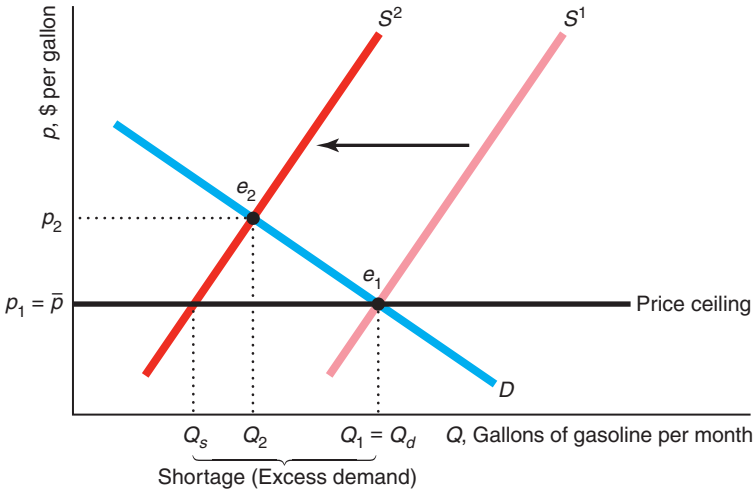
The government told gas stations that they could charge no more than $\overline{p} = p_1$. Figure 2.9 shows the price ceiling as a solid horizontal line extending from the price axis at $\overline{p}$. The price control is binding because $p_2 > \overline{p}$. The observed price is the price ceiling. At $\overline{p}$, consumers *want* to buy $Q_d = Q_1$ gallons of gasoline, which is the equilibrium quantity they bought before OPEC acted. However, firms supply only $Q_s$ gallons at the intersection of the price control line and $S^2$. As a result of the binding price control, the excess demand is $Q_d - Q_s$.

Were it not for the price controls, market forces would drive up the market price to $p_2$ and eliminate the excess demand. The government price ceiling prevents this adjustment from occurring. As a result, an enforced price ceiling causes a **shortage**: a persistent excess demand.

**shortage**
a persistent excess demand

**Figure 2.9** Price Ceiling on Gasoline MyLab Economics Video

After a supply shock, the supply curve shifts from $S^1$ to $S^2$. Under the government's price control program, gasoline stations may not charge a price above the price ceiling, $\bar{p} = p_1$. At that price, producers are willing to supply only $Q_s$, which is less than the amount $Q_1 = Q_d$ that consumers want to buy. The result is excessive demand, or a shortage of $Q_d - Q_s$.




At the time of the controls, some government officials argued that the shortages were caused by OPEC cutting off its supply of oil to the United States, but that's not true. Without the price controls, the new equilibrium would be $e_2$. In this equilibrium, the price, $p_2$, is much higher than before, $p_1$; however, no shortage results. Moreover, without controls, the quantity sold, $Q_2$, is greater than the quantity sold under the control program, $Q_s$.

With a binding price ceiling, the supply-and-demand model predicts an *equilibrium with a shortage*. In this equilibrium, the quantity demanded does not equal the quantity supplied. The reason that we call this situation an equilibrium, even though a shortage exists, is that no consumers or firms want to act differently, given the law. Without the price controls, consumers facing a shortage would try to get more output by offering to pay more, or firms would raise prices. With effective government price controls, the price cannot rise, so consumers have to live with the shortage.

What happens? Some lucky consumers get to buy $Q_s$ units at the low price of $\bar{p}$. Other potential customers are disappointed: They would like to buy at that price, but they cannot find anyone willing to sell gas to them.

What determines which consumers are lucky enough to find goods to buy at the low price when the government imposes a price control? With enforced price controls, sellers use criteria other than price to allocate the scarce commodity. Firms may supply their friends, long-term customers, or people of a certain race, gender, age, or religion. They may sell their goods on a first-come, first-served basis. Or, they may limit everyone's purchases to only a few gallons.

Another possibility is for firms and customers to evade the price controls. A consumer could go to a gas station owner and say, "Let's not tell anyone, but I'll pay you twice the price the government sets if you'll sell me as much gas as I want." If enough customers and gas station owners behaved that way, no shortage would occur. A study of 92 major U.S. cities during the 1973 gasoline price controls found no gasoline lines in 52 of the cities. However, in cities such as Chicago, Hartford, New York, Portland, and Tucson, potential customers waited in line at the pump for an hour or more.[12] Deacon and Sonstelie (1989) calculated that for every dollar

[12]See MyLab Economics, Chapter 2, "Gas Lines," for a discussion of the effects of the 1973 and 1979 gasoline price controls.

consumers saved during the 1980 gasoline price controls, they lost $1.16 in waiting time and other factors.

More recently, Hawaii, New York, and New Jersey have imposed gasoline price controls. Hawaii imposed price controls on the wholesale price of gasoline starting in September 2005, but suspended the controls indefinitely in early 2006 due to the public's unhappiness with the law. Following tight supplies of gasoline after Superstorm Sandy hit the East Coast in 2012, both New York and New Jersey enacted price controls for a couple of weeks.

## Application

### Venezuelan Price Ceilings and Shortages

Venezuela traditionally has been one of the richest countries in Latin America. It is a leading oil producer, and it has many other agricultural and non-agricultural industries.

So why do people start lining up to buy groceries in Venezuela at 4 A.M., when shops open at 8 A.M.? Strict price ceilings on food and other goods create shortages throughout the country.

According to Venezuela's central bank, 28% of products were unavailable in shops in 2014, an all-time high. In 2015, Venezuelans were particularly vexed by condom, birth control pill, and toilet paper shortages. By 2016, the country's economy was melting down. Eighty-seven percent of Venezuelans said that they did not have enough money to buy food. Consumers could not buy Coca-Cola because sugar was not available. Empresas Polar SA, which makes 80% of the beer that Venezuelans consume, ceased operation. Supermarket shelves were often empty, firms transported food under armed guard, and soldiers stood watch over bakeries. Mobs stormed grocery stores, pharmacies, and butcher shops.

One would think that Venezuela should be able to supply its citizens with coffee, which it has produced in abundance for centuries. Indeed, Venezuela exported coffee until 2009. However, since then, it has been importing large amounts of coffee to compensate for a drop in production. Why have farmers and coffee roasters cut production? Due to low retail price ceilings, they would have to produce at a loss.


Because Venezuela regulates the prices of many goods such as gasoline and corn flour and Colombia, its direct neighbor to the west, does not, smuggling occurs. Given that gasoline sold in 2015 for 4¢ a gallon in Venezuela, and the price was 72¢ a gallon in most of Colombia, the temptation to smuggle is great. Venezuela's Táchira state is adjacent to the Colombian border. Its government says that as much as 40% of the food sent to Táchira is smuggled into Colombia. Why sell corn flour at an artificially low price in Venezuela if you can sell it at a higher, market price in Colombia?[13]

Venezuela's populist President Hugo Chávez and his hand-picked successor, Nicolás Maduro, imposed strict price

[13]According to news reports in late 2016, seven border-state governments have stopped enforcing price controls on some basic goods such as food. They are allowing imported food to sell at market prices, which are often 5 to 20 times the regulated prices.

ceilings purportedly to rein in inflation and make the goods more affordable for the poor. Do the ceilings help the poor?

For many Venezuelans, the answer is "No!" As Nery Reyes, a restaurant worker, said, "Venezuela is too rich a country to have this. I'm wasting my day here standing in line to buy one chicken and some rice."[14]

For several years, demonstrators have taken to the streets to protest persistent economic and social problems, including shortages. In 2016, demonstrations average 17 per day across the country. Many people died in violent clashes with the National Guard, including a student beauty queen who had been crowned Miss Tourism for the state of Carabobo. The ultimate irony is that President Nicolás Maduro has advised Venezuelans to consume less to alleviate the shortages.

**Price Floors** Governments also commonly use price floors. One of the most important examples of a price floor is a minimum wage in a labor market. A minimum wage law forbids employers from paying less than the minimum wage, $w$.

Minimum wage laws date from 1894 in New Zealand, 1909 in the United Kingdom, and 1912 in Massachusetts. The Fair Labor Standards Act of 1938 set a federal U.S. minimum wage of 25¢ per hour. Today, the federal minimum wage is $7.25 an hour, but 31 states, the District of Columbia, and many cities also set a higher minimum wage. For example, Washington State's minimum wage is $9.47, and Oakland, California's rate is $12.25. In 2016, the United Kingdom's minimum hourly wage was £6.70 for adult workers. The 2015 statutory monthly minimum wage ranged from the equivalent of 107€ in the Russian Federation to 505€ in Portugal, 1,457.52€ in France, and 1,922.96€ in Luxembourg.[15]

## Solved Problem 2.5

Suppose everyone receives the same wage in a labor market. What happens to the equilibrium in this market if the government imposes a binding minimum wage, $\underline{w}$?

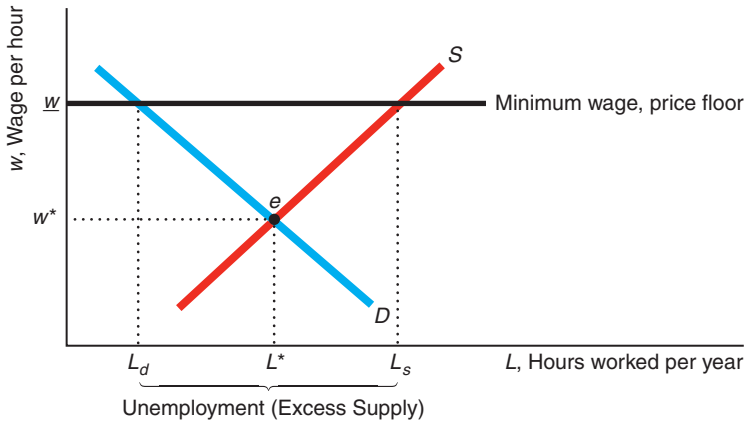
### Answer

1. *Show the initial equilibrium before the government imposes the minimum wage.* The figure shows the supply and demand curves for labor services (hours worked). Firms buy hours of labor service—they hire workers. The quantity measure on the horizontal axis is hours worked per year, and the price measure on the vertical axis is the wage per hour. With no government intervention, the intersection of the supply and demand curves determine the market equilibrium at $e$, where the wage is $\underline{w}^*$ and the number of hours worked is $L^*$.

2. *Draw a horizontal line at the minimum wage, and show how the market equilibrium changes.* The minimum wage creates a price floor, a horizontal line, at $w$. At that wage, the quantity demanded falls to $L_d$ and the quantity supplied rises to $L_s$. As a result, excess supply or unemployment is $L_s - L_d$. The minimum

[14]William Neuman, "With Venezuelan Food Shortages, Some Blame Price Controls," *New York Times*, April 20, 2012.

[15]The U.S. Department of Labor maintains at its website, **www.dol.gov**, an extensive history of the federal minimum wage law, labor markets, state minimum wage laws, and other information. For European minimum wages, see **www.fedee.com/minwage.html**. See **www.direct.gov.uk** for British rates.




wage prevents market forces from eliminating this excess supply, so it leads to an equilibrium with unemployment.[16]

*Comment*: The original 1938 U.S. minimum wage law caused massive unemployment in Puerto Rico.[17] Depending on the law's coverage and the type of labor market, the minimum wage may not cause unemployment (see Chapters 10 and 15). Card and Krueger (1995) argued, based on alternatives to the simple supply-and-demand model, that minimum wage laws raise wages in some markets (such as fast foods) without significantly reducing employment. In contrast, Neumark et al. (2014) concluded, based on an extensive review of minimum wage research, that increases in the minimum wage often have negative effects on employment.

## Why the Quantity Supplied Need Not Equal the Quantity Demanded

The price ceiling and price floor examples show that the quantity supplied does not necessarily equal the quantity demanded. Many people fail to understand this key point when they blindly parrot:

**Common Confusion:** Demand must equal supply.

Their claim is true only, in an uninteresting accounting sense, that the amount firms *actually* sell must equal the amount that consumers *actually* purchase. Because we define the quantities supplied and demanded in terms of people's *wants* and not *actual* quantities bought and sold, the statement that "supply equals demand" has content: It is shorthand for a theory, not merely an accounting equality. The supply-and-demand theory says that the intersection of the supply curve and the demand curve determines the equilibrium price and quantity in a market if the government does not intervene.

When the government sets a price ceiling or a price floor, the quantity supplied does not equal the quantity demanded because of the way we define these two concepts. We

[16]The minimum wage could raise the wage enough that total wage payments, $wL$, rise despite the fall in demand for labor services. If the workers could share the unemployment—everyone works fewer hours than he or she wants—all workers could benefit from the minimum wage.

[17]See MyLab Economics, Chapter 2, "Minimum Wage Law in Puerto Rico."

define the quantity supplied as the amount firms *want to sell* at a given price, holding other factors that affect supply, such as the price of inputs, constant. The quantity demanded is the quantity that consumers *want to buy* at a given price, holding constant other factors that affect demand. When the government regulates price in a market, the quantity that firms want to sell and the quantity that consumers want to buy at a given price do not equal the *actual* quantity that firms sell and consumers buy.

For example, when the government imposes a binding price ceiling on gasoline, the quantity demanded is greater than the quantity supplied. Despite the lack of equality between the quantity supplied and the quantity demanded, the supply-and-demand model is useful in analyzing this market because it predicts the excess demand.

## 2.6 When to Use the Supply-and-Demand Model

As we've seen, supply-and-demand theory can help us to understand and predict real-world events in many markets. Through Chapter 10, we discuss competitive markets in which the supply-and-demand model is a powerful tool for predicting what will happen to market equilibrium if underlying conditions—tastes, incomes, and prices of inputs—change. The types of markets for which the supply-and-demand model is useful are described at length in these chapters, particularly in Chapters 8 and 9. Briefly, this model is applicable to markets in which:

- **Everyone is a price taker.** Because no consumer or firm is a very large part of the market, no one can affect the market price. Easy entry of firms into the market, which leads to a large number of firms, is usually necessary to ensure that firms are price takers.
- **Firms sell identical products.** Consumers do not prefer one firm's good to another.
- **Everyone has full information about the price and quality of goods.** Consumers know if a firm is charging a price higher than the price others set, and they know if a firm tries to sell them inferior-quality goods.
- **Costs of trading are low.** It is not time-consuming, difficult, or expensive for a buyer to find a seller and make a trade or for a seller to find and trade with a buyer.

Economists call markets with these properties *perfectly competitive markets*.

In a market with many firms and consumers, no single firm or consumer is a large enough part of the market to affect the price. If you stop buying bread or if one of the many thousands of wheat farmers stops selling the wheat used to make the bread, the price of bread will not change. Consumers and firms are *price takers*: They cannot affect the market price.

In contrast, if a market has only one seller of a good or service—a *monopoly* (see Chapter 11)—that seller is a *price setter* and can affect the market price. Because demand curves slope downward, a monopoly can increase the price it receives by reducing the amount of a good it supplies. Firms are also price setters in an *oligopoly*—a market with only a small number of firms—or in markets where they sell differentiated products so that a consumer prefers one product to another (see Chapter 13). In markets with price setters, the market price is usually higher than that predicted by the supply-and-demand model. That doesn't make the model generally wrong. It means only that the supply-and-demand model does not apply to markets with a small number of sellers or buyers. In such markets, we use other models.

If consumers have less information than a firm, the firm can take advantage of consumers by selling them inferior-quality goods or by charging a much higher price

than that charged by other firms. In such a market, the observed price is usually higher than that predicted by the supply-and-demand model, the market may not exist at all (consumers and firms cannot reach agreements), or different firms may charge different prices for the same good (see Chapter 19).

**transaction costs** the expenses of finding a trading partner and making a trade for a good or service beyond the price paid for that good or service

The supply-and-demand model is also not entirely appropriate for markets in which it is costly to trade with others because the cost of a buyer finding a seller or of a seller finding a buyer is high. **Transaction costs** are the expenses of finding a trading partner and making a trade for a good or service other than the price paid for that good or service. These costs include the time and money spent to find someone with whom to trade. For example, you may have to pay to place an ad to sell your gray 1999 Honda with 137,000 miles on it. Or, you may have to go to many stores to find one that sells a shirt that fits exactly the way you like, so your transaction costs include transportation costs and your time. The labor cost of filling out a form to place an order is a transaction cost. Other transaction costs include the costs of writing and enforcing a contract, such as the cost of a lawyer's time. Where transaction costs are high, no trades may occur, or if they do occur, individual trades may occur at a variety of prices (see Chapters 12 and 19).

Thus, the supply-and-demand model is not appropriate in markets with only one or a few firms (such as electricity), differentiated products (movies), consumers who know less than sellers about quality or price (used cars), or high transaction costs (nuclear turbine engines). Markets in which the supply-and-demand model has proved useful include agriculture, finance, labor, construction, services, wholesale, and retail.

## Challenge Solution

### Quantities and Prices of Genetically Modified Foods

MyLab Economics Solved Problem

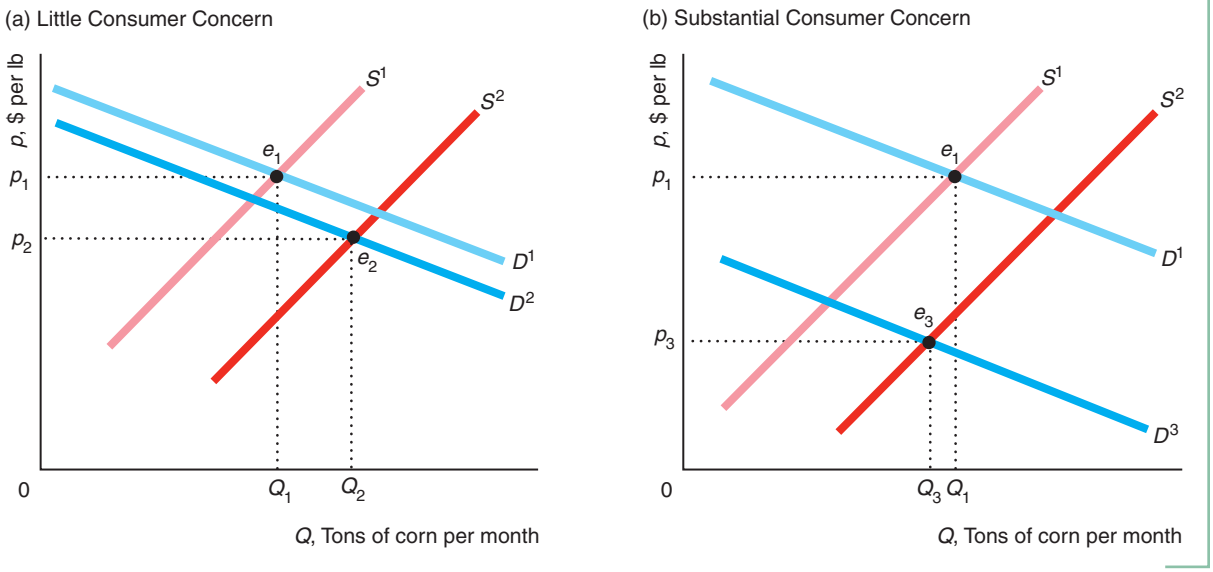
We conclude this chapter by returning to the challenge posed at its beginning where we asked about the effects on the price and quantity of a crop, such as corn, from the introduction of GM seeds. The supply curve shifts to the right because GM seeds produce more output than traditional seeds, holding all else constant. If consumers fear GM products, the demand curve for corn shifts to the left. We want to determine how the after-GM equilibrium compares to the before-GM equilibrium. When an event shifts both curves, the qualitative effect on the equilibrium price and quantity may be difficult to predict, even if we know the direction in which each curve shifts. Changes in the equilibrium price and quantity depend on exactly how much the curves shift. In our analysis, we want to take account of the possibility that the demand curve may shift only slightly in some countries where consumers don't mind GM products (or product labels don't show they contain GM products) but substantially in others where many consumers fear GM products.

In the figure, the intersection of the before-GM supply curve, $S^1$, and the before-GM demand curve, $D^1$, determines the before-GM equilibrium, $e_1$, at price $p_1$ and quantity $Q_1$. Both panels a and b of the figure show this same equilibrium. After GM seeds are introduced, the supply curve, $S^2$, shifts to the right of the original supply curve, $S^1$ in both panels.

Panel a shows the situation if consumers have little concern about GM crops, so that the new demand curve, $D^2$, lies only slightly to the left of the original demand curve, $D^1$. In panel b, where consumers are greatly concerned about GM crops, the new demand curve, $D^3$, lies substantially to the left of $D^1$.

In panel a, the new equilibrium $e_2$ is determined by the intersection of $S^2$ and $D^2$. In panel b, the new equilibrium $e_3$ reflects the intersection of $S^2$ and $D^3$. The equilibrium price falls from $p_1$ to $p_2$ in panel a and to $p_3$ in panel b. However,

the equilibrium quantity rises from $Q_1$ to $Q_2$ in panel a, but falls to $Q_3$ in panel b. That is, the price falls in both cases, but the quantity may rise or fall depending on how much the demand curve shifts. Thus, whether growers in a country decide to adopt GM seeds depends crucially on consumer resistance to these new products.




## Summary

1. **Demand.** The quantity of a good or service demanded by consumers depends on their tastes, the price of the good, the price of substitutes and complements, consumers' income, information, government regulations, and other factors. The *Law of Demand*—which is based on observation—says that *demand curves slope downward*. Consumers demand less of the good, the higher the price, holding constant other factors that affect their demand. A change in price causes a *movement along the demand curve*. A change in income, tastes, or another factor that affects demand, other than price, causes a *shift of the demand curve*. To get a total demand curve, we horizontally sum the demand curves of individuals or types of consumers or countries. That is, we add the quantities demanded by each individual at a given price to get the total demand.

2. **Supply.** The quantity of a good or service supplied by firms depends on its price, cost, government regulation, and other factors. The market supply curve need not slope upward but usually does. A change in price causes a *movement along the supply curve*. A change in a government regulation or the price of an input causes a *shift of the supply curve*. The total supply curve is the horizontal sum of the supply curves for individual firms.

3. **Market Equilibrium.** The intersection of the demand curve and the supply curve determines the equilibrium price and quantity in a market. Market forces—actions of consumers and firms—drive the price and quantity to the equilibrium levels if they are initially too low or too high.

4. **Shocking the Equilibrium.** A change in an underlying factor other than price causes a shift of the supply curve or the demand curve, which alters the equilibrium. For example, if consumer income rises, the demand curve for coffee shifts to the right, causing a movement along the supply curve and leading to a new equilibrium at a higher price and quantity. If changes in these underlying factors follow one after the other, a market that adjusts slowly may stay out of equilibrium for an extended period.

5. **Effects of Government Interventions.** Some government policies—such as a ban on imports—cause a shift in the supply or demand curves, which alters the equilibrium. Other government policies—such as price controls or a minimum wage—cause the quantity supplied to be greater or less than the quantity demanded, leading to persistent excesses or shortages.

6. **When to Use the Supply-and-Demand Model.** The supply-and-demand model is a powerful tool

to explain what happens in a market or to make predictions about what will happen if an underlying factor in a market changes. This model, however, is applicable only to markets with many buyers and sellers; identical goods; certainty and full information about price, quantity, quality, incomes, costs, and other market characteristics; and low transaction costs.

## Questions

*Select questions are available on* MyLab Economics*; * = answer appears at the back of this book;* **A** *= algebra problem.*

### 1. Demand

*1.1 Suppose that the demand function for lamb in Australia is $Q = 63 - 11p + 7p_b + 3p_c + 2Y$, where $Q$ is the quantity in million kilograms (kg) of lamb per year, $p$ is the dollar price per kg (all prices cited are in Australian dollars), $p_b$ is the price of beef per kg, $p_c$ is the price of chicken per kg, and $Y$ is annual per capita income in thousands of Australian dollars. What is the demand curve if we hold $p_b$, $p_c$, and $Y$ at their typical values during the period studied: $p_b = 19$, $p_c = 6$, and $Y = 78$? **A**

*1.2 Using the demand function for lamb from Question 1.1, show how the quantity demanded at a given price changes as annual per capita income, $Y$, increases by AU$200. (*Hint*: See Solved Problem 2.1.) **A**

1.3 Based on the Application "Calorie Counting," show the effect of New York City's calorie posting requirement on Starbucks' demand curve.

1.4 Given an estimated monthly demand function for avocados of $Q = 104 - 40p + 20p_t + 0.01Y$, show how the demand curve shifts as per capita income, $Y$, increases from $4,000 to $5,000 per month. (*Note*: The price of tomatoes, $p_t$, is $0.80.) Illustrate this shift in a diagram. **A**

1.5 Given the inverse demand function for lamb (Question 1.1) is $p = 33.64 - 0.09Q$, how much would the price have to rise for consumers to want to buy 2 million kg of lamb less per year? (*Hint*: See Solved Problem 2.1.) **A**

1.6 The food and feed demand curves used in the Application "Aggregating Corn Demand Curves" were estimated by McPhail and Babcock (2012) to be $Q_{food} = 1{,}487 - 22.1p$ and $Q_{feed} = 6{,}247.5 - 226.7p$, respectively. Mathematically derive the total demand curve, which the Application's figure illustrates. (*Hint*: Remember that the demand curve for feed is zero at prices above $27.56.) **A**

*1.7 Suppose that the inverse demand function for movies is $p = 120 - Q_1$ for college students and $p = 120 - 2Q_2$ for other town residents. What is the town's total demand function ($Q = Q_1 + Q_2$ as a function of $p$)? Use a diagram to illustrate your answer. (*Hint*: See the Application "Aggregating Corn Demand Curves.") **A**

1.8 Duffy-Deno (2003) estimated the demand functions for broadband service are $Q_s = 15.6p^{-0.563}$ for small firms and $Q_l = 16.0p^{-0.296}$ for larger ones, where price is in cents per kilobyte per second and quantity is in millions of kilobytes per second (Kbps). What is the total demand function for all firms? (*Hint*: See the Application "Aggregating Corn Demand Curves.") **A**

1.9 Based on the estimates of Ghose and Han (2014), the demand function for mobile applications at Apple's App Store is $Q_A = 1.4p^{-2}$ and the demand function at Google Play is $1.4p^{-3.7}$, where the quantity is in millions of apps. What is the total demand function for apps? If the price for an app is $1, what is the equilibrium quantity demanded by Apple customers, Google customers, and all customers? (*Hint*: Look at the Application "Aggregating Corn Demand Curves.") **A**

### 2. Supply

*2.1 Suppose that the supply function for lamb in Australia is $Q = 149 + 8p - 9p_s$, where $Q$ is the quantity in millions of kg of lamb per year, and $p$ and $p_s$ are the prices of lamb and sheep, respectively, in Australian dollars per kg. How does the supply curve change if the price of sheep increases from AU$5 to AU$5.50 per kg? (*Hint*: See Solved Problem 2.1.) **A**

2.2 The estimated supply function for avocados is $Q = 58 + 15p - 20p_f$, where $p_f$ is the price of fertilizer. Determine how much the supply curve for avocados shifts if the price of fertilizer rises from $0.40 to $1.50 per lb. Illustrate this shift in a diagram.

2.3 If the supply curve for fertilizer in Jordan is $Q_j = -2 + 4p$ and the supply curve for fertilizer in the rest of the world is $Q_{row} = 25 + 8p$, what is the world supply curve? **A**

2.4 How would a quota of $\overline{Q} = 6$ million tons set by Iran on foreign wheat imports affect the total Iranian supply curve given the domestic supply curve $Q_s^d = 5p - 15$ and the foreign supply curve $Q_s^f = 2p$, where the quantities are in millions of tons and the price is in rials per ton? How much wheat would domestic and foreign producers supply at a price of IRR5 per ton, both with and without the quota?

### 3. Market Equilibrium

*3.1 Use a supply-and-demand diagram to explain the statement "Talk is cheap because supply exceeds demand." At what price is this comparison being made?

3.2 Every house in a small town has a well that provides water at no cost. However, if the town wants more than 10,000 gallons a day, it has to buy the extra water from firms located outside of the town. The town currently consumes 9,000 gallons per day.

a. Draw the linear demand curve.

b. The firms' supply curve is linear and starts at the origin. Draw the market supply curve, which includes the supply from the town's wells.

c. Show the equilibrium. What is the equilibrium quantity? What is the equilibrium price? Explain.

3.3 A large number of firms are capable of producing chocolate-covered cockroaches. The linear, upward-sloping supply curve starts on the price axis at \$6 per box. A few hardy consumers are willing to buy this product (possibly to use as gag gifts). Their linear, downward-sloping demand curve hits the price axis at \$4 per box. Draw the supply and demand curves. Does this market have an equilibrium at a positive price and quantity? Explain your answer.

3.4 The demand function for lamb in Australia (see Question 1.1) is $Q_d = 63 - 11p + 7p_b + 3p_c + 2Y$, and the supply function (see Question 2.1) is $Q_s = 149 + 8p - 9p_s$. Solve for the equilibrium price and quantity in terms of the price of beef, $p_b = 19$, the price of chicken, $p_c = 6$, the price of sheep, $p_s = 5$, and annual per capita income, $Y = 78$. All prices are in Australian dollars per kg, quantities in million kg, and income in thousands of Australian dollars.

*3.5 The demand function for a good is $Q = a - bp$, and the supply function is $Q = c + ep$, where $a$, $b$, $c$, and $e$ are positive constants. Solve for the equilibrium price and quantity in terms of these four constants. **A**

*3.6 Suppose the supply function for processing coffee beans from coffee cherries in Mexico is $Q_s = 3.15 + 0.1p - 0.5p_c$ and the demand curve for coffee beans is $Q_d = 4.1 - 0.2p$, where $Q_s$ and $Q_d$ are quantities of coffee beans in thousands of 60-kg bags, $p$ is the price of coffee beans in millions of pesos per thousand 60-kg bags, and $p_c = 0.8$ is the price of coffee cherries in millions of pesos per thousand 60-kg bags. What is the supply curve for coffee beans (that is, supply as a function of only the price of coffee beans)? Solve for the equilibrium price and quantity of coffee beans. **A**

### 4. Shocking the Equilibrium

*4.1 Use a figure to explain the fisher's comment about the effect of a large catch on the market price in the cartoon about catching lobsters near the beginning of Section 2.4. What is the supply shock?

4.2 Airbnb is a website that lets apartment dwellers list and rent lodging for a few days to out-of-town visitors. Use a figure to show how this new website affects the equilibrium rental price and quantity of apartments in popular tourist cities.

4.3 Suppose that a combination of public health warnings, school programs, a ban on advertising, and warnings on package labelling cut the demand for cigarettes in half (that is, the demand curve shifted left for cigarettes at any price by 50%). Using a supply-and-demand diagram of a competitive market, show the likely effect on equilibrium price and equilibrium quantity. Would you expect equilibrium quantity to change by 50%? Show how the answer depends on the slope of the supply curve.

4.4 The last major outbreak of mad cow disease in the United Kingdom occurred in the mid 1990s. It is estimated that up to 6 million cows were destroyed at that time in an attempt to control the disease. What was the effect of the disease on the price and quantity of beef sold in the United Kingdom?

4.5 Use a supply-and-demand diagram of a competitive market to illustrate the qualitative effects of the following possible shocks in the Italian market for red wine.

a. A new research study shows that red wine helps prevent heart disease, stave off aging, and reduce age-related memory decline.

b. Trade barriers that restricted imports of red wine from countries outside the European Union are eliminated.

c. A recession in Italy causes a decline in per capita income.

d. Genetically engineered wine grapes are created that allow for greater red wine production without increasing cost.

4.6 Increasingly, instead of advertising in newspapers, individuals and firms use websites that offer free or inexpensive classified ads, such as **Classified Ads.com**, **Craigslist.org**, **Realtor.com**, **Jobs.com**, **Monster.com**, and portals like Google and Yahoo!. Using a supply-and-demand model, explain what will happen to the equilibrium levels of newspaper advertising as the use of the Internet grows. Will the growth of the Internet affect the supply curve, the demand curve, or both? Why?

4.7 Ethanol, a fuel, is made from corn. Ethanol production increased 8.5 times from 2000 to 2015 (**www.ethanolrfa.org**). Show the effect of this increased use of corn for producing ethanol on the price of corn and the consumption of corn as food using a supply-and-demand diagram.

4.8 The demand function is $Q = 220 - 2p$, and the supply function is $Q = 20 + 3p - 20r$, where $r$ is the rental cost of capital. Show how the equilibrium price and quantity vary with $r$? (*Hint*: See Solved Problem 2.3.) **A**

4.9 Using the information in Question 3.6, determine how the equilibrium price and quantity of coffee beans change if the price of coffee cherries falls by 25%. (*Hint*: See Solved Problem 2.3.) **A**

### 5. Effects of Government Interventions

5.1 The Application "Occupational Licensing" analyzed the effect of exams in licensed occupations given that their only purpose was to shift the supply curve to the left. How would the analysis change if the exam also raised the average ability of people in that occupation, which affects the demand curve?

*5.2 Is it possible that an outright ban on foreign imports will have no effect on the equilibrium price? (*Hint*: Suppose that imports occur only at relatively high prices.)

5.3 In 2015, the European Commission proposed giving individual member states the right to ban imports of genetically modified fruits and vegetables even if those products are still permitted at the European Union level. If a member state acted to ban such imports, what would be the likely effect of that policy on world prices and quantities? Would such a ban help deter the production of genetically modified products? (*Hint*: See Solved Problem 2.4.)

5.4 What is the effect of an import quota $\overline{Q} > 0$ on equilibrium price and quantity? (*Hint*: Carefully show how the total supply curve changes. See Solved Problem 2.4.)

5.5 There has been a great deal of movement of physicians across borders within the European Union, and this migration has raised concerns about patient safety and quality of care. Some member states have responded by tightening certification requirements for foreign-trained physicians. What effect would such a policy have on the equilibrium quantity and price of doctors' services in the country that introduces it? How would doctors trained in that country and the country's consumers be affected? In answering this question, assume that the supply curves for both domestically trained and foreign-trained physicians initially intersect the wage axis at the same point. (*Hint*: See Solved Problem 2.4.)

5.6 Usury laws place a ceiling on interest rates that lenders such as banks can charge borrowers. Low-income households in states with usury laws have significantly lower levels of consumer credit (loans) than comparable households in states without usury laws. Why? (*Hint*: The interest rate is the price of a loan, and the amount of the loan is the quantity measure.)

5.7 The Thai government actively intervenes in markets (Nophakhun Limsamarnphun, "Govt Imposes Price Controls in Response to Complaints," *The Nation*, May 12, 2012).

a. The government increased the daily minimum wage by 40% to Bt300 (300 bahts $\approx$ \$9.63). Show the effect of a higher minimum wage on the number of workers demanded, the supply of workers, and unemployment if the law is applied to the entire labor market.

b. Show how the increase in the minimum wage and higher rental fees at major shopping malls and retail outlets affected the supply curve of ready-to-eat meals. Explain why the equilibrium price of a meal rose to Bt40 from Bt30.

c. In response to complaints from citizens about higher prices of meals, the government imposed price controls on ten popular meals. Show the effect of these price controls in the market for meals.

d. What is the likely effect of the price controls on meals on the labor market?

5.8 Rent control laws are in place in states such as Maharashtra and Karnataka in India. Such price controls establish the price of rental accommodations and limit annual increases in rent up to a maximum amount. Use a supply-and-demand diagram of a competitive market to show the effect of binding rent controls on the equilibrium price and quantity of rental properties.

*5.9 The tsunamis that hit Japan in 2011 and India and Sri Lanka in 2004 were devastating, and their effects were felt for many years afterward. Natural disasters of this type as well as international events often result in severe disruptions to the supply of

goods and services and in sharp spikes in product prices. Governments may respond to public outcries against dramatically higher prices by imposing price ceilings to lower product prices or to keep them from rising too high. What effect would such a binding price ceiling have? Who would benefit from this policy, and who would be harmed?

5.10 Suppose the Mexican government decides to control the price of coffee beans to support coffee bean producers in that country. It does so by imposing a binding price floor of 7.5 million pesos per thousand 60-kg bags and by committing to buy any resulting excess supply. Use the information in Question 3.6 to determine the quantities of coffee beans demanded, supplied, and purchased by the government. (*Hint*: See Solved Problem 2.5.) **A**

5.11 Based on the Application "Venezuela Price Ceilings and Shortages," use two figures to show the effects of Venezuela's price control on corn flour in Venezuela and in Colombia's corn flour markets.

### 6. When to Use the Supply-and-Demand Model

6.1 Are predictions using the supply-and-demand model likely to be reliable in each of the following markets? Why or why not?

a. Apples.

b. Convenience stores.

c. Electronic games (a market with three major firms).

d. Used cars.

### 7. Challenge

*7.1 Brazil is one of the world's largest exporters of beef and China is a major purchaser of that beef (an estimated 30% of China's beef imports in 2016 came from Brazil). However, in March 2017, China, South Korea, the European Union, and Chile suspended imports of meat products from Brazil as a precautionary measure in response to allegations that meat inspectors and politicians had received bribes to overlook improper meat packing practices and allow sales of tainted food. How would the closing of export markets for a country's beef products together with a fall in domestic sales of beef products and an increase in the domestic equilibrium quantity be reflected in supply-and-demand diagrams of that country's foreign and domestic markets for beef in the short run?

7.2 Question 7.1 asks you to illustrate why an import ban might cause the equilibrium quantity of beef in the domestic market to rise. Depending on how the supply and demand curves shift, could the equilibrium quantity of beef in the domestic market have fallen instead? Would it ever be possible for the equilibrium price in the domestic market to rise?

7.3 When he was the top American administrator in Iraq, L. Paul Bremer III set a rule that upheld Iraqi law: anyone 25 years and older with a "good reputation and character" could own one firearm, including an AK-47 assault rifle. Iraqi citizens quickly began arming themselves. After the bombing of a sacred Shiite shrine in Samarra at the end of February 2006 and the subsequent rise in sectarian violence, the demand for guns increased, resulting in higher prices. The average price of a legal, Russian-made Kalashnikov AK-47 assault rifle jumped from $112 to $290 from February to March 2006, and the price of bullets shot up from 24¢ to 33¢ each (Jeffrey Gettleman, "Sectarian Suspicion in Baghdad Fuels a Seller's Market for Guns," *New York Times*, April 3, 2006). This increase occurred despite the hundreds of thousands of firearms and millions of rounds of ammunition that American troops had been providing to Iraqi security forces, some of which eventually ended up in the hands of private citizens. Use a graph to illustrate why prices rose. Did the price need to rise, or was the rise related to the shapes of and relative shifts in the demand and supply curves?