Supply and Demand

2

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 farmer's supply and whether consumers want to buy that crop.

The first commercial GM food was Calgene's Flavr Savr tomato that resisted rotting, which the company claimed could stay on the vine longer to ripen to full flavor. It was first marketed in 1994 without any special labeling. Other common GM crops include canola, corn, cotton, rice, soybean, and sugar cane. Using GM techniques, farmers can produce more output at a given cost. In 2008, farmers in 25 countries (including the United States, Argentina, Canada, Brazil, China, and South Africa) were planting GM crops, which comprised 8% of global cropland. In 2009, more than four-fifths of the U.S. sugar beet crop used GM seeds that were introduced only one year earlier.

Some scientists and consumer groups have raised safety concerns about GM crops. In the European Union (EU), Australia, and several other countries, governments have required labeling of GM products. Although Japan has not approved the cultivation of GM crops, it is the nation with the greatest GM food consumption and does not require labeling. 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 GM products cannot be distinguished). In some countries, certain GM foods have been banned. In 2008, the EU was forced to end its de facto ban on GM crop imports when the World Trade Organization ruled that the ban lacked scientific merit and hence violated international trade rules. As of 2010, most of the EU still bans planting GM crops. Consumers in other countries, such as the United States, are less concerned about GM foods.

In yet other countries, consumers may not even be aware of the use of GM seeds. In 2008, Vietnam announced that it was going to start using GM soybean, corn, and cotton seeds to lower food prices and reduce imports. By 2010, a study found that one-third of crops sampled in Vietnam were genetically modified (many imported). Vietnam's government has announced labeling regulations but has not yet explained how it will implement these regulations.

Whether a country approves GM crops turns on questions of safety and of economics. 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 return to these questions at the end of this chapter.)

[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.

To analyze questions concerning the price and quantity responses from introducing new products or technologies, imposing 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 of a good or service sold in a market and the price at which it is sold. 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. 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 model 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. **Equilibrium 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 their own 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 uses of a good affects consumers' decisions. A few 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 spend 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 are now banned in most countries. 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 have telephones if most of their friends have telephones. 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 such as income and tastes that affect demand.

The Demand Curve

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

The amount of a good that consumers are *willing* to buy at a given price, holding constant the 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 DVDs for $1 each today only. At that low price, you might want to buy 25 DVDs, but because the store ran out of stock, you can buy only 10 DVDs. The quantity you demand is 25—it's the amount you *want*, even though the amount you *actually buy* is only 10.

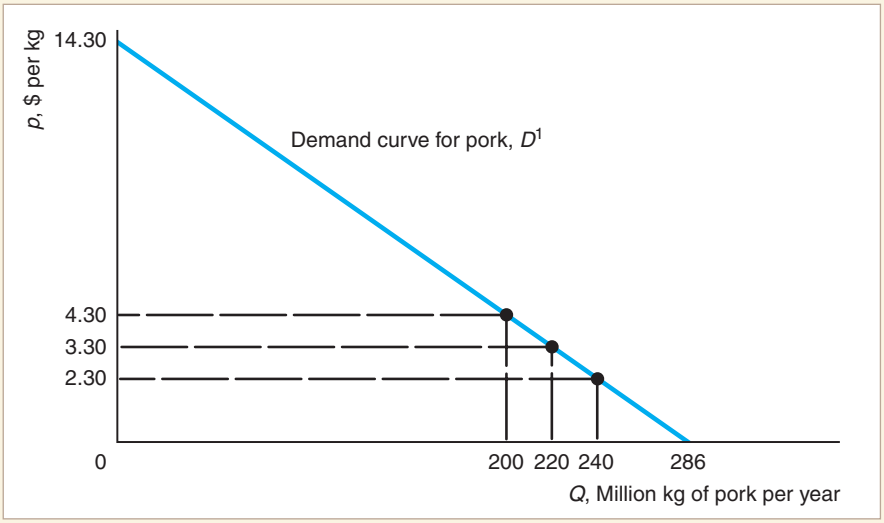
demand curve
the *quantity demanded* at each possible price, holding constant the other factors that influence purchases

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 the other factors that influence purchases. Figure 2.1 shows the estimated demand curve, D^1, for processed pork in Canada (Moschini and Meilke, 1992). (Although this demand curve is a straight line, demand curves may also be smooth

[2]When a Mississippi woman attempted to sell her granddaughter 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.)

Figure 2.1 A Demand Curve

The estimated demand curve, D^1, for processed pork in Canada (Moschini and Meilke, 1992) shows the relationship between the quantity demanded per year and the price per kg. The downward slope of the demand curve shows that, holding other factors that influence demand constant, consumers demand less of a good when its price is high and more when the price is low. A change in price causes a movement along the demand curve.



curves or wavy lines.) By convention, the vertical axis of the graph measures the price, p, per unit of the good—here dollars per kilogram (kg). The horizontal axis measures the quantity, Q, of the good, which is usually expressed in some *physical measure* (million kg of dressed cold pork carcass weight) *per time period* (per year).

The demand curve hits the vertical axis at \$14.30, indicating that no quantity is demanded when the price is \$14.30 (or higher). The demand curve hits the horizontal quantity axis at 286 million kg—the amount of pork that consumers want if the price is zero. To find out what quantity is demanded at a price between these extremes, pick that price on the vertical axis—say, \$3.30 per kg—draw a horizontal line across until you hit the demand curve, and then draw a line straight down to the horizontal quantity axis: 220 million kg of pork per year is demanded at that price.

One of the most important things to know about a graph of a demand curve is what is *not* shown. All relevant economic variables that are not explicitly shown on the demand curve graph—tastes, information, prices of other goods (such as beef and chicken), income of consumers, and so on—are held constant. Thus the demand curve shows how quantity varies with price but not how quantity varies with tastes, information, the price of substitute goods, or other variables.[3]

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 tastes, the prices of other goods, and other factors that influence the amount they consume. According to the Law of Demand, *demand curves slope downward*, as in Figure 2.1.[4]

[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). Moschini and Meilke (1992) used such techniques to estimate the pork demand curve. As with any estimate, their estimates are probably more accurate in the observed range of prices (\$1 to \$6 per kg) than at very high or very low prices.

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

A downward-sloping demand curve illustrates that consumers demand more of this good when its price is lower and less when its price is higher. What happens to the quantity of pork demanded if the price of pork drops and all other variables remain constant? If the price of pork falls by \$1 from \$3.30 to \$2.30 in Figure 2.1, the quantity consumers want to buy increases from 220 to 240.[5] Similarly, if the price increases from \$3.30 to \$4.30, the quantity consumers demand decreases from 220 to 200. These changes in the quantity demanded in response to changes in price are *movements along the demand curve*. Thus the demand curve is a concise summary of the answers to the question "What happens to the quantity demanded as the price changes, when all other factors are held constant?"

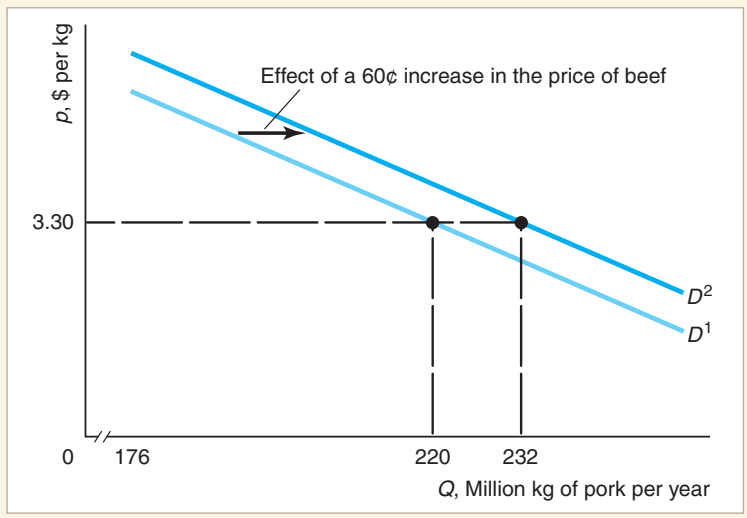
Effects of Other Factors on Demand If a demand curve measures the effects of price changes when all other factors that affect demand are held constant, how can we use demand curves to show the effects of a change in one of these other factors, such as the price of beef? One solution is to draw the demand curve in a three-dimensional diagram with the price of pork on one axis, the price of beef on a second axis, and the quantity of pork on the third axis. But just thinking about drawing such a diagram probably makes your head hurt.

Economists use a simpler approach to show the effect on demand of a change in a factor that affects demand other than the price of the good. A change in any factor other than the price of the good itself causes a *shift of the demand curve* rather than a *movement along the demand curve*.

Many people view beef as a close substitute for pork. Thus at a given price of pork, if the price of beef rises, some people will switch from beef to pork. Figure 2.2 shows how the demand curve for pork shifts to the right from the original demand curve D^1 to a new demand curve D^2 as the price of beef rises from \$4.00 to \$4.60

Figure 2.2 A Shift of the Demand Curve

The demand curve for processed pork shifts to the right from D^1 to D^2 as the price of beef rises from \$4 to \$4.60. As a result of the increase in beef prices, more pork is demanded at any given price.



[5]Economists typically do not state the relevant physical and time 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 \$3.30 (with the "per kg" understood) and the quantity as 220 (with the "million kg per year" understood).

per kg. (The quantity axis starts at 176 instead of 0 in the figure to emphasize the relevant portion of the demand curve.) On the new demand curve, D^2, more pork is demanded at any given price than on D^1. At a price of pork of \$3.30, the quantity of pork demanded goes from 220 on D^1, before the change in the price of beef, to 232 on D^2, after the price change.

Other factors such as addictiveness may also affect demand. A 2007 Harvard School of Public Health study concluded that cigarette manufacturers raised nicotine levels in cigarettes by 11% over the last decade to make them more addictive. Although some cigarette makers denied such actions, the Massachusetts Department of Public Health issued a study citing the industry's own reports that the amount of nicotine that could be inhaled from cigarettes had risen by an average of 10% from 1998 through 2004. Presumably, if cigarettes have become more addictive, the demand curve of existing smokers would shift to the right.[6]

To properly analyze the effects of a change in some variable 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*.

APPLICATION

Calorie Counting at Starbucks

A change in information can also shift the demand curve. New York City started requiring mandatory posting of calories on menus in chain restaurants in mid-2008. (Some states have since passed similar laws and Congress is considering federal legislation.) Bollinger, Leslie, and Sorensen (2010) found that New York City's mandatory calorie posting 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.

The Demand Function

In addition to drawing the demand curve, you can write it as a mathematical relationship called the *demand function*. The processed pork demand function is

$$Q = D(p, p_b, p_c, Y), \tag{2.1}$$

where Q is the quantity of pork demanded, p is the price of pork, p_b is the price of beef, p_c is the price of chicken, and Y is the income of consumers. This expression says that the amount of pork demanded varies with the price of pork, the price of substitutes (beef and chicken), and the income of consumers. Any other factors that are not explicitly listed in the demand function are assumed to be irrelevant (the price of llamas in Peru) or held constant (the price of fish).

By writing the demand function in this general way, we are not explaining exactly how the quantity demanded varies as p, p_b, p_c, or Y changes. Instead, we can rewrite Equation 2.1 as a specific function:

$$Q = 171 - 20p + 20pb + 3pc + 2Y. \tag{2.2}$$

[6]Gardiner Harris, "Study Showing Boosted Nicotine Levels Spurs Calls for Controls," *San Francisco Chronicle*, January 19, 2007, A-4.

Equation 2.2 is the estimated demand function that corresponds to the demand curve D^1 in Figures 2.1 and 2.2.[7]

When we drew the demand curve D^1 in Figures 2.1 and 2.2, we held p_b, p_c, and Y at their typical values during the period studied: $p_b = 4$ (dollars per kg), $p_c = 3\frac{1}{3}$ (dollars per kg), and $Y = 12.5$ (thousand dollars). If we substitute these values for p_b, p_c, and Y in Equation 2.2, we can rewrite the quantity demanded as a function of only the price of pork:

$$\begin{aligned} Q &= 171 - 20p + 20p_b + 3p_c + 2Y \\ &= 171 - 20p + (20 \times 4) + (3 \times 3\tfrac{1}{3}) + (2 \times 12.5) \\ &= 286 - 20p \end{aligned} \tag{2.3}$$

The straight-line demand curve D^1 in Figures 2.1 and 2.2—where we hold the price of beef, the price of chicken, and disposable income constant at these typical values—is described by the *linear* demand function in Equation 2.3.

See Problems 27 and 28.

The constant term, 286, in Equation 2.3 is the quantity demanded if the price is zero. Setting the price equal to zero in Equation 2.3, we find that the quantity demanded is $Q = 286 - (20 \times 0) = 286$. Figure 2.1 shows that $Q = 286$ where D^1 hits the quantity axis at a price of zero.

This equation also shows us how quantity demanded changes with a change in price: a movement *along* the demand curve. If the price increases from p_1 to p_2, the change in price, Δp, equals $p_2 - p_1$. (The Δ symbol, the Greek letter delta, means "change in" the following variable, so Δp means "change in price.") As Figure 2.1 illustrates, if the price of pork increases by \$1 from $p_1 = \$3.30$ to $p_2 = \$4.30$, $\Delta p = \$1$ and $\Delta Q = Q_2 - Q_1 = 200 - 220 = -20$ million kg 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

$$\begin{aligned} \Delta Q &= Q_2 - Q_1 \\ &= D(p_2) - D(p_1) \\ &= (286 - 20p_2) - (286 - 20p_1) \\ &= -20(p_2 - p_1) \\ &= -20\Delta p. \end{aligned}$$

Thus the change in the quantity demanded, ΔQ, is -20 times the change in the price, Δp. If $\Delta p = \$1$, $\Delta Q = -20\Delta p = 20$.

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

$$\text{Slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta p}{\Delta Q} = \frac{\$1 \text{ per kg}}{-20 \text{ million kg per year}} = -\$0.05 \text{ per million kg per year.}$$

The negative sign of this slope is consistent with the Law of Demand. The slope says that the price rises by \$1 per kg as the quantity demanded falls by 20 million kg per year. Turning that statement around: The quantity demanded falls by 20 million kg per year as the price rises by \$1 per kg.

[7] The numbers are rounded slightly from the estimates to simplify the calculation. For example, the estimate of the coefficient on the price of beef is 19.5, not 20, as the equation shows.

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

How much would the price have to fall for consumers to be willing to buy 1 million more kg of pork per year?

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 and adding $20p$ to both sides, we find that $20p = 286 - Q$. Dividing both sides of the equation by 20, we obtain the inverse demand function:

$$p = 14.30 - 0.05Q \tag{2.4}$$

2. *Use the inverse demand curve to determine how much the price must change for consumers to buy 1 million more kg of pork per year.* We take the difference between the inverse demand function, Equation 2.4, at the new quantity, $Q_2 + 1$, and at the original quantity, Q_1, to determine how the price must change:

$$\begin{aligned}\Delta p &= p_2 - p_1 \\ &= (14.30 - 0.05Q_2) - (14.30 - 0.05Q_1) \\ &= -0.05(Q_2 - Q_1) \\ &= -0.05\Delta Q.\end{aligned}$$

The change in quantity is $\Delta Q = Q_2 - Q_1 = (Q_1 + 1) - Q_1 = 1$, so the change in price is $\Delta p = -0.05$. That is, for consumers to demand 1 million more kg of pork per year, the price must fall by 5¢ a kg, which is a *movement along the demand curve.*

See Problem 29.

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:

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

See Problems 30 and 31.

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.

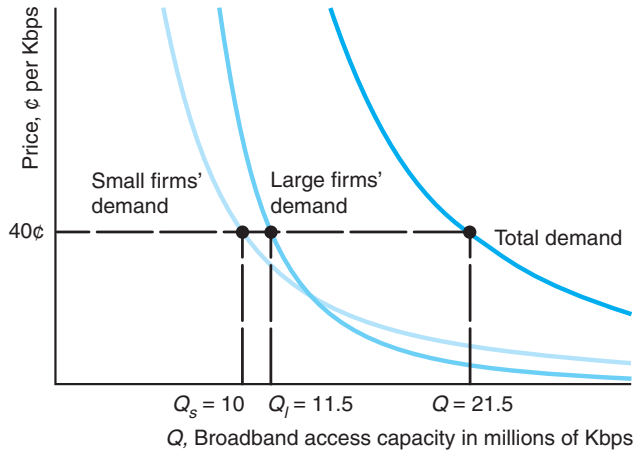
APPLICATION

Aggregating the Demand for Broadband Service

We illustrate how to combine individual demand curves to get a total demand curve graphically using estimated demand curves of broadband (high-speed) Internet service (Duffy-Deno, 2003). The figure shows the demand curve for small firms (1–19 employees), the demand curve for larger firms, and the total demand curve for all firms, which is the horizontal sum of the other two demand curves.

At the current average rate of 40¢ per kilobyte per second (Kbps), the quantity demanded by small firms is $Q_s = 10$ (in millions of Kbps) and the quantity demanded by larger firms is $Q_l = 11.5$. Thus, the total quantity demanded at that price is $Q = Q_s + Q_l = 10 + 11.5 = 21.5$.

See Problem 32.



2.2 Supply

Knowing how much consumers want is not enough, by itself, to tell us what price and quantity are observed in a market. 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 on the basis of 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 are allowed to sell. Taxes and many government regulations—such as those covering

pollution, sanitation, and health insurance—alter the costs of production. Other regulations affect when and how the product can be sold. In Germany, retailers may not sell most goods and services on Sundays or during evening hours. In the United States, the sale of cigarettes and liquor to children is prohibited. New York, San Francisco, and many other cities restrict the number of taxicabs.

The Supply Curve

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

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

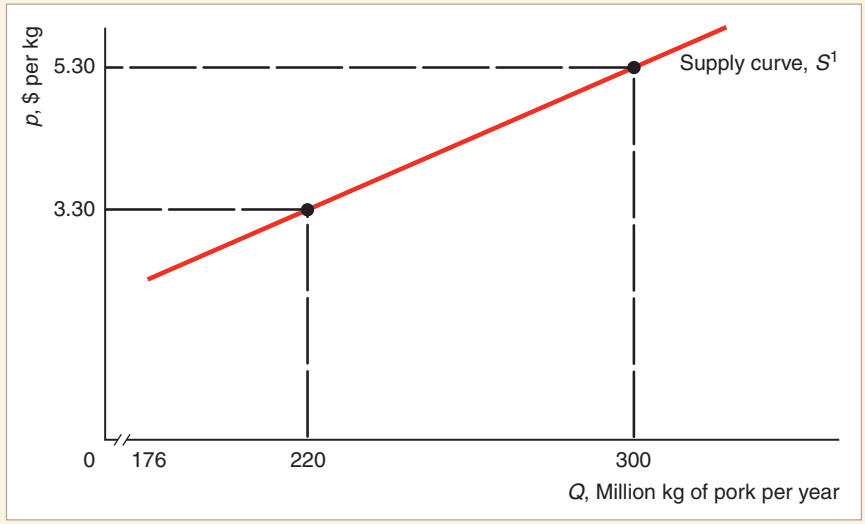
The **quantity supplied** is the amount of a good that firms *want* to sell at a given price, holding constant other factors that influence firms' supply decisions, such as costs and government actions. We can show the relationship between price and the quantity supplied graphically. A **supply curve** shows the quantity supplied at each possible price, holding constant the other factors that influence firms' supply decisions. Figure 2.3 shows the estimated supply curve, S^1, for processed pork (Moschini and Meilke, 1992). As with the demand curve, the price on the vertical axis is measured in dollars per physical unit (dollars per kg), and the quantity on the horizontal axis is measured in physical units per time period (millions of kg per year). Because we hold fixed other variables that may 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?"

Effect of Price on Supply We illustrate how price affects the quantity supplied using the supply curve for processed pork in Figure 2.3. The supply curve for pork is upward sloping. As the price of pork increases, firms supply more. If the price is \$3.30, the market supplies a quantity of 220 (million kg per year). If the price rises to \$5.30, the quantity supplied rises to 300. An increase in the price of pork causes a *movement along the supply curve*, resulting in more pork being supplied.

Although the Law of Demand requires that the demand curve slope downward, there is *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 pork.

Figure 2.3 A Supply Curve

The estimated supply curve, S^1, for processed pork in Canada (Moschini and Meilke, 1992) shows the relationship between the quantity supplied per year and the price per kg, holding cost and other factors that influence supply constant. The upward slope of this supply curve indicates that firms supply more of this good when its price is high and less when the price is low. An increase in the price of pork causes a movement *along the supply curve*, resulting in a larger quantity of pork supplied.



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 variable other than the price of pork causes the entire *supply curve to shift*. Suppose the price, p_h, of hogs—the main factor used to produce processed pork—increases from \$1.50 per kg to \$1.75 per kg. Because it is now more expensive to produce pork, firms are willing to sell fewer units at any given price, so the supply curve shifts to the left, from S^1 to S^2 in Figure 2.4.[8] Firms want to supply less pork at any given price than before the price of hogs rose. At a price of processed pork of \$3.30, the quantity supplied falls from 220 on S^1 (before the increase in the hog price) to 205 on S^2 (after the increase in the hog price).

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

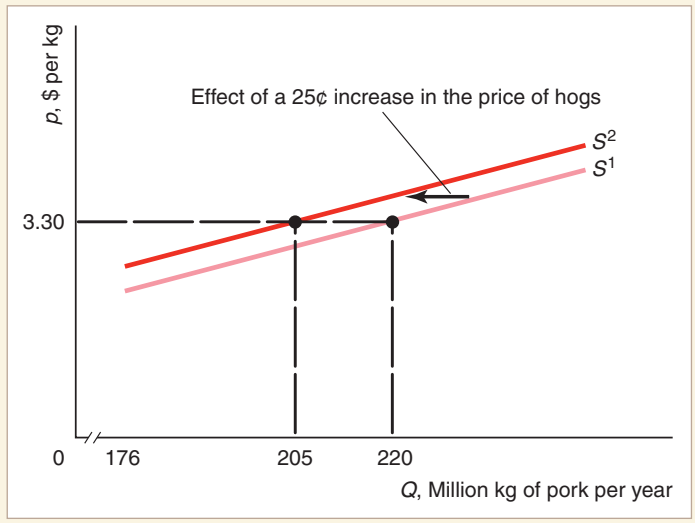
We can write the relationship between the quantity supplied and price and other factors as a mathematical relationship called the *supply function*. Written generally, the processed pork supply function is

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

where Q is the quantity of processed pork supplied, p is the price of processed pork, and p_h is the price of a hog. The supply function, Equation 2.5, may also be a function of other factors such as wages, but by leaving them out, we are implicitly holding them constant.

Figure 2.4 A Shift of a Supply Curve

An increase in the price of hogs from \$1.50 to \$1.75 per kg causes the supply curve for processed pork to shift from S^1 to S^2. At the price of processed pork of \$3.30, the quantity supplied falls from 220 on S^1 to 205 on S^2.



[8]Alternatively, we may say that the supply curve shifts up because firms' costs of production have increased, so that firms will supply a given quantity only at a higher price.

Based on Moschini and Meilke (1992), the linear pork supply function in Canada is

$$Q = 178 + 40p - 60p_h, \tag{2.6}$$

where quantity is in millions of kg per year and the prices are in Canadian dollars per kg. If we hold the price of hogs fixed at its typical value of \$1.50 per kg, we can rewrite the supply function in Equation 2.6 as[9]

See Problem 33.

$$Q = 88 + 40p. \tag{2.7}$$

What happens to the quantity supplied if the price of processed pork increases by $\Delta p = p_2 - p_1$? Using the same approach as before, we learn from Equation 2.7 that $\Delta Q = 40\Delta p$.[10] A \$1 increase in price ($\Delta p = 1$) causes the quantity supplied to increase by $\Delta Q = 40$ million kg per year. This change in the quantity of pork 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 either of the other two supply curves.

See Problem 34.

Effects of Government Import Policies on 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 banned the importation of foreign rice. We want to determine how much less is supplied at any given price to the Japanese market because of this ban.

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 has no effect on the domestic supply curve, S^d, so the supply curve is 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

---

[9]Substituting $p_h = \$1.50$ into Equation 2.6, we find that

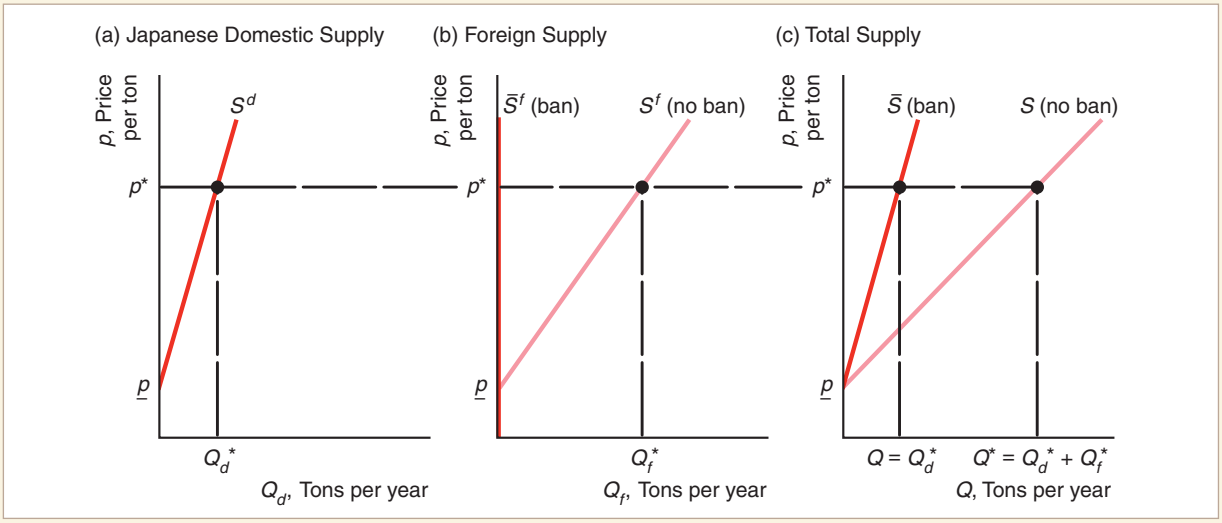
$$Q = 178 + 40p - 60p_h = 178 + 40p - (60 \times 1.50) = 88 + 40p.$$

[10]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

$$\Delta Q = Q_2 - Q_1 = (88 + 40p_2) - (88 + 40p_1) = 40(p_2 - p_1) = 40\Delta p.$$

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.



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 of a foreign-produced good that may be imported is called a **quota**. By absolutely banning the importation of rice, the Japanese government sets a quota of zero on rice imports. Sometimes governments set positive quotas, $\overline{Q} > 0$. The 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

How does a quota set by the United States on foreign sugar imports of $\overline{Q}$ 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?

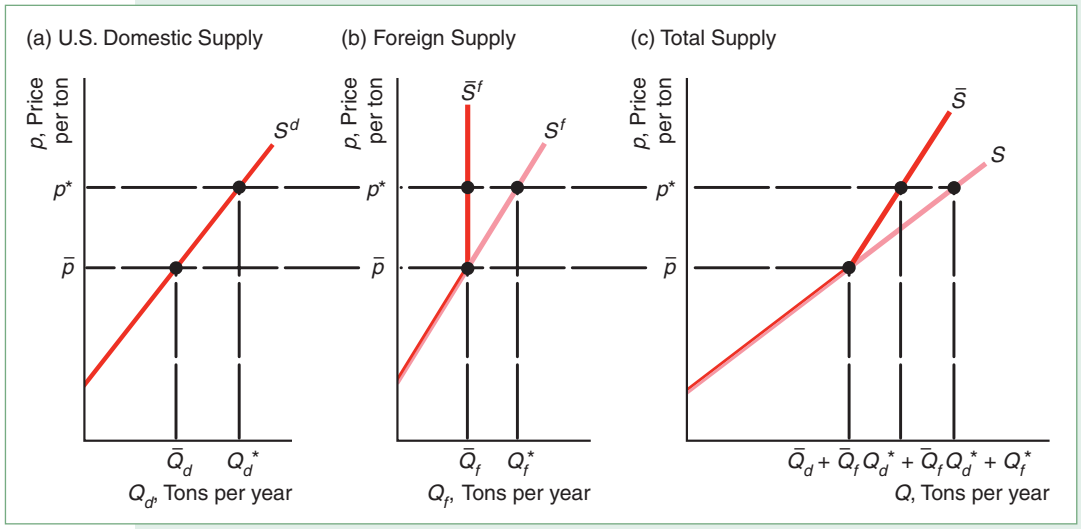
Answer

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 sup-

ply 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 by less with a quota than without one.

See Question 1.



2.3 Market Equilibrium

The supply and demand curves determine the price and quantity at which goods and services are bought and sold. The demand curve shows the quantities consumers want to buy at various prices, and the supply curve shows the quantities 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.

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

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 participant wants to change its behavior. A price at which consumers can buy as much as they want and sellers can sell as much as they want is called an *equilibrium price*. The quantity that is bought and sold at the equilibrium price is called the *equilibrium quantity*.

Using a Graph to Determine the Equilibrium

This little piggy went to market…

To illustrate how supply and demand curves determine the equilibrium price and quantity, we use our old friend, the processed pork example. Figure 2.6 shows the supply, S, and demand, D, curves for pork. The supply and demand curves intersect at point e, the market equilibrium, where the equilibrium price is \$3.30 and the equilibrium quantity is 220 million kg per year, which is the quantity firms want to sell *and* the quantity consumers want to buy.

See Questions 2–4.

Using Math to Determine the Equilibrium

We can determine the processed pork market equilibrium mathematically, using the supply and demand functions. We use these two functions to solve for the equilibrium price at which the quantity demanded equals the quantity supplied (the equilibrium quantity).

The demand function, Equation 2.3, shows the relationship between the quantity demanded, Q_d, and the price:

$$Q_d = 286 - 20p.$$

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

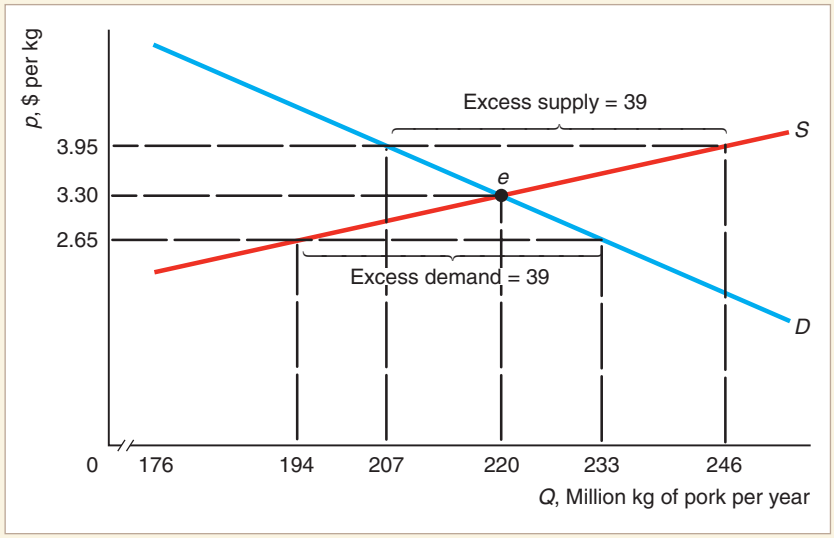
$$Q_s = 88 + 40p.$$

We want to find the p at which $Q_d = Q_s = Q$, the equilibrium quantity. Because the left sides of the two equations are equal in equilibrium, $Q_s = Q_d$, the right sides of the two equations must be equal:

$$286 - 20p = 88 + 40p.$$

Figure 2.6 Market Equilibrium

The intersection of the supply curve, S, and the demand curve, D, for processed pork determines the market equilibrium point, e, where p = \$3.30 per kg and Q = 220 million kg per year. At the lower price of p = \$2.65, the quantity supplied is only 194, whereas the quantity demanded is 233, so there is excess demand of 39. At p = \$3.95, a price higher than the equilibrium price, there is excess supply of 39 because the quantity demanded, 207, is less than the quantity supplied, 246. When there is excess demand or supply, market forces drive the price back to the equilibrium price of \$3.30.



Adding $20p$ to both sides of this expression and subtracting 88 from both sides, we find that $198 = 60p$. Dividing both sides of this last expression by 60, we learn that the equilibrium price is $p = \$3.30$. We can determine the equilibrium quantity by substituting this p into either the supply or the demand equation:

$$\begin{aligned} Q_d &= Q_s \\ 286 - (20 \times 3.30) &= 88 + (40 \times 3.30) \\ 220 &= 220. \end{aligned}$$

See Problems 35–37.

Thus the equilibrium quantity is 220 million kg.

Forces That Drive the Market to Equilibrium

A market equilibrium is not just an abstract concept or a theoretical possibility. We can observe markets in equilibrium. Indirect evidence that a market is in equilibrium is that you can buy as much as you want of the good at the market price. You can almost always buy as much as you want of such common goods as milk and ballpoint pens.

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; 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 a market equilibrium.

What really causes the market to move to an equilibrium? If the price is not at the equilibrium level, consumers or firms have an incentive to change their behavior in a way that will drive the price to the equilibrium level, as we now illustrate.

If the price were initially lower than the equilibrium price, consumers would want to buy more than suppliers want to sell. If the price of pork is \$2.65 in Figure 2.6, firms are willing to supply 194 million kg per year but consumers demand 233 million kg. At this price, the market is in *disequilibrium*, meaning that the quantity demanded is not equal to the quantity supplied. There is **excess demand**—the amount by which the quantity demanded exceeds the quantity supplied at a specified price—of 39 (= 233 − 194) million kg per year at a price of \$2.65.

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

Some consumers are lucky enough to buy the pork at \$2.65. Other consumers cannot find anyone who is willing to sell them pork at that price. What can they do? Some frustrated consumers may offer to pay suppliers more than \$2.65. Alternatively, suppliers, noticing these disappointed consumers, may raise their prices. Such actions by consumers and producers cause the market price to rise. As the price rises, the quantity that firms want to supply increases and the quantity that consumers want to buy decreases. This upward pressure on price continues until it reaches the equilibrium price, \$3.30, where there is 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 of pork of \$3.95, suppliers want to sell 246 million kg per year but consumers want to buy only 207 million, as Figure 2.6 shows. At \$3.95, the market is in disequilibrium. There is an **excess supply**—the amount by which the quantity supplied is greater than the quantity demanded at a specified price—of 39 (= 246 − 207) at a price of \$3.95. Not all firms can sell as much as they want. Rather than incur storage costs (and possibly have their unsold pork spoil), firms lower the price to attract additional customers. As long as the price remains above the equilibrium price, some firms have

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

unsold pork and want to lower the price further. The price falls until it reaches the equilibrium level, $3.30, where there is no excess supply and hence no more pressure to lower the price further.[11]

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 people 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: There is no excess demand or excess supply at the equilibrium price.

2.4 Shocking the Equilibrium

Once an equilibrium is achieved, it can persist indefinitely because no one applies 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 were 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 Shift in the Demand Curve

Suppose that the price of beef increases by 60¢, and so consumers substitute pork for beef. As a result, the demand curve for pork shifts outward from D^1 to D^2 in panel a of Figure 2.7. At any given price, consumers want more pork than they did before the price of beef rose. In particular, at the original equilibrium price of pork, $3.30, consumers now want to buy 232 million kg of pork per year. At that price, however, suppliers still want to sell only 220. As a result, there is excess demand of 12. Market pressures drive the price up until it reaches a new equilibrium at $3.50. At that price, firms want to sell 228 and consumers want to buy 228, the new equilibrium quantity. Thus the pork equilibrium goes from e_1 to e_2 as a result of the increase in the price of beef. Both the equilibrium price and the equilibrium quantity of pork rise as a result of the outward shift of the pork demand curve. Here the increase in the price of beef causes a *shift of the demand curve*, causing a *movement along the supply curve*.

See Questions 5 and 6.

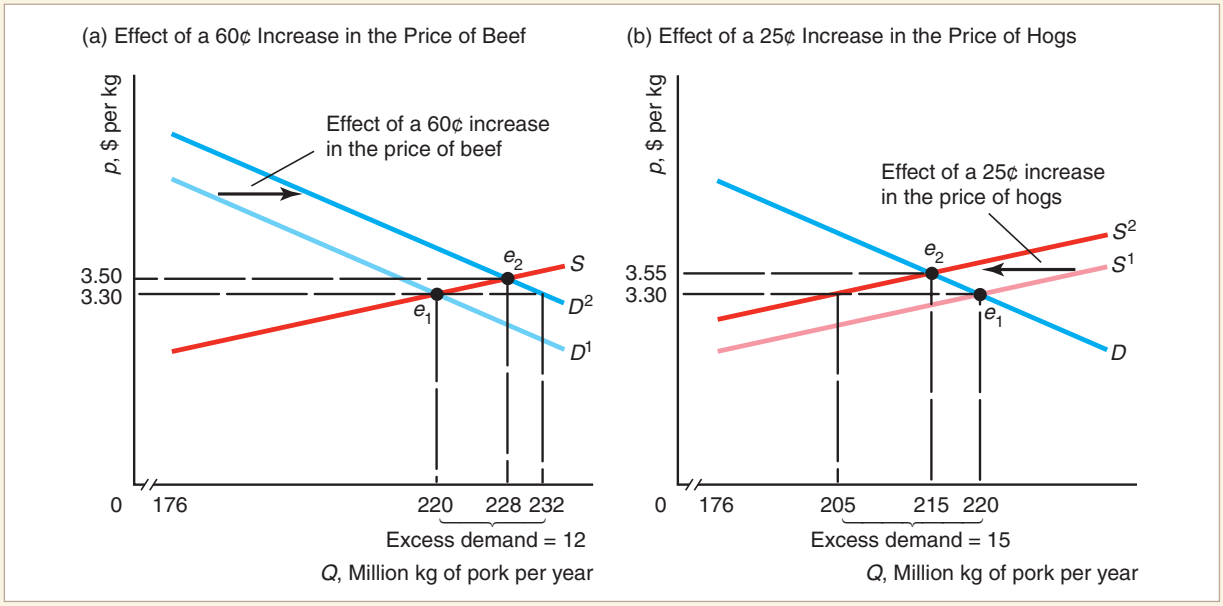
Effects of a Shift in the Supply Curve

Now suppose that the price of beef stays constant at its original level but the price of hogs increases by 25¢. It is now more expensive to produce pork because the price of a major input, hogs, has increased. As a result, the supply curve for pork shifts to the left from S^1 to S^2 in panel b of Figure 2.7. At any given price, firms want

[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 Web site). 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.

Figure 2.7 Equilibrium Effects of a Shift of a Demand or Supply Curve

(a) An increase in the price of beef by 60¢ causes the demand curve for processed pork to shift outward from D^1 to D^2. At the original equilibrium, E_1, price, \$3.30, there is excess demand of 12. Market pressures drive the price up until it reaches \$3.50 at the new equilibrium, E_2. (b) An increase in the price of hogs by 25¢ causes the supply curve for processed pork to shift to the left from S^1 to S^2, driving the market equilibrium from E_1 to E_2.



to supply less pork than they did before the price of hogs increased. At the original equilibrium price of pork of \$3.30, consumers still want 220, but suppliers are now willing to supply only 205, so there is excess demand of 15. Market pressure forces the price of pork up until it reaches a new equilibrium at e_2, where the equilibrium price is \$3.55 and the equilibrium quantity is 215. The increase in the price of hogs causes the equilibrium price to rise but the equilibrium quantity to fall. Here a *shift of the supply curve* results in a *movement along the demand curve*.

In summary, a change in an underlying factor, such as the price of a substitute or the price of an input, shifts the demand or supply curve. As a result of this shift in the demand or supply curve, the equilibrium changes. To describe the effect of this change in the underlying factor on the market, we compare the original equilibrium price and quantity to the new equilibrium values.

See Questions 7–10.

SOLVED PROBLEM 2.3

Mathematically, how does the equilibrium price of pork vary as the price of hogs changes if the variables that affect demand are held constant at their typical values?

Answer

1. *Solve for the equilibrium price of pork in terms of the price of hogs.* The demand function does not depend on the price of hogs, so we can use Equation 2.3 from before,

$$Q_d = 286 - 20p.$$

To see how the equilibrium depends on the price of hogs, we use supply function Equation 2.6:

$$Q_s = 178 + 40p - 60p_h.$$

The equilibrium is determined by equating the right sides of these demand-and-supply equations:

$$286 - 20p = 178 + 40p - 60p_h.$$

Rearranging terms in this last expression, we find that $60p = 108 + 60p_h$. Dividing both sides by 60, we have an expression for the equilibrium price of processed pork as a function of the price of hogs:

$$p = 1.8 + p_h. \tag{2.8}$$

(As a check, when p_h equals its typical value, \$1.50, Equation 2.8 says that the equilibrium price of pork is p = \$3.30, which we know is correct from our earlier calculations.)

We find the equilibrium quantity as a function of the price of hogs by substituting this expression for the equilibrium price, Equation 2.8, into the demand equation (though we could use the supply function instead):

$$Q = 286 - 20p = 286 - 20(1.8 + p_h) = 250 - 20p_h.$$

(Again, as a check, if p_h equals its typical value of \$1.50, Q = 220, which we know is the original equilibrium quantity.)

2. *Show how the equilibrium price of pork varies with the price of hogs.* We know from Equation 2.8 that $\Delta p = \Delta p_h$. Any increase in the price of hogs causes an equal increase in the price of processed pork. As panel b of Figure 2.7 illustrates, if the price of hogs increases by Δp_h = \$0.25 (from \$1.50 to \$1.75), the price of pork, p, increases by $\Delta p = \Delta p_h$ = \$0.25 (from \$3.30 to \$3.55).

See Problems 38–40.

2.5 Equilibrium Effects of Government Interventions

A government can affect a market equilibrium in many ways. Sometimes government actions cause a shift in the supply curve, the demand curve, or both curves, which causes the equilibrium to change. Some government interventions, however, cause the quantity demanded to differ from the quantity supplied.

Policies That Shift Supply Curves

Governments employ a variety of policies that shift supply curves. Two common policies are 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, licenses are distributed to early entrants or exams are used to determine who is licensed. In developing countries, licenses often go to relatives of government officials or to whomever offers those officials the largest bribe.

APPLICATION

Occupational Licensing

Licensing also affects labor markets, where the price is the wage or salary paid to a worker per day and the quantity is the number of workers (or hours that they work). In the United States, more than 800 occupations require licenses issued by local, state, or federal government agencies, including animal trainers, dietitians and nutritionists, doctors, electricians, embalmers, funeral directors, hairdressers, librarians, nurses, psychologists, real estate brokers, respiratory therapists, salespeople, teachers, and tree trimmers (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 workers has grown, reaching nearly 18% by the 1980s, at least 20% in 2000, and 29% in 2008. Licensing is more common in occupations that require extensive education: more than 40% of workers with a post-college education are required to have a license, compared to only 15% of those in which workers have less than a high school education.

To obtain a license in some occupations, you must pass a test, which is frequently designed by licensed members of the occupation. By making exams difficult, current members of the occupation can limit entry by new workers. For example, only 37.1% of people taking the California State Bar Examination in February 2010 passed it, although all of them had law degrees. (The national rate for lawyers passing state bar exams in February 2009 was higher, but still only 53%.)

To the degree that testing is objective, licensing may raise the average quality of the workforce. However, too often its primary effect is to restrict the number of workers in an occupation. To analyze the effects of licensing, we 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, which reduces the equilibrium quantity of workers and raises the equilibrium wage. Kleiner and Krueger (2010) find that licensing raises occupational wages by 15% on average.

See Question 11.

Quotas Quotas typically limit the amount of a good that can be sold (rather than the number of firms that sell it). Quotas are commonly used to limit imports. As we saw earlier, quotas on imports affect the supply curve. We illustrate the effect of quotas on market equilibrium.

The Japanese government's ban (the quota is 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 without a ban, S. The intersection of S and D determines the equilibrium, e_1, if rice imports are allowed.

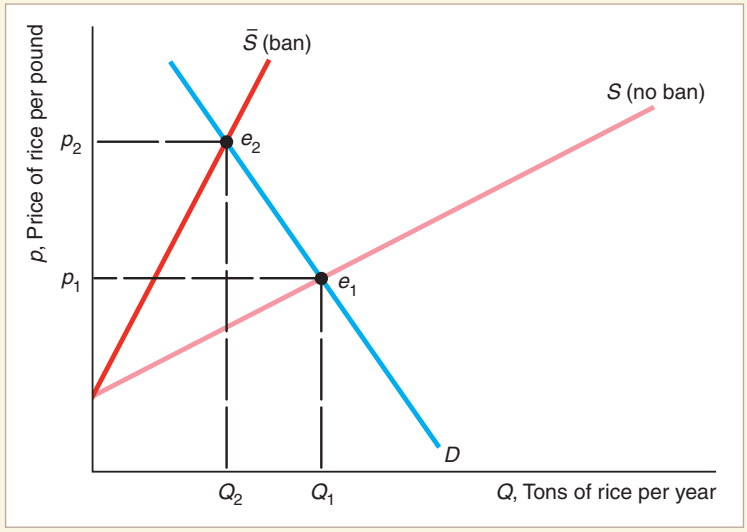
What is the effect of a ban on foreign rice on Japanese supply and demand? The ban has no effect on demand if Japanese consumers do not care whether they eat domestic or foreign rice. The ban causes the total supply curve to rotate toward the origin from S (total supply is the horizontal sum of domestic 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 leads to a fall in the equilibrium quantity from Q_1 to Q_2 and a rise in the equilibrium price from p_1 to p_2. Because of the Japanese nearly total ban on imported rice, the price of rice in Japan was 10.5 times higher than the price in the rest of the world in 2001, but is only about 50% higher today.

See Questions 12 and 13.

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

A ban on rice imports shifts the total supply of rice in Japan without a ban, S, to $\overline{S}$, 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.



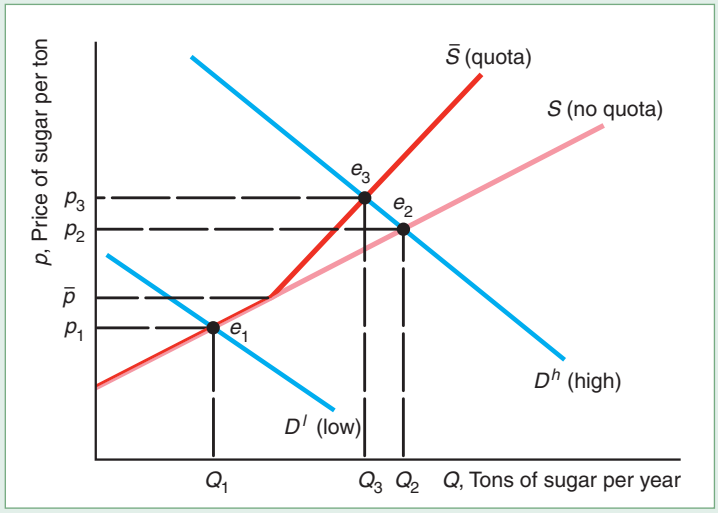
A quota of $\overline{Q}$ may have a similar effect to an outright ban; however, a quota may have no effect on the equilibrium if the quota is set so high that it does not limit imports. We investigate this possibility in Solved Problem 2.4.

SOLVED PROBLEM 2.4

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, 85% of the sugar Americans consume is produced domestically, while the rest is imported from about 40 countries under a quota system.[12] Due to the quota, the 2010 U.S. price of sugar was roughly double 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.

See Questions 14–16.

Policies That Cause Demand to Differ from Supply

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, would be above the price ceiling $\overline{p}$, the price that is actually observed in the market is 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

[12]Mark J. Perry, **www.benzinga.com/174032/more-on-the-sickeningly-sweet-deal-for-big-sugar**, March 15, 2010. The United States also imports sugar from Mexico, which is not covered by a quota due to a free-trade treaty. See MyEconLab, Chapter 2, "American Steel Quotas" for a discussion of another U.S. industry with quotas.

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, which is determined by the intersection of the price control line with S^2. As a result of the binding price control, there is excess demand of $Q_d - Q_s$.

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

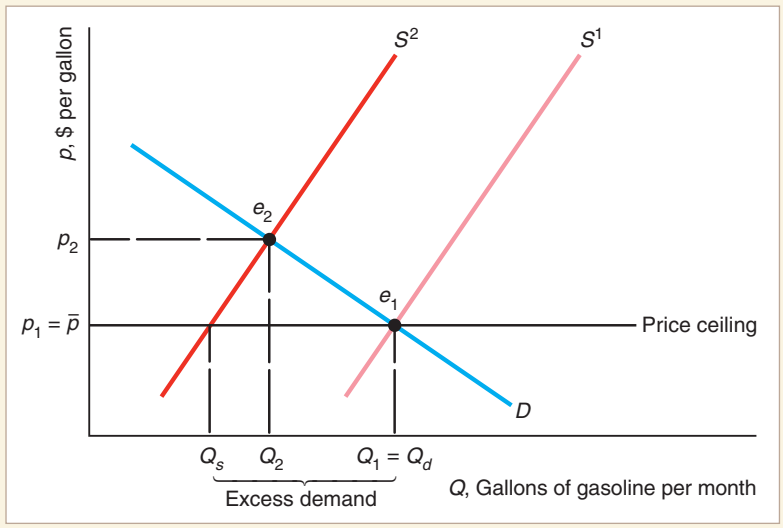
shortage
a persistent excess demand

At the time of the controls, some government officials argued that the shortages were caused by OPEC's 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, there is no shortage. 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

Figure 2.9 Price Ceiling on Gasoline

Supply 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 $\overline{p} = p_1$. 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 $Q_d - Q_s$.



get more output by offering to pay more, or firms would raise prices. With effective government price controls, they know that they can't drive up the price, so they live with the shortage.

What happens? Some lucky consumers get to buy Q_s units at the low price of $\overline{p}$. 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 there are price controls? 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 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 them. 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.[13] Deacon and Sonstelie (1989) calculated that for every dollar consumers saved during the 1980 gasoline price controls, they lost $1.16 in waiting time and other factors.

This experience dissuaded most U.S. jurisdictions from imposing gasoline price controls, even when gasoline prices spiked following Hurricane Katrina in the summer of 2008. The one exception was Hawaii, which 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.

See Questions 17–20.

APPLICATION

Price Controls Kill

Robert G. Mugabe, who has ruled Zimbabwe with an iron fist for nearly three decades, has used price controls to try to stay in power by currying favor among the poor.[14] In 2001, he imposed price controls on many basic commodities, including food, soap, and cement, which led to shortages of these goods, and a thriving *black,* or *parallel, market* in which the controls were ignored developed. Prices on the black market were two or three times higher than the controlled prices.

He imposed more extreme controls in 2007. A government edict cut the prices of 26 essential items by up to 70%, and a subsequent edict imposed price controls on a much wider range of goods. Gangs of price inspectors patrolled shops and factories, imposing arbitrary price reductions. State-run newspapers exhorted citizens to turn in store owners whose prices exceeded the limits.

The Zimbabwean police reported that they arrested at least 4,000 businesspeople for not complying with the price controls. The government took over the nation's slaughterhouses after meat disappeared from stores, but in a typi-

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

[14]Mr. Mugabe justified price controls as a means to deal with profiteering businesses that he said were part of a Western conspiracy to reimpose colonial rule. Actually, they were a vain attempt to slow the hyperinflation that resulted from his printing Zimbabwean money rapidly. Prices increased several billion times in 2008, and the government printed currency with a face value of 100 trillion Zimbabwe dollars.

cal week, butchers killed and dressed only 32 cows for the entire city of Bulawayo, which consists of 676,000 people.

Ordinary citizens initially greeted the price cuts with euphoria because they had been unable to buy even basic necessities because of hyperinflation and past price controls. Yet most ordinary citizens were unable to obtain much food because most of the cut-rate merchandise was snapped up by the police, soldiers, and members of Mr. Mugabe's governing party, who were tipped off prior to the price inspectors' rounds.

Manufacturing slowed to a crawl because firms could not buy raw materials and because the prices firms received were less than their costs of production. Businesses laid off workers or reduced their hours, impoverishing the 15% or 20% of adult Zimbabweans who still had jobs. The 2007 price controls on manufacturing crippled this sector, forcing manufacturers to sell goods at roughly half of what it cost to produce them. By mid-2008, the output by Zimbabwe's manufacturing sector had fallen 27% compared to the previous year. As a consequence, Zimbabweans died from starvation. Although we have no exact figures, according to the World Food Program, over five million Zimbabweans faced starvation in 2008.

Aid shipped into the country from international relief agencies and the two million Zimbabweans who have fled abroad have helped keep some people alive. In 2008, the World Food Program made an urgent appeal for $140 million in donations to feed Zimbabweans, stating that drought and political upheaval would soon exhaust the organization's stockpiles. Thankfully, the price controls were lifted in 2009.

Price Floors Governments also commonly use price floors. One of the most important examples of a price floor is the minimum wage in labor markets. The minimum wage law forbids employers from paying less than the minimum wage, $\underline{w}$. 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¢. The U.S. federal minimum wage rose to $7.25 on July 24, 2009. The statutory monthly minimum wage ranges from the equivalent of 19€ in the Russian Federation to 475€ in Portugal, 1,344€ in France, and 1,683€ in Luxembourg. If the minimum wage binds—exceeds the equilibrium wage, w^*—the minimum wage creates *unemployment*, which is a persistent excess supply of labor.[15] The original 1938 U.S. minimum wage law caused massive unemployment in Puerto Rico (see MyEconLab, Chapter 2, "Minimum Wage Law in Puerto Rico").

[15]Where the minimum wage applies to only a few labor markets (Chapter 10) or where only a single firm hires all the workers in a market (Chapter 15), a minimum wage may not cause unemployment (see Card and Krueger, 1995, for empirical evidence). The U.S. Department of Labor maintains at its Web site (**www.dol.gov**) an extensive history of the minimum wage law, labor markets, state minimum wage laws, and other information. For European countries, see **www.fedee.com/minwage.html**.

SOLVED PROBLEM 2.5

Suppose that there is a single labor market in which everyone is paid the same wage. If a binding minimum wage, $\underline{w}$, is imposed, what happens to the equilibrium in this market?

Answer

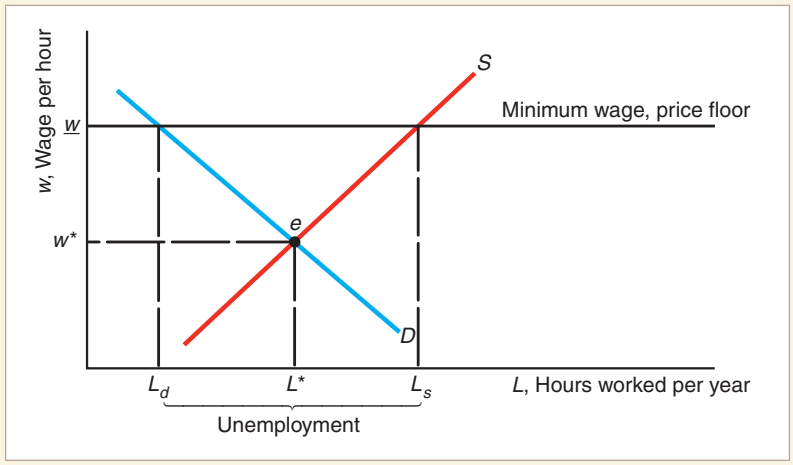
1. *Show the initial equilibrium before the minimum wage is imposed.* Figure 2.10 shows the supply and demand curves for labor services (hours worked). Firms buy hours of labor service—they hire workers. The quantity measure on the horizontal axis is hours worked per year, and the price measure on the 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 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 $\underline{w}$. At that wage, the quantity demanded falls to L_d and the quantity supplied rises to L_s. As a result, there is an excess supply or unemployment of $L_s - L_d$. The minimum wage prevents market forces from eliminating this excess supply, so it leads to an equilibrium with unemployment.

Comment: It is ironic that a law designed to help workers by raising their wages may harm some of them by causing them to become unemployed. A minimum wage law benefits only those who remain employed.[16]

See Problem 41.

Figure 2.10 Minimum Wage

In the absence of a minimum wage, the equilibrium wage is w^* and the equilibrium number of hours worked is L^*. A minimum wage, $\underline{w}$, set above w^*, leads to unemployment—persistent excess supply—because the quantity demanded, L_d, is less than the quantity supplied, L_s.



Why Supply Need Not Equal Demand

The price ceiling and price floor examples show that the quantity supplied does not necessarily equal the quantity demanded in a supply-and-demand model. The quantity supplied need not equal the quantity demanded because of the way we defined these two concepts. We defined 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

[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—everybody works fewer hours than he or she wants—all workers could benefit from the minimum wage.

inputs, constant. The quantity demanded is the quantity that consumers *want to buy* at a given price, if other factors that affect demand are held constant. The quantity that firms want to sell and the quantity that consumers want to buy at a given price need not equal the *actual* quantity that is bought and sold.

When the government imposes a binding price ceiling of $\overline{p}$ 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 that is actually observed.

We could have defined the quantity supplied and the quantity demanded so that they must be equal. If we were to define the quantity supplied as the amount firms *actually* sell at a given price and the quantity demanded as the amount consumers *actually* buy, supply must equal demand in all markets because the quantity demanded and the quantity supplied are *defined* to be the same quantity.

It is worth pointing out this distinction because many people, including politicians and newspaper reporters, are confused on this point. Someone insisting that "demand *must* equal supply" must be defining supply and demand as the *actual* quantities sold.

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" is a theory, not merely a definition. This theory says that the equilibrium price and quantity in a market are determined by the intersection of the supply curve and the demand curve if the government does not intervene. Further, we use the model to predict excess demand or excess supply when a government does control price. The observed gasoline shortages during the period when the U.S. government controlled gasoline prices are consistent with this prediction.

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 Chapter 8. Briefly, this model is applicable in 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.

Markets with these properties are called *perfectly competitive markets*.

Where there are 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 there is 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 in 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 are 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 a newspaper advertisement 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 in exactly the color you want, so your transaction costs includes 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 in which there are only one or a few sellers (such as electricity), firms produce differentiated products (music CDs), consumers know less than sellers about quality or price (used cars), or there are 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

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, then 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 but substantially in others where many consumers fear GM products.

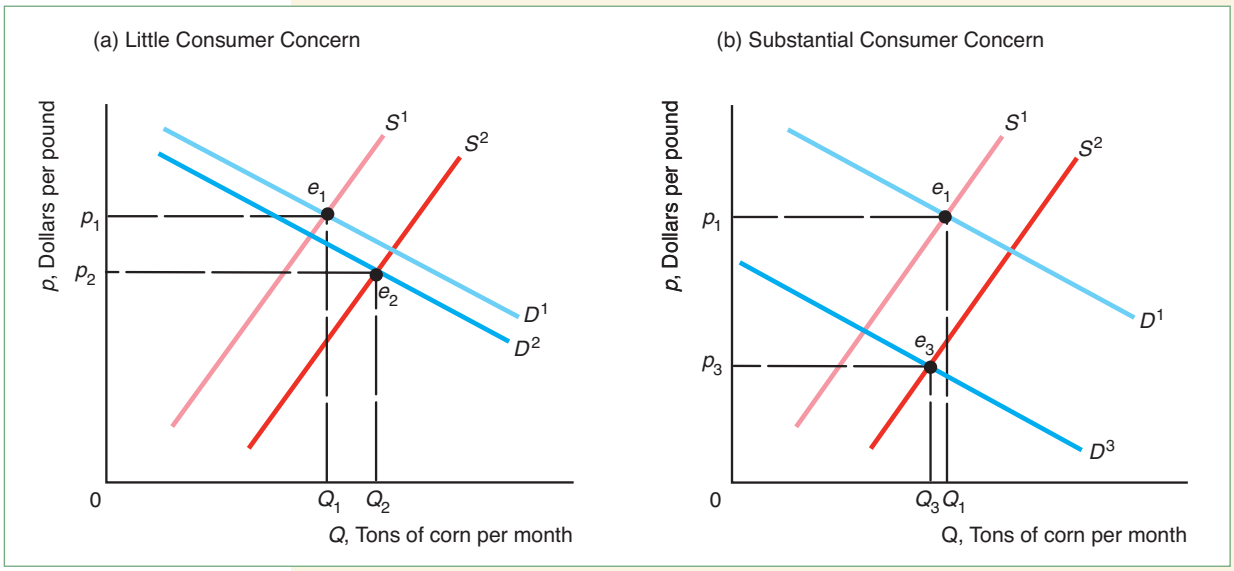
In the figure, the original, before-GM equilibrium, e_1, is determined by the intersection of the before-GM supply curve, S^1, and the before-GM demand curve, D^1, at price p_1 and quantity Q_1. Both panels a and b of the figure show this same equilibrium.

When GM seeds are introduced, the new supply curve, S^2, lies to the right of S^1. In panel a, the new demand curve, D^2, lies only slightly to the left of D^1, while in panel b, 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 from Q_1 to Q_3 in panel b.

Thus, when both curves shift, we cannot predict the direction of change of both the equilibrium price and quantity without knowing how much each curve shifts. Whether growers in a country decide to adopt GM seeds turns crucially on consumer resistance to these new products.

See Questions 21–26.



SUMMARY

1. **Demand.** The quantity of a good or service demanded by consumers depends on their tastes, the price of a good, the price of goods that are substitutes and complements, their income, information, government regulations, and other factors. The *Law of Demand*—which is based on observation—says that *demand curves slope downward*. The higher the price, the less of the good is demanded, holding constant other factors that affect 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 demanded.

2. **Supply.** The quantity of a good or service supplied by firms depends on the price, costs, government regulations, 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 the price of an input or government regulation 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 the price of beef rises, the demand curve for pork shifts outward, 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. **Equilibrium Effects of Government Interventions.** Some government policies—such as a ban on imports—cause a shift in the supply or demand curves, thereby altering 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 in 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

If you ask me anything I don't know, I'm not going to answer. —Yogi Berra

■ = *a version of the exercise is available in MyEconLab;* * = *answer appears at the back of this book;* **C** = *use of calculus may be necessary;* **V** = *video answer by James Dearden is available in MyEconLab.*

1. How would the shape of the total supply curve in Solved Problem 2.2 change if the U.S. domestic supply curve hit the vertical axis at a price above $\overline{p}$?

*2. 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. 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.
4. 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. Is there an equilibrium at a positive price and quantity? Explain your answer.
5. Increased outsourcing to India by firms in the United States and other developed countries has driven up the wage of some Indian skilled workers by 10% to 15% (Adam Geller, "Offshore Savings Can Be Iffy," *San Francisco Chronicle,* June 21, 2005: D1, D4). Use a supply-and-demand diagram to explain why, and discuss the effect on the number of people employed.
6. In December 2000, Japan reported that test shipments of U.S. corn had detected StarLink, a genetically modified corn that is not approved for human consumption in the United States. As a result, Japan and some other nations banned U.S. imports. Use a graph to illustrate why this ban, which caused U.S.

corn exports to fall 4%, resulted in the price of corn falling 11.1% in the United States in 2001–2002.

7. The U.S. supply of frozen orange juice comes from Florida and Brazil. What is the effect of a freeze that damages oranges in Florida on the price of frozen orange juice in the United States and on the quantities of orange juice sold by Floridian and Brazilian firms?

8. The Federation of Vegetable Farmers Association of Malaysia reported that a lack of workers caused a 25% drop in production that drove up vegetable prices by 50% to 100% in 2005 ("Vegetable Price Control Sought," **thestar.com.my**, June 6, 2005). Consumers called for price controls on vegetables. Show why the price increased, and predict the effects of a binding price control. **V**

9. Increasingly, instead of advertising in newspapers, individuals and firms use Web sites that offer free or inexpensive classified ads, such as Classifiedads.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?

10. Ethanol, a fuel, is made from corn. Ethanol production increased 5.5 times from 2000 to 2008 (**www.ethanolrfa.org**, May 2010). What effect did this increased use of corn for producing ethanol have on the price of corn and the consumption of corn as food?

11. 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 quality of people in that occupation, thereby also affecting demand?

*12. 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.)

13. In 2002, the U.S. Fish and Wildlife Service proposed banning imports of beluga caviar to protect the beluga sturgeon in the Caspian and Black seas, whose sturgeon population had fallen 90% in the last two decades. The United States imports 60% of the world's beluga caviar. On the world's legal wholesale market, a kilogram of caviar costs an average of $500, and about $100 million worth is sold per year. What effect would the U.S. ban have on world prices and quantities? Would such a ban help protect the beluga sturgeon? (In 2005, the service decided not to ban imports.)

14. On January 1, 2005, a three-decades-old system of global quotas that had limited how much China and other countries could ship to the United States and other wealthy nations ended. Over the next four months, U.S. imports of Chinese-made cotton trousers rose by more than 1,505% and their price fell 21% in the first quarter of the year (Tracie Rozhon, "A Tangle in Textiles," *New York Times,* April 21, 2005, C1). The U.S. textile industry demanded quick action, saying that 18 plants had already been forced to close that year and 16,600 textile and apparel jobs had been lost. The Bush administration reacted to the industry pressure. The United States (and Europe, which faced similar large increases in imports) pressed China to cut back its textile exports, threatening to restore quotas on Chinese exports or to take other actions. Illustrate what happened, and show how the U.S. quota reimposed in May 2005 affected the equilibrium price and quantity in the United States.

15. What is the effect of a quota $\overline{Q} > 0$ on equilibrium price and quantity? (*Hint*: Carefully show how the total supply curve changes.)

16. In 1996, a group of American doctors called for a limit on the number of foreign-trained physicians permitted to practice in the United States. What effect would such a limit have on the equilibrium quantity and price of doctors' services in the United States? How are American-trained doctors and consumers affected?

17. 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 (Villegas, 1989). Why? (*Hint*: The interest rate is the price of a loan, and the amount of the loan is the quantity measure.)

18. Argentines love a sizzling steak, consuming twice as much per capita as U.S. citizens. Thus, when the price of beef started to shoot up, Argentina's President Néstor Kirchner took dramatic action to force down beef prices. (Larry Rohter, "For Argentina's Sizzling Economy, a Cap on Steak Prices," *New York Times*, April 3, 2006.) He ordered government ministries to cease their purchases, prohibited the export of most cuts of beef, and urged consumers to boycott beef. But beef-loving Argentines, benefiting from higher wages due to a growing economy, largely ignored his call. When these actions failed to lower prices substantially, he turned to "voluntary" price controls

("encouraging" grocery chains and others not to raise prices for extended periods of time). Use graphs to illustrate this sequence of events.

19. In 1999, after nearly 20 years of rent control in Berkeley, California, the elimination of the law led to an estimated rise in rents of nearly 40%. Using supply-and-demand models, illustrate how the law and then its elimination affected the rental housing market. Discuss the effects on the equilibrium rental price and the quantity of housing rented.

*20. After a major earthquake struck Los Angeles in January 1994, several stores raised the price of milk to over $6 a gallon. The local authorities announced that they would investigate and that they would enforce a law prohibiting price increases of more than 10% during an emergency period. What is the likely effect of such a law?

*21. Humans who consume beef products made from diseased animal parts can develop mad cow disease (bovine spongiform encephalopathy, or BSE, a new variant of Creutzfeldt-Jakob disease), a deadly affliction that slowly eats holes in sufferers' brains. (See MyEconLab, Chapter 2, "Mad Cow: Shifting Supply and Demand Curves," for background and a history in Europe, Canada, Japan, and the United States.) The first U.S. case, in a cow imported from Canada, was reported in December 2003. As soon as the United States revealed the discovery of the single mad cow, more than 40 countries slapped an embargo on U.S. beef, causing beef supply curves to shift to the left in those importing countries. At least initially, a few U.S. consumers stopped eating beef, causing demand curves in these countries to move slightly to the left. (Schlenker and Villas-Boas, 2009, found that U.S. consumers regained confidence and resumed their earlier levels of beef buying within three months.) In the first few weeks after the U.S. ban, the quantity of beef sold in Japan fell substantially, and the price rose. In contrast, in January 2004, three weeks after the first discovery, the U.S. price fell by about 15% and the quantity sold increased by 43% over the last week in October 2003. Use supply-and-demand diagrams to explain why these events occurred.

22. In the previous question, you were asked to illustrate why the mad cow disease announcement initially caused the U.S. equilibrium price of beef to fall and the quantity to rise. Show that if the supply and demand curves had shifted in the same directions as above but to greater or lesser degrees, the equilibrium quantity might have fallen. Could the equilibrium price have risen?

23. Due to fear about mad cow disease, Japan stopped importing animal feed from Britain in 1996, beef imports and processed beef products from 18 countries including EU members starting in 2001, and similar imports from Canada and the United States in 2003. After U.S. beef imports were banned, McDonald's Japan and other Japanese importers replaced much of the banned U.S. beef with Australian beef, causing an export boom for Australia ("China Bans U.S. Beef," **cnn.com**, December 24, 2003; "Beef Producers Are on the Lookout for Extra Demand," **abc.net.au**, June 13, 2005). Use supply and demand curves to show the impact of these events on the domestic Australian beef market.

24. 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. Akram Abdulzahra has a revolver handy at his job in an Internet cafe. Haidar Hussein, a Baghdad bookseller, has a new fully automatic assault rifle. 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. 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 have to rise, or did the rise have to do with the shapes of and relative shifts in the demand and supply curves?

25. The prices received by soybean farmers in Brazil, the world's second-largest soybean producer and exporter, tumbled 30%, in part because of China's decision to cut back on imports and in part because of a bumper soybean crop in the United States, the world's leading exporter (Todd Benson, "A Harvest at Peril," *New York Times,* January 6, 2005, C6). In addition, Asian soy rust, a deadly crop fungus, is destroying large quantities of the Brazilian crops.

    a. Use a supply-and-demand diagram to illustrate why Brazilian farmers are receiving lower prices.

    b. If you knew only the *direction* of the shifts in both the supply and the demand curves, could you predict that prices would fall? Why or why not? V

26. Due to a slight recession that lowered incomes, the 2002 market prices for last-minute rentals of U.S. beachfront properties were lower than usual (June

Fletcher, "Last-Minute Beach Rentals Offer Summer's Best Deals," *Wall Street Journal,* June 21, 2002, D1).

a. How does a recession affect the demand curve and the supply curve for rental properties? In answering the supply curve question, consider the two options of owners of beach homes: staying in the homes or renting them to others.

b. Use a supply-and-demand analysis to show the effect of decreased income on the price of rental homes. V

PROBLEMS

myeconlab *Versions of these problems are available in MyEconLab.*

*27. Using the estimated demand function for processed pork in Canada (Equation 2.2), show how the quantity demanded at a given price changes as per capita income, Y, increases by \$100 a year.

28. In Equation 2.2, suppose that the price of beef, p_b, in Canada increased by 30%, from \$4 to \$5.20. In what direction and by how much does the demand curve for processed pork shift?

29. Given the inverse demand function in Equation 2.4, how much would the price have to rise for consumers to want to buy 2 million fewer kg of pork per year?

*30. 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.

31. The demand function for movies is $Q_1 = 120 - p$ for college students and $Q_2 = 120 - 2p$ for other town residents. What is the total demand function? Use a diagram to illustrate your answer. (*Hint*: By looking at your diagram, you'll see that some care must be used in writing the demand function.)

32. In the application "Aggregating the Demand for Broadband Service" (based on Duffy-Deno, 2003), the demand function is $Q_s = 15.6p^{-0.563}$ 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?

33. Given the pork supply function in Equation 2.6, how does the supply function Equation 2.7 change if the price of hogs doubles to \$3 per kg?

34. If the supply of corn by the United States is $Q_a = a + bp$, and the supply by the rest of the world is $Q_r = c + ep$, what is the world supply?

35. Using the equations for processed pork demand (Equation 2.2) and supply (Equation 2.6), solve for the equilibrium price and quantity in terms of the price of hogs, p_h; the price of beef, p_b; the price of chicken, p_c; and income, Y. If $p_h = 1.5$ (dollars per kg), $p_b = 4$ (dollars per kg), $p_c = 3\frac{1}{3}$ (dollars per kg), and $Y = 12.5$ (thousands dollars), what are the equilibrium price and quantity?

*36. 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.

*37. Green et al. (2005) estimate the supply and demand curves for California processed tomatoes. The supply function is $\ln(Q) = 0.2 + 0.55 \ln(p)$, where Q is the quantity of processing tomatoes in millions of tons per year and p is the price in dollars per ton. The demand function is $\ln(Q) = 2.6 - 0.2 \ln(p) + 0.15 \ln(p_t)$, where p_t is the price of tomato paste (which is what processing tomatoes are used to produce) in dollars per ton. In 2002, $p_t = 110$. What is the demand function for processing tomatoes, where the quantity is solely a function of the price of processing tomatoes? Solve for the equilibrium price and quantity of processing tomatoes (explain your calculations, and round to two digits after the decimal point). Draw the supply and demand curves (note that they are not straight lines), and label the equilibrium and axes appropriately.

38. Using the information in the previous problem, determine how the equilibrium price and quantity of processing tomatoes change if the price of tomato paste falls by 10%.

39. Use Equations 2.2 and 2.7 and other information in the chapter to show how the equilibrium quantity of pork varies with income.

40. The demand function for roses is $Q = a - bp$, and the supply function is $Q = c + ep + ft$, where a, b, c, e, and f are positive constants and t is the average temperature in a month. Show how the equilibrium quantity and price vary with temperature.

41. Suppose that the government imposes a price support (price floor) on processing tomatoes at \$65 per ton. The government will buy as much as farmers want to sell at that price. Thus processing firms pay \$65. Use the information in Problem 37 to determine how many tons firms buy and how many tons the government buys. Illustrate your answer in a supply-and-demand diagram.