CHAPTER

5

Elasticity and Its Application

Imagine that some event drives up the price of gasoline in the United States. It could be a war in the Middle East that disrupts the world supply of oil, a booming Chinese economy that boosts the world demand for oil, or a new tax on gasoline passed by Congress. How would U.S. consumers respond to the higher price?

It is easy to answer this question in broad fashion: Consumers would buy less. That is simply the law of demand we learned in the previous chapter. But you might want a precise answer. By how much would consumption of gasoline fall? This question can be answered using a concept called *elasticity*, which we develop in this chapter.

Elasticity is a measure of how much buyers and sellers respond to changes in market conditions. When studying how some event or policy affects a market, we can discuss not only the direction of the effects but their magnitude as well. Elasticity is useful in many applications, as we will see toward the end of this chapter.

Before proceeding, however, you might be curious about the answer to the gasoline question. Many studies have examined consumers' response to gasoline prices, and they typically find that the quantity demanded responds more in the

long run than it does in the short run. A 10 percent increase in gasoline prices reduces gasoline consumption by about 2.5 percent after a year and about 6 percent after five years. About half of the long-run reduction in quantity demanded arises because people drive less and half because they switch to more fuel-efficient cars. Both responses are reflected in the demand curve and its elasticity.

THE ELASTICITY OF DEMAND

When we introduced demand in Chapter 4, we noted that consumers usually buy more of a good when its price is lower, when their incomes are higher, when the prices of substitutes for the good are higher, or when the prices of complements of the good are lower. Our discussion of demand was qualitative, not quantitative. That is, we discussed the direction in which quantity demanded moves but not the size of the change. To measure how much consumers respond to changes in these variables, economists use the concept of **elasticity**.

elasticity
a measure of the responsiveness of quantity demanded or quantity supplied to one of its determinants

price elasticity of demand
a measure of how much the quantity demanded of a good responds to a change in the price of that good, computed as the percentage change in quantity demanded divided by the percentage change in price

The Price Elasticity of Demand and Its Determinants

The law of demand states that a fall in the price of a good raises the quantity demanded. The **price elasticity of demand** measures how much the quantity demanded responds to a change in price. Demand for a good is said to be *elastic* if the quantity demanded responds substantially to changes in the price. Demand is said to be *inelastic* if the quantity demanded responds only slightly to changes in the price.

The price elasticity of demand for any good measures how willing consumers are to buy less of the good as its price rises. Thus, the elasticity reflects the many economic, social, and psychological forces that shape consumer preferences. Based on experience, however, we can state some general rules about what determines the price elasticity of demand.

Availability of Close Substitutes Goods with close substitutes tend to have more elastic demand because it is easier for consumers to switch from that good to others. For example, butter and margarine are easily substitutable. A small increase in the price of butter, assuming the price of margarine is held fixed, causes the quantity of butter sold to fall by a large amount. By contrast, because eggs are a food without a close substitute, the demand for eggs is less elastic than the demand for butter.

Necessities versus Luxuries Necessities tend to have inelastic demands, whereas luxuries have elastic demands. When the price of a doctor's visit rises, people will not dramatically reduce the number of times they go to the doctor, although they might go somewhat less often. By contrast, when the price of sailboats rises, the quantity of sailboats demanded falls substantially. The reason is that most people view doctor visits as a necessity and sailboats as a luxury. Of course, whether a good is a necessity or a luxury depends not on the intrinsic properties of the good but on the preferences of the buyer. For avid sailors with little concern over their health, sailboats might be a necessity with inelastic demand and doctor visits a luxury with elastic demand.

Definition of the Market The elasticity of demand in any market depends on how we draw the boundaries of the market. Narrowly defined markets tend to have more elastic demand than broadly defined markets because it is easier to find close substitutes for narrowly defined goods. For example, food, a broad category, has a fairly inelastic demand because there are no good substitutes for food. Ice cream, a narrower category, has a more elastic demand because it is easy to substitute other desserts for ice cream. Vanilla ice cream, a very narrow category, has a very elastic demand because other flavors of ice cream are almost perfect substitutes for vanilla.

Time Horizon Goods tend to have more elastic demand over longer time horizons. When the price of gasoline rises, the quantity of gasoline demanded falls only slightly in the first few months. Over time, however, people buy more fuel-efficient cars, switch to public transportation, and move closer to where they work. Within several years, the quantity of gasoline demanded falls more substantially.

Computing the Price Elasticity of Demand

Now that we have discussed the price elasticity of demand in general terms, let's be more precise about how it is measured. Economists compute the price elasticity of demand as the percentage change in the quantity demanded divided by the percentage change in the price. That is,

$$\text{Price elasticity of demand} = \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in price}}.$$

For example, suppose that a 10 percent increase in the price of an ice-cream cone causes the amount of ice cream you buy to fall by 20 percent. We calculate your elasticity of demand as

$$\text{Price elasticity of demand} = \frac{20 \text{ percent}}{10 \text{ percent}} = 2.$$

In this example, the elasticity is 2, reflecting that the change in the quantity demanded is proportionately twice as large as the change in the price.

Because the quantity demanded of a good is negatively related to its price, the percentage change in quantity will always have the opposite sign as the percentage change in price. In this example, the percentage change in price is a *positive* 10 percent (reflecting an increase), and the percentage change in quantity demanded is a *negative* 20 percent (reflecting a decrease). For this reason, price elasticities of demand are sometimes reported as negative numbers. In this book, we follow the common practice of dropping the minus sign and reporting all price elasticities of demand as positive numbers. (Mathematicians call this the *absolute value*.) With this convention, a larger price elasticity implies a greater responsiveness of quantity demanded to price.

The Midpoint Method: A Better Way to Calculate Percentage Changes and Elasticities

If you try calculating the price elasticity of demand between two points on a demand curve, you will quickly notice an annoying problem: The elasticity from

point A to point B seems different from the elasticity from point B to point A. For example, consider these numbers:

Point A:	Price = \$4	Quantity = 120
Point B:	Price = \$6	Quantity = 80

Going from point A to point B, the price rises by 50 percent, and the quantity falls by 33 percent, indicating that the price elasticity of demand is 33/50, or 0.66. By contrast, going from point B to point A, the price falls by 33 percent, and the quantity rises by 50 percent, indicating that the price elasticity of demand is 50/33, or 1.5. This difference arises because the percentage changes are calculated from a different base.

One way to avoid this problem is to use the *midpoint method* for calculating elasticities. The standard procedure for computing a percentage change is to divide the change by the initial level. By contrast, the midpoint method computes a percentage change by dividing the change by the midpoint (or average) of the initial and final levels. For instance, \$5 is the midpoint between \$4 and \$6. Therefore, according to the midpoint method, a change from \$4 to \$6 is considered a 40 percent rise because $(6 - 4) / 5 \times 100 = 40$. Similarly, a change from \$6 to \$4 is considered a 40 percent fall.

Because the midpoint method gives the same answer regardless of the direction of change, it is often used when calculating the price elasticity of demand between two points. In our example, the midpoint between point A and point B is:

Midpoint:	Price = \$5	Quantity = 100

According to the midpoint method, when going from point A to point B, the price rises by 40 percent, and the quantity falls by 40 percent. Similarly, when going from point B to point A, the price falls by 40 percent, and the quantity rises by 40 percent. In both directions, the price elasticity of demand equals 1.

The following formula expresses the midpoint method for calculating the price elasticity of demand between two points, denoted (Q_1, P_1) and (Q_2, P_2):

$$\text{Price elasticity of demand} = \frac{(Q_2 - Q_1) / [(Q_2 + Q_1) / 2]}{(P_2 - P_1) / [(P_2 + P_1) / 2]}.$$

The numerator is the percentage change in quantity computed using the midpoint method, and the denominator is the percentage change in price computed using the midpoint method. If you ever need to calculate elasticities, you should use this formula.

In this book, however, we rarely perform such calculations. For most of our purposes, what elasticity represents—the responsiveness of quantity demanded to a change in price—is more important than how it is calculated.

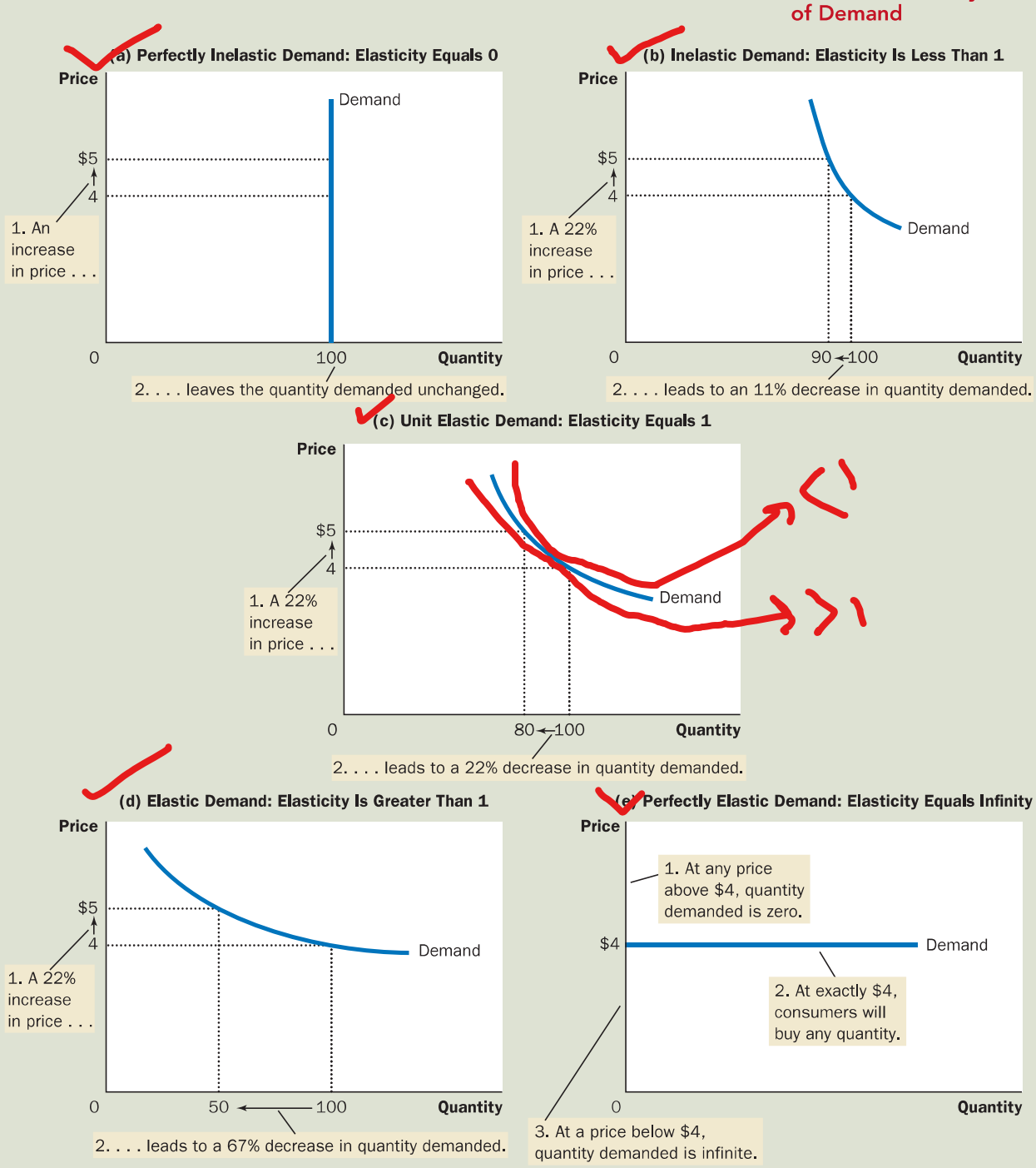
The Variety of Demand Curves

Economists classify demand curves according to their elasticity. Demand is considered *elastic* when the elasticity is greater than 1, which means the quantity moves proportionately more than the price. Demand is considered *inelastic* when the elasticity is less than 1, which means the quantity moves proportionately less

FIGURE 1

The Price Elasticity of Demand

The price elasticity of demand determines whether the demand curve is steep or flat. Note that all percentage changes are calculated using the midpoint method.



than the price. If the elasticity is exactly 1, the quantity moves the same amount proportionately as the price, and demand is said to have *unit elasticity*.

Because the price elasticity of demand measures how much quantity demanded responds to changes in the price, it is closely related to the slope of the demand curve. The following rule of thumb is a useful guide: The flatter the demand curve that passes through a given point, the greater the price elasticity of demand. The steeper the demand curve that passes through a given point, the smaller the price elasticity of demand.

Figure 1 on the previous page shows five cases. In the extreme case of a zero elasticity, shown in panel (a), demand is *perfectly inelastic*, and the demand curve is vertical. In this case, regardless of the price, the quantity demanded stays the same. As the elasticity rises, the demand curve gets flatter and flatter, as shown in panels (b), (c), and (d). At the opposite extreme, shown in panel (e), demand is *perfectly elastic*. This occurs as the price elasticity of demand approaches infinity and the demand curve becomes horizontal, reflecting the fact that very small changes in the price lead to huge changes in the quantity demanded.

Finally, if you have trouble keeping straight the terms *elastic* and *inelastic*, here's a memory trick for you: *I*nelastic curves, such as in panel (a) of Figure 1, look like the letter I. This is not a deep insight, but it might help on your next exam.

Total Revenue and the Price Elasticity of Demand

total revenue
the amount paid by buyers and received by sellers of a good, computed as the price of the good times the quantity sold

When studying changes in supply or demand in a market, one variable we often want to study is **total revenue**, the amount paid by buyers and received by sellers of the good. In any market, total revenue is $P \times Q$, the price of the good times the quantity of the good sold. We can show total revenue graphically, as in Figure 2. The height of the box under the demand curve is P, and the width is Q. The area of this box, $P \times Q$, equals the total revenue in this market. In Figure 2, where $P =$ \$4 and $Q = 100$, total revenue is \$4 × 100, or \$400.

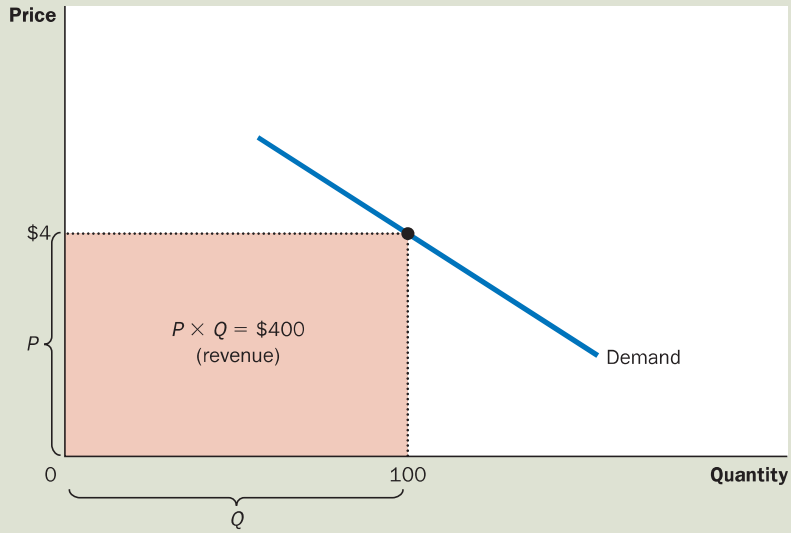
How does total revenue change as one moves along the demand curve? The answer depends on the price elasticity of demand. If demand is inelastic, as in panel (a) of Figure 3, then an increase in the price causes an increase in total revenue. Here an increase in price from \$1 to \$3 causes the quantity demanded to fall from 100 to 80, so total revenue rises from \$100 to \$240. An increase in price raises $P \times Q$ because the fall in Q is proportionately smaller than the rise in P.

We obtain the opposite result if demand is elastic: An increase in the price causes a decrease in total revenue. In panel (b) of Figure 3, for instance, when the price rises from \$4 to \$5, the quantity demanded falls from 50 to 20, so total revenue falls from \$200 to \$100. Because demand is elastic, the reduction in the quantity demanded is so great that it more than offsets the increase in the price. That is, an increase in price reduces $P \times Q$ because the fall in Q is proportionately greater than the rise in P.

Although the examples in this figure are extreme, they illustrate some general rules:

- When demand is inelastic (a price elasticity less than 1), price and total revenue move in the same direction.
- When demand is elastic (a price elasticity greater than 1), price and total revenue move in opposite directions.

FIGURE 2



Total Revenue
The total amount paid by buyers, and received as revenue by sellers, equals the area of the box under the demand curve, $P \times Q$. Here, at a price of $4, the quantity demanded is 100, and total revenue is $400.

If demand is unit elastic (a price elasticity exactly equal to 1), total revenue remains constant when the price changes.

Elasticity and Total Revenue along a Linear Demand Curve

Let's examine how elasticity varies along a linear demand curve, as shown in Figure 4. We know that a straight line has a constant slope. Slope is defined as "rise over run," which here is the ratio of the change in price ("rise") to the change in quantity ("run"). This particular demand curve's slope is constant because each $1 increase in price causes the same two-unit decrease in the quantity demanded.

Even though the slope of a linear demand curve is constant, the elasticity is not. This is true because the slope is the ratio of *changes* in the two variables, whereas the elasticity is the ratio of *percentage changes* in the two variables. You can see this by looking at the table in Figure 4, which shows the demand schedule for the linear demand curve in the graph. The table uses the midpoint method to calculate the price elasticity of demand. At points with a low price and high quantity, the demand curve is inelastic. At points with a high price and low quantity, the demand curve is elastic.

The table also presents total revenue at each point on the demand curve. These numbers illustrate the relationship between total revenue and elasticity. When the price is $1, for instance, demand is inelastic, and a price increase to $2 raises total revenue. When the price is $5, demand is elastic, and a price increase to $6 reduces total revenue. Between $3 and $4, demand is exactly unit elastic, and total revenue is the same at these two prices.

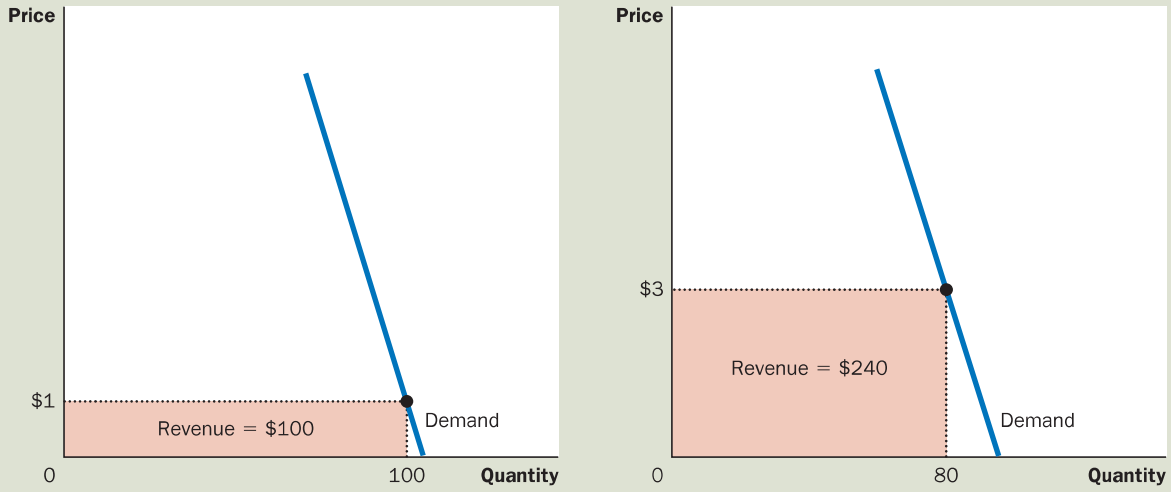
The linear demand curve illustrates that the price elasticity of demand need not be the same at all points on a demand curve. A constant elasticity is possible, but it is not always the case.

3 FIGURE

How Total Revenue Changes When Price Changes

The impact of a price change on total revenue (the product of price and quantity) depends on the elasticity of demand. In panel (a), the demand curve is inelastic. In this case, an increase in the price leads to a decrease in quantity demanded that is proportionately smaller, so total revenue increases. Here an increase in the price from $1 to $3 causes the quantity demanded to fall from 100 to 80. Total revenue rises from $100 to $240. In panel (b), the demand curve is elastic. In this case, an increase in the price leads to a decrease in quantity demanded that is proportionately larger, so total revenue decreases. Here an increase in the price from $4 to $5 causes the quantity demanded to fall from 50 to 20. Total revenue falls from $200 to $100.

(a) The Case of Inelastic Demand



(b) The Case of Elastic Demand

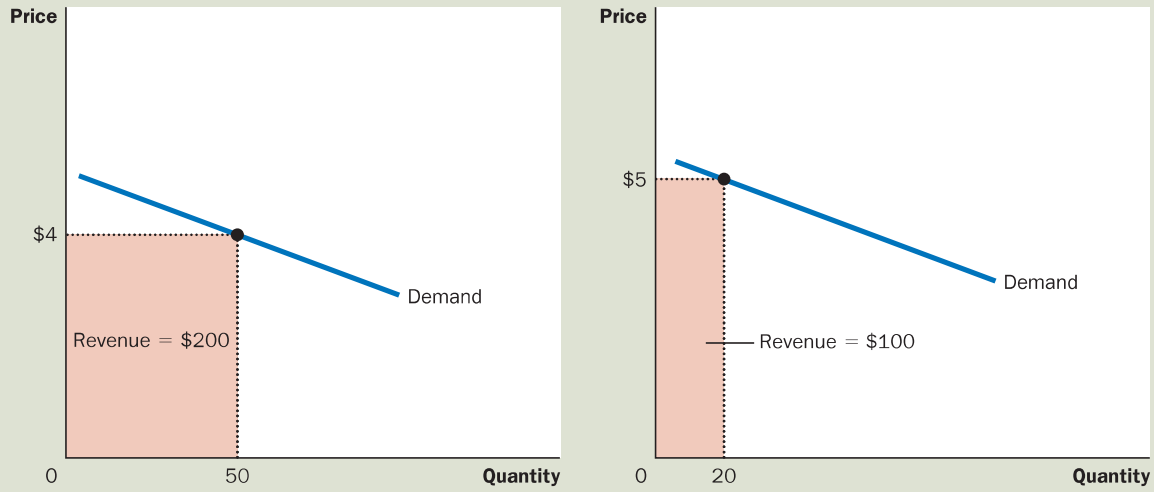
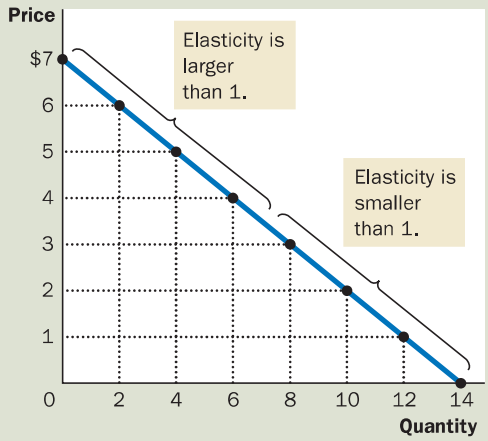


FIGURE 4



Elasticity of a Linear Demand Curve
The slope of a linear demand curve is constant, but its elasticity is not. The demand schedule in the table was used to calculate the price elasticity of demand by the midpoint method. At points with a low price and high quantity, the demand curve is inelastic. At points with a high price and low quantity, the demand curve is elastic.

Price	Quantity	Total Revenue (Price × Quantity)	Percentage Change in Price	Percentage Change in Quantity	Elasticity	Description
$7	0	$ 0				
			15	200	13.0	Elastic
6	2	12				
			18	67	3.7	Elastic
5	4	20				
			22	40	1.8	Elastic
4	6	24				
			29	29	1.0	Unit elastic
3	8	24				
			40	22	0.6	Inelastic
2	10	20				
			67	18	0.3	Inelastic
1	12	12				
			200	15	0.1	Inelastic
0	14	0				

Other Demand Elasticities

In addition to the price elasticity of demand, economists use other elasticities to describe the behavior of buyers in a market.

The Income Elasticity of Demand The **income elasticity of demand** measures how the quantity demanded changes as consumer income changes. It is calculated as the percentage change in quantity demanded divided by the percentage change in income. That is,

$$\text{Income elasticity of demand} = \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in income}}.$$

income elasticity of demand
a measure of how much the quantity demanded of a good responds to a change in consumers' income, computed as the percentage change in quantity demanded divided by the percentage change in income

As we discussed in Chapter 4, most goods are *normal goods:* Higher income raises the quantity demanded. Because quantity demanded and income move in the same direction, normal goods have positive income elasticities. A few goods, such as bus rides, are *inferior goods:* Higher income lowers the quantity demanded. Because quantity demanded and income move in opposite directions, inferior goods have negative income elasticities.

In The News

Energy Demand

What would induce consumers to use less gasoline and electricity?

Real Energy Savers Don't Wear Cardigans. Or Do They?

By Anna Bernasek

When oil and gas prices surged after Hurricanes Katrina and Rita, President Bush appealed to Americans to conserve energy. He asked people to cut back on nonessential travel, for example, and to carpool to work. Then, in October, the White House started a campaign for energy conservation in American homes, dusting off some old ideas like switching to fluorescent light bulbs and installing better insulation in attics.

Some critics derided the program as a bizarre flashback from the 1970's—a collection of worn-out ideas that evoked feelings of deprivation and gloom. It will be a pity, though, if an effective energy policy never gets off the ground. Much has been learned since the 70's about what works and what doesn't. . . .

There are reasons for optimism. One is that market forces can help provide solutions: higher prices, on their own, can make people cut back. Just how responsive consumers are to price changes—what economists call the elasticity of demand—has been the focus of much research. Today, economists believe that they have developed a pretty good rule of thumb for energy use. In the case of electricity, which is relatively easy to measure, they have found that

when the price rises 10 percent, electricity use falls roughly 3 percent. At the gas pump, a 10 percent increase in price leads to a decline of around 2 percent in demand. [*Author's note:* It would be more precise to say that the price increase leads to a 2 percent decline in quantity demanded, because the change represents a movement along the demand curve.]

Consumer behavior can change quickly in a crisis. A study by Peter C. Reiss, a professor of economics at Stanford, and Matthew W. White, a professor of business and public policy at the Wharton School of the University of Pennsylvania, provides some recent evidence. In examining San Diego households during the California electricity crisis of 2000 and 2001, they found that use of electricity dropped surprisingly fast. In the summer of 2000, within 60 days of seeing monthly electric bills rise by about $60—an increase of 130 percent—the average household cut its use of electricity by 12 percent.

That kind of drop requires a big change in behavior. The authors found that households had turned off air-conditioners in the middle of summer and had invested in new energy-efficient appliances, among other things.

High costs aren't the only force that will influence consumers to cut back. Although public appeals to save energy may be ridiculed by comedians on late-night television—recall President Jimmy Carter's cardigan sweater—the efforts can have a substantial impact.

Professors Reiss and White found that to be true in San Diego. In February 2001, with electricity prices capped, the state of California began a campaign to have households conserve electricity. It worked. "It was clear by about six months into 2001 that public appeals were having a big impact," Professor White said. Such campaigns can have significant effects on consumer behavior, he said, if they offer a clear explanation of what people can do and how it will make a difference.

Perhaps the most important reason for optimism is technology's role in promoting energy savings. From 1979 to 1985, in the aftermath of energy shortages, Americans reduced their oil consumption by 15 percent. The single biggest factor was a shift in car-buying habits. Americans found that driving fuel-efficient cars, instead of gas guzzlers, didn't stop them from going where they wanted to go.

Source: *New York Times,* November 13, 2005.

PHOTO: © DENNIS BRACK/LANDOV

Even among normal goods, income elasticities vary substantially in size. Necessities, such as food and clothing, tend to have small income elasticities because consumers choose to buy some of these goods even when their incomes are low. Luxuries, such as caviar and diamonds, tend to have large income elasticities because consumers feel that they can do without these goods altogether if their incomes are too low.

The Cross-Price Elasticity of Demand The **cross-price elasticity of demand** measures how the quantity demanded of one good responds to a change in the price of another good. It is calculated as the percentage change in quantity demanded of good 1 divided by the percentage change in the price of good 2. That is,

$$\text{Cross-price elasticity of demand} = \frac{\text{Percentage change in quantity demanded of good 1}}{\text{Percentage change in the price of good 2}}.$$

cross-price elasticity of demand
a measure of how much the quantity demanded of one good responds to a change in the price of another good, computed as the percentage change in quantity demanded of the first good divided by the percentage change in the price of the second good

Whether the cross-price elasticity is a positive or negative number depends on whether the two goods are substitutes or complements. As we discussed in Chapter 4, substitutes are goods that are typically used in place of one another, such as hamburgers and hot dogs. An increase in hot dog prices induces people to grill hamburgers instead. Because the price of hot dogs and the quantity of hamburgers demanded move in the same direction, the cross-price elasticity is positive. Conversely, complements are goods that are typically used together, such as computers and software. In this case, the cross-price elasticity is negative, indicating that an increase in the price of computers reduces the quantity of software demanded.

QUICK QUIZ Define the price elasticity of demand. • Explain the relationship between total revenue and the price elasticity of demand.

THE ELASTICITY OF SUPPLY

When we introduced supply in Chapter 4, we noted that producers of a good offer to sell more of it when the price of the good rises. To turn from qualitative to quantitative statements about quantity supplied, we once again use the concept of elasticity.

THE PRICE ELASTICITY OF SUPPLY AND ITS DETERMINANTS

The law of supply states that higher prices raise the quantity supplied. The **price elasticity of supply** measures how much the quantity supplied responds to changes in the price. Supply of a good is said to be *elastic* if the quantity supplied responds substantially to changes in the price. Supply is said to be *inelastic* if the quantity supplied responds only slightly to changes in the price.

price elasticity of supply
a measure of how much the quantity supplied of a good responds to a change in the price of that good, computed as the percentage change in quantity supplied divided by the percentage change in price

The price elasticity of supply depends on the flexibility of sellers to change the amount of the good they produce. For example, beachfront land has an inelastic supply because it is almost impossible to produce more of it. By contrast, manufactured goods, such as books, cars, and televisions, have elastic supplies because

firms that produce them can run their factories longer in response to a higher price.

In most markets, a key determinant of the price elasticity of supply is the time period being considered. Supply is usually more elastic in the long run than in the short run. Over short periods of time, firms cannot easily change the size of their factories to make more or less of a good. Thus, in the short run, the quantity supplied is not very responsive to the price. By contrast, over longer periods, firms can build new factories or close old ones. In addition, new firms can enter a market, and old firms can shut down. Thus, in the long run, the quantity supplied can respond substantially to price changes.

Computing the Price Elasticity of Supply

Now that we have a general understanding about the price elasticity of supply, let's be more precise. Economists compute the price elasticity of supply as the percentage change in the quantity supplied divided by the percentage change in the price. That is,

$$\text{Price elasticity of supply} = \frac{\text{Percentage change in quantity supplied}}{\text{Percentage change in price}}.$$

For example, suppose that an increase in the price of milk from \$2.85 to \$3.15 a gallon raises the amount that dairy farmers produce from 9,000 to 11,000 gallons per month. Using the midpoint method, we calculate the percentage change in price as

$$\text{Percentage change in price} = (3.15 - 2.85) \,/\, 3.00 \times 100 = 10 \text{ percent}.$$

Similarly, we calculate the percentage change in quantity supplied as

$$\text{Percentage change in quantity supplied} = (11{,}000 - 9{,}000) \,/\, 10{,}000 \times 100 = 20 \text{ percent}.$$

In this case, the price elasticity of supply is

$$\text{Price elasticity of supply} = \frac{20 \text{ percent}}{10 \text{ percent}} = 2.0.$$

In this example, the elasticity of 2 indicates that the quantity supplied changes proportionately twice as much as the price.

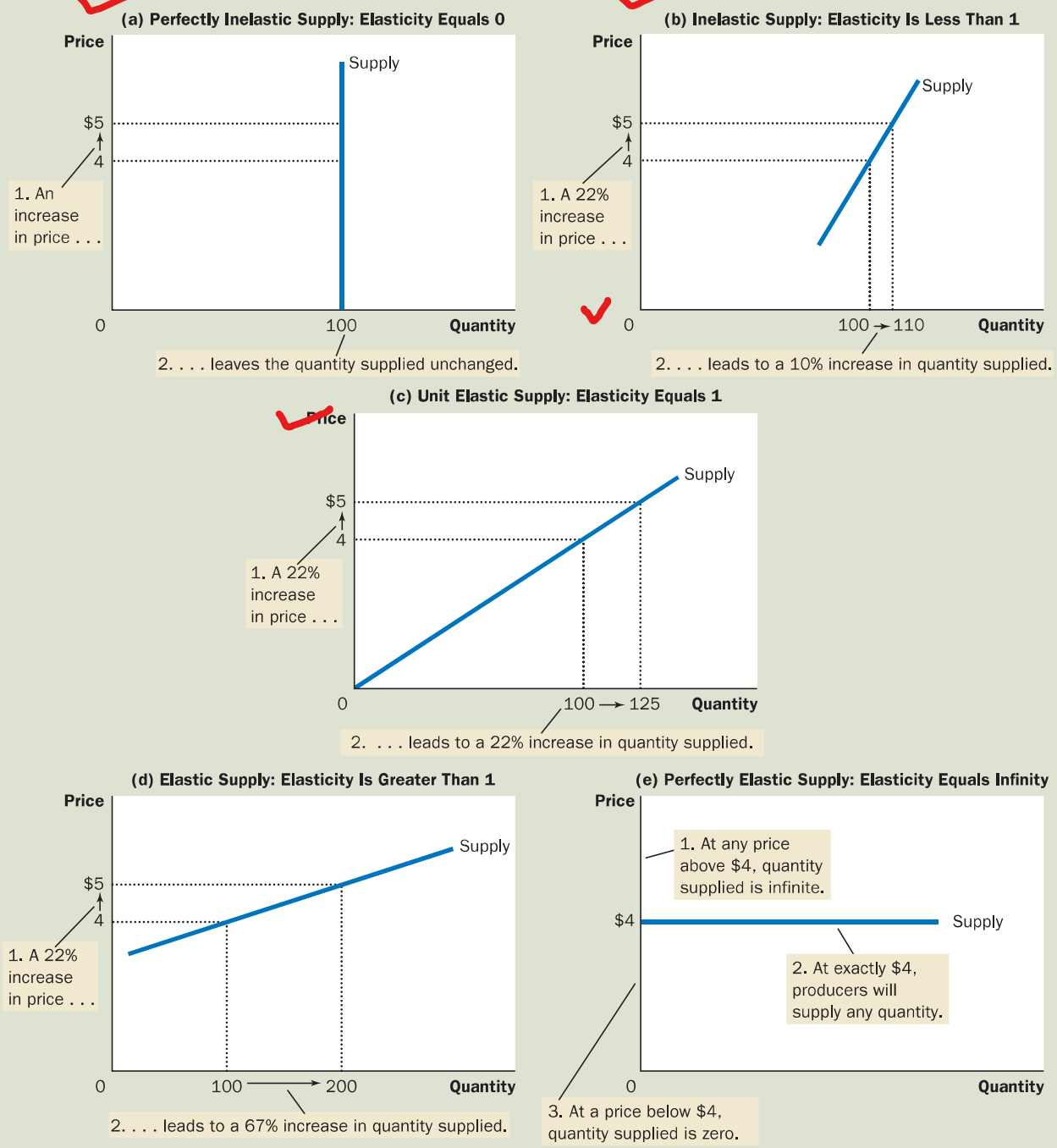
The Variety of Supply Curves

Because the price elasticity of supply measures the responsiveness of quantity supplied to the price, it is reflected in the appearance of the supply curve. Figure 5 shows five cases. In the extreme case of a zero elasticity, as shown in panel (a), supply is *perfectly inelastic*, and the supply curve is vertical. In this case, the quantity supplied is the same regardless of the price. As the elasticity rises, the supply curve gets flatter, which shows that the quantity supplied responds more to changes in the price. At the opposite extreme, shown in panel (e), supply is *perfectly elastic*. This occurs as the price elasticity of supply approaches infinity and the supply curve becomes horizontal, meaning that very small changes in the price lead to very large changes in the quantity supplied.

The price elasticity of supply determines whether the supply curve is steep or flat. Note that all percentage changes are calculated using the midpoint method.

FIGURE 5

The Price Elasticity of Supply



In some markets, the elasticity of supply is not constant but varies over the supply curve. Figure 6 shows a typical case for an industry in which firms have factories with a limited capacity for production. For low levels of quantity supplied, the elasticity of supply is high, indicating that firms respond substantially to changes in the price. In this region, firms have capacity for production that is not being used, such as plants and equipment idle for all or part of the day. Small increases in price make it profitable for firms to begin using this idle capacity. As the quantity supplied rises, firms begin to reach capacity. Once capacity is fully used, increasing production further requires the construction of new plants. To induce firms to incur this extra expense, the price must rise substantially, so supply becomes less elastic.

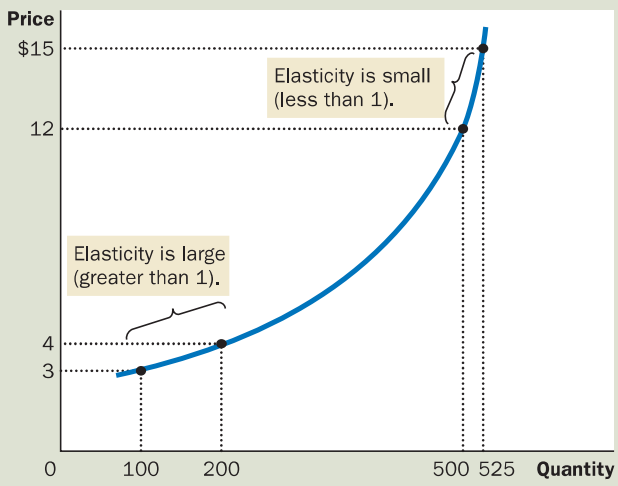
Figure 6 presents a numerical example of this phenomenon. When the price rises from $3 to $4 (a 29 percent increase, according to the midpoint method), the quantity supplied rises from 100 to 200 (a 67 percent increase). Because quantity supplied changes proportionately more than the price, the supply curve has elasticity greater than 1. By contrast, when the price rises from $12 to $15 (a 22 percent increase), the quantity supplied rises from 500 to 525 (a 5 percent increase). In this case, quantity supplied moves proportionately less than the price, so the elasticity is less than 1.

QUICK QUIZ Define the price elasticity of supply. • Explain why the price elasticity of supply might be different in the long run and in the short run.

THREE APPLICATIONS OF SUPPLY, DEMAND, AND ELASTICITY

Can good news for farming be bad news for farmers? Why did OPEC fail to keep the price of oil high? Does drug interdiction increase or decrease drug-related crime? At first, these questions might seem to have little in common. Yet all three

6 FIGURE



How the Price Elasticity of Supply Can Vary
Because firms often have a maximum capacity for production, the elasticity of supply may be very high at low levels of quantity supplied and very low at high levels of quantity supplied. Here an increase in price from $3 to $4 increases the quantity supplied from 100 to 200. Because the 67 percent increase in quantity supplied (computed using the midpoint method) is larger than the 29 percent increase in price, the supply curve is elastic in this range. By contrast, when the price rises from $12 to $15, the quantity supplied rises only from 500 to 525. Because the 5 percent increase in quantity supplied is smaller than the 22 percent increase in price, the supply curve is inelastic in this range.

questions are about markets, and all markets are subject to the forces of supply and demand. Here we apply the versatile tools of supply, demand, and elasticity to answer these seemingly complex questions.

Can Good News for Farming Be Bad News for Farmers?

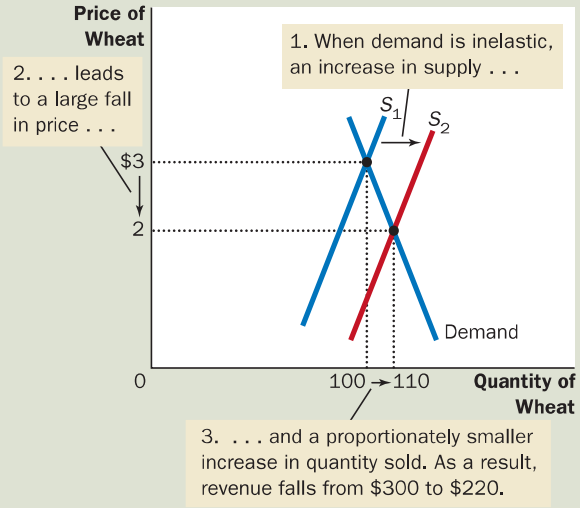
Imagine yourself as a Kansas wheat farmer. Because you earn all your income from selling wheat, you devote much effort to making your land as productive as possible. You monitor weather and soil conditions, check your fields for pests and disease, and study the latest advances in farm technology. You know that the more wheat you grow, the more you will have to sell after the harvest, and the higher will be your income and your standard of living.

One day, Kansas State University announces a major discovery. Researchers in its agronomy department have devised a new hybrid of wheat that raises the amount farmers can produce from each acre of land by 20 percent. How should you react to this news? Does this discovery make you better off or worse off than you were before?

Recall from Chapter 4 that we answer such questions in three steps. First, we examine whether the supply or demand curve shifts. Second, we consider in which direction the curve shifts. Third, we use the supply-and-demand diagram to see how the market equilibrium changes.

In this case, the discovery of the new hybrid affects the supply curve. Because the hybrid increases the amount of wheat that can be produced on each acre of land, farmers are now willing to supply more wheat at any given price. In other words, the supply curve shifts to the right. The demand curve remains the same because consumers' desire to buy wheat products at any given price is not affected by the introduction of a new hybrid. Figure 7 shows an example of such a change. When the supply curve shifts from S_1 to S_2, the quantity of wheat sold increases from 100 to 110, and the price of wheat falls from \$3 to \$2.

FIGURE 7



An Increase in Supply in the Market for Wheat
When an advance in farm technology increases the supply of wheat from S_1 to S_2, the price of wheat falls. Because the demand for wheat is inelastic, the increase in the quantity sold from 100 to 110 is proportionately smaller than the decrease in the price from \$3 to \$2. As a result, farmers' total revenue falls from \$300 (\$3 × 100) to \$220 (\$2 × 110).

Does this discovery make farmers better off? As a first cut to answering this question, consider what happens to the total revenue received by farmers. Farmers' total revenue is $P \times Q$, the price of the wheat times the quantity sold. The discovery affects farmers in two conflicting ways. The hybrid allows farmers to produce more wheat (Q rises), but now each bushel of wheat sells for less (P falls).

Whether total revenue rises or falls depends on the elasticity of demand. In practice, the demand for basic foodstuffs such as wheat is usually inelastic because these items are relatively inexpensive and have few good substitutes. When the demand curve is inelastic, as it is in Figure 7, a decrease in price causes total revenue to fall. You can see this in the figure: The price of wheat falls substantially, whereas the quantity of wheat sold rises only slightly. Total revenue falls from \$300 to \$220. Thus, the discovery of the new hybrid lowers the total revenue that farmers receive from the sale of their crops.

If farmers are made worse off by the discovery of this new hybrid, one might wonder why they adopt it. The answer goes to the heart of how competitive markets work. Because each farmer is only a small part of the market for wheat, he or she takes the price of wheat as given. For any given price of wheat, it is better to use the new hybrid to produce and sell more wheat. Yet when all farmers do this, the supply of wheat increases, the price falls, and farmers are worse off.

Although this example may at first seem hypothetical, it helps to explain a major change in the U.S. economy over the past century. Two hundred years ago, most Americans lived on farms. Knowledge about farm methods was sufficiently primitive that most Americans had to be farmers to produce enough food to feed the nation's population. Yet over time, advances in farm technology increased the amount of food that each farmer could produce. This increase in food supply, together with inelastic food demand, caused farm revenues to fall, which in turn encouraged people to leave farming.

A few numbers show the magnitude of this historic change. As recently as 1950, there were 10 million people working on farms in the United States, representing 17 percent of the labor force. Today, fewer than 3 million people work on farms, or 2 percent of the labor force. This change coincided with tremendous advances in farm productivity: Despite the 70 percent drop in the number of farmers, U.S. farms now produce more than twice the output of crops and livestock that they did in 1950.

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This analysis of the market for farm products also helps to explain a seeming paradox of public policy: Certain farm programs try to help farmers by inducing them *not* to plant crops on all of their land. The purpose of these programs is to reduce the supply of farm products and thereby raise prices. With inelastic demand for their products, farmers as a group receive greater total revenue if they supply a smaller crop to the market. No single farmer would choose to leave his land fallow on his own because each takes the market price as given. But if all farmers do so together, each of them can be better off.

When analyzing the effects of farm technology or farm policy, it is important to keep in mind that what is good for farmers is not necessarily good for society as a whole. Improvement in farm technology can be bad for farmers because it makes farmers increasingly unnecessary, but it is surely good for consumers who pay less for food. Similarly, a policy aimed at reducing the supply of farm products may raise the incomes of farmers, but it does so at the expense of consumers.

Why Did OPEC Fail to Keep the Price of Oil High?

Many of the most disruptive events for the world's economies over the past several decades have originated in the world market for oil. In the 1970s, members of the Organization of Petroleum Exporting Countries (OPEC) decided to raise the world price of oil to increase their incomes. These countries accomplished this goal by jointly reducing the amount of oil they supplied. From 1973 to 1974, the price of oil (adjusted for overall inflation) rose more than 50 percent. Then, a few years later, OPEC did the same thing again. From 1979 to 1981, the price of oil approximately doubled.

Yet OPEC found it difficult to maintain a high price. From 1982 to 1985, the price of oil steadily declined about 10 percent per year. Dissatisfaction and disarray soon prevailed among the OPEC countries. In 1986, cooperation among OPEC members completely broke down, and the price of oil plunged 45 percent. In 1990, the price of oil (adjusted for overall inflation) was back to where it began in 1970, and it stayed at that low level throughout most of the 1990s. (In the first decade of the 21st century, the price of oil rose again, but the main driving force was not OPEC supply restrictions but, rather, increased world demand, in part from a large and rapidly growing Chinese economy.)

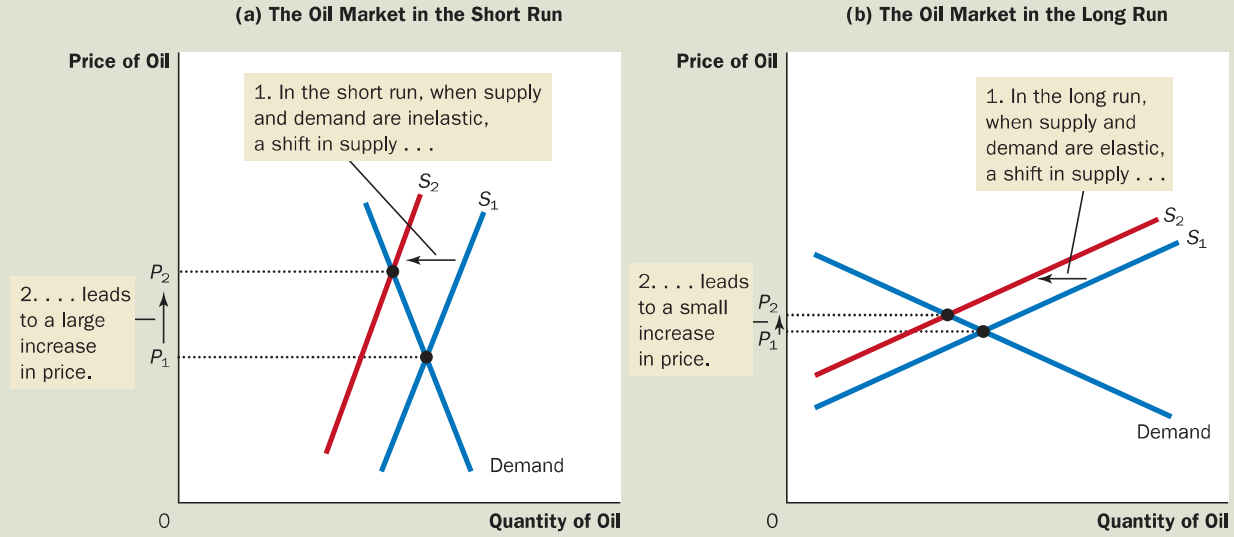
This OPEC episode of the 1970s and 1980s shows how supply and demand can behave differently in the short run and in the long run. In the short run, both the supply and demand for oil are relatively inelastic. Supply is inelastic because the quantity of known oil reserves and the capacity for oil extraction cannot be changed quickly. Demand is inelastic because buying habits do not respond immediately to changes in price. Thus, as panel (a) of Figure 8 shows, the short-run supply and demand curves are steep. When the supply of oil shifts from S_1 to S_2, the price increase from P_1 to P_2 is large.

The situation is very different in the long run. Over long periods of time, producers of oil outside OPEC respond to high prices by increasing oil exploration and by building new extraction capacity. Consumers respond with greater conservation, for instance by replacing old inefficient cars with newer efficient ones. Thus, as panel (b) of Figure 8 shows, the long-run supply and demand curves are more elastic. In the long run, the shift in the supply curve from S_1 to S_2 causes a much smaller increase in the price.

8 FIGURE

A Reduction in Supply in the World Market for Oil

When the supply of oil falls, the response depends on the time horizon. In the short run, supply and demand are relatively inelastic, as in panel (a). Thus, when the supply curve shifts from S_1 to S_2, the price rises substantially. By contrast, in the long run, supply and demand are relatively elastic, as in panel (b). In this case, the same size shift in the supply curve (S_1 to S_2) causes a smaller increase in the price.



This analysis shows why OPEC succeeded in maintaining a high price of oil only in the short run. When OPEC countries agreed to reduce their production of oil, they shifted the supply curve to the left. Even though each OPEC member sold less oil, the price rose by so much in the short run that OPEC incomes rose. By contrast, in the long run, when supply and demand are more elastic, the same reduction in supply, measured by the horizontal shift in the supply curve, caused a smaller increase in the price. Thus, OPEC's coordinated reduction in supply proved less profitable in the long run. The cartel learned that raising prices is easier in the short run than in the long run.

Does Drug Interdiction Increase or Decrease Drug-Related Crime?

A persistent problem facing our society is the use of illegal drugs, such as heroin, cocaine, ecstasy, and crack. Drug use has several adverse effects. One is that drug dependence can ruin the lives of drug users and their families. Another is that drug addicts often turn to robbery and other violent crimes to obtain the money needed to support their habit. To discourage the use of illegal drugs, the U.S. government devotes billions of dollars each year to reduce the flow of drugs into the country. Let's use the tools of supply and demand to examine this policy of drug interdiction.

Suppose the government increases the number of federal agents devoted to the war on drugs. What happens in the market for illegal drugs? As is usual, we answer this question in three steps. First, we consider whether the supply or demand curve shifts. Second, we consider the direction of the shift. Third, we see how the shift affects the equilibrium price and quantity.

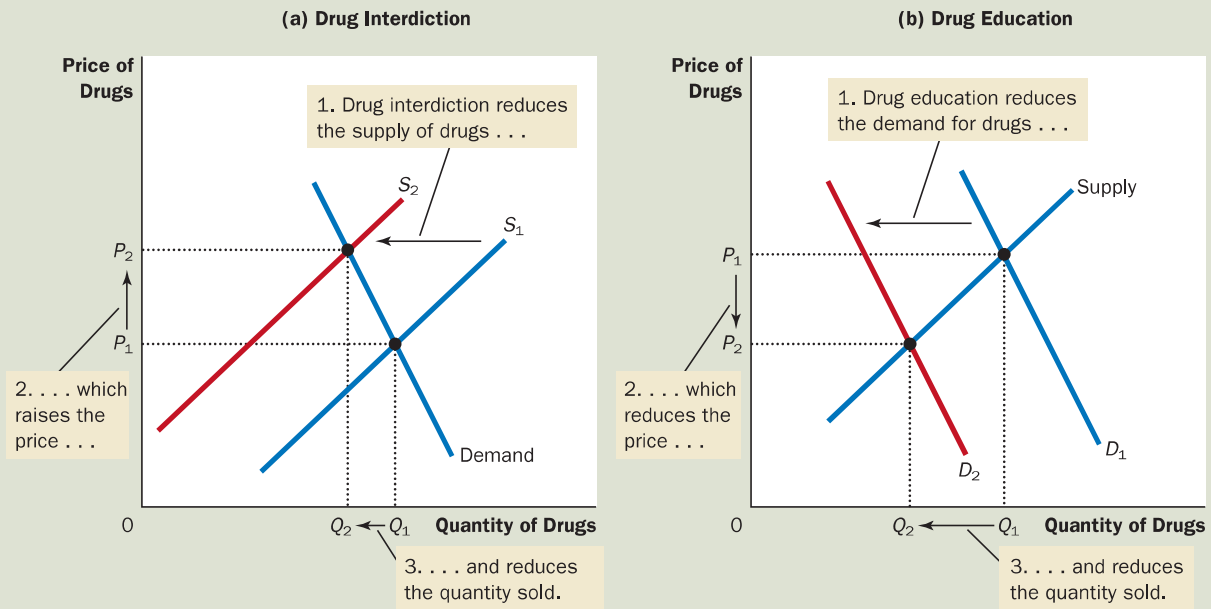
Although the purpose of drug interdiction is to reduce drug use, its direct impact is on the sellers of drugs rather than the buyers. When the government stops some drugs from entering the country and arrests more smugglers, it raises the cost of selling drugs and, therefore, reduces the quantity of drugs supplied at any given price. The demand for drugs—the amount buyers want at any given price—is not changed. As panel (a) of Figure 9 shows, interdiction shifts the supply curve to the left from S_1 to S_2 and leaves the demand curve the same. The equilibrium price of drugs rises from P_1 to P_2, and the equilibrium quantity falls from Q_1 to Q_2. The fall in the equilibrium quantity shows that drug interdiction does reduce drug use.

But what about the amount of drug-related crime? To answer this question, consider the total amount that drug users pay for the drugs they buy. Because few drug addicts are likely to break their destructive habits in response to a higher price, it is likely that the demand for drugs is inelastic, as it is drawn in the figure.

FIGURE 9

Policies to Reduce the Use of Illegal Drugs

Drug interdiction reduces the supply of drugs from S_1 to S_2, as in panel (a). If the demand for drugs is inelastic, then the total amount paid by drug users rises, even as the amount of drug use falls. By contrast, drug education reduces the demand for drugs from D_1 to D_2, as in panel (b). Because both price and quantity fall, the amount paid by drug users falls.



If demand is inelastic, then an increase in price raises total revenue in the drug market. That is, because drug interdiction raises the price of drugs proportionately more than it reduces drug use, it raises the total amount of money that drug users pay for drugs. Addicts who already had to steal to support their habits would have an even greater need for quick cash. Thus, drug interdiction could increase drug-related crime.

Because of this adverse effect of drug interdiction, some analysts argue for alternative approaches to the drug problem. Rather than trying to reduce the supply of drugs, policymakers might try to reduce the demand by pursuing a policy of drug education. Successful drug education has the effects shown in panel (b) of Figure 9. The demand curve shifts to the left from D_1 to D_2. As a result, the equilibrium quantity falls from Q_1 to Q_2, and the equilibrium price falls from P_1 to P_2. Total revenue, which is price times quantity, also falls. Thus, in contrast to drug interdiction, drug education can reduce both drug use and drug-related crime.

Advocates of drug interdiction might argue that the long-run effects of this policy are different from the short-run effects because the elasticity of demand depends on the time horizon. The demand for drugs is probably inelastic over short periods because higher prices do not substantially affect drug use by established addicts. But demand may be more elastic over longer periods because higher prices would discourage experimentation with drugs among the young and, over time, lead to fewer drug addicts. In this case, drug interdiction would increase drug-related crime in the short run while decreasing it in the long run.

QUICK QUIZ How might a drought that destroys half of all farm crops be good for farmers? If such a drought is good for farmers, why don't farmers destroy their own crops in the absence of a drought?

CONCLUSION

According to an old quip, even a parrot can become an economist simply by learning to say "supply and demand." These last two chapters should have convinced you that there is much truth in this statement. The tools of supply and demand allow you to analyze many of the most important events and policies that shape the economy. You are now well on your way to becoming an economist (or at least a well-educated parrot).

SUMMARY

- The price elasticity of demand measures how much the quantity demanded responds to changes in the price. Demand tends to be more elastic if close substitutes are available, if the good is a luxury rather than a necessity, if the market is narrowly defined, or if buyers have substantial time to react to a price change.
- The price elasticity of demand is calculated as the percentage change in quantity demanded divided by the percentage change in price. If quantity demanded moves proportionately less than the price, then the elasticity is less than 1, and demand is said to be inelastic. If quantity demanded moves proportionately more than the

price, then the elasticity is greater than 1, and demand is said to be elastic.

- Total revenue, the total amount paid for a good, equals the price of the good times the quantity sold. For inelastic demand curves, total revenue rises as price rises. For elastic demand curves, total revenue falls as price rises.
- The income elasticity of demand measures how much the quantity demanded responds to changes in consumers' income. The cross-price elasticity of demand measures how much the quantity demanded of one good responds to changes in the price of another good.
- The price elasticity of supply measures how much the quantity supplied responds to changes in the price. This elasticity often depends on the time horizon under consideration. In most markets, supply is more elastic in the long run than in the short run.
- The price elasticity of supply is calculated as the percentage change in quantity supplied divided by the percentage change in price. If quantity supplied moves proportionately less than the price, then the elasticity is less than 1, and supply is said to be inelastic. If quantity supplied moves proportionately more than the price, then the elasticity is greater than 1, and supply is said to be elastic.
- The tools of supply and demand can be applied in many different kinds of markets. This chapter uses them to analyze the market for wheat, the market for oil, and the market for illegal drugs.

KEY CONCEPTS

elasticity, *p. 90*
price elasticity of demand, *p. 90*
total revenue, *p. 93*
income elasticity of demand, *p. 97*
cross-price elasticity of demand, *p. 99*
price elasticity of supply, *p. 99*

QUESTIONS FOR REVIEW

1. Define the price elasticity of demand and the income elasticity of demand.
2. List and explain the four determinants of the price elasticity of demand discussed in the chapter.
3. What is the main advantage of using the midpoint method for calculating elasticity?
4. If the elasticity is greater than 1, is demand elastic or inelastic? If the elasticity equals 0, is demand perfectly elastic or perfectly inelastic?
5. On a supply-and-demand diagram, show equilibrium price, equilibrium quantity, and the total revenue received by producers.
6. If demand is elastic, how will an increase in price change total revenue? Explain.
7. What do we call a good whose income elasticity is less than 0?
8. How is the price elasticity of supply calculated? Explain what it measures.
9. What is the price elasticity of supply of Picasso paintings?
10. Is the price elasticity of supply usually larger in the short run or in the long run? Why?
11. How did elasticity help explain why drug interdiction could reduce the supply of drugs, yet possibly increase drug-related crime?

PROBLEMS AND APPLICATIONS

1. For each of the following pairs of goods, which good would you expect to have more elastic demand and why?
   a. required textbooks or mystery novels
   b. Beethoven recordings or classical music recordings in general
   c. subway rides during the next 6 months or subway rides during the next 5 years
   d. root beer or water
2. Suppose that business travelers and vacationers have the following demand for airline tickets from New York to Boston:

Price	Quantity Demanded (business travelers)	Quantity Demanded (vacationers)
$150	2,100 tickets	1,000 tickets
200	2,000	800
250	1,900	600
300	1,800	400

   a. As the price of tickets rises from $200 to $250, what is the price elasticity of demand for (i) business travelers and (ii) vacationers? (Use the midpoint method in your calculations.)
   b. Why might vacationers have a different elasticity from business travelers?
3. Suppose the price elasticity of demand for heating oil is 0.2 in the short run and 0.7 in the long run.
   a. If the price of heating oil rises from $1.80 to $2.20 per gallon, what happens to the quantity of heating oil demanded in the short run? In the long run? (Use the midpoint method in your calculations.)
   b. Why might this elasticity depend on the time horizon?
4. A price change causes the quantity demanded of a good to decrease by 30 percent, while the total revenue of that good increases by 15 percent. Is the demand curve elastic or inelastic? Explain.
5. The equilibrium price of coffee mugs rose sharply last month, but the equilibrium quantity was the same as ever. Three people tried to explain the situation. Which explanations could be right? Explain your logic.

   BILLY: Demand increased, but supply was totally inelastic.
   MARIAN: Supply increased, but so did demand.
   VALERIE: Supply decreased, but demand was totally inelastic.
6. Suppose that your demand schedule for compact discs is as follows:

Price	Quantity Demanded (income = $10,000)	Quantity Demanded (income = $12,000)
$ 8	40 CDs	50 CDs
10	32	45
12	24	30
14	16	20
16	8	12

   a. Use the midpoint method to calculate your price elasticity of demand as the price of compact discs increases from $8 to $10 if (i) your income is $10,000 and (ii) your income is $12,000.
   b. Calculate your income elasticity of demand as your income increases from $10,000 to $12,000 if (i) the price is $12 and (ii) the price is $16.
7. You have the following information about good X and good Y:
   - Income elasticity of demand for good X: –3
   - Cross-price elasticity of demand for good X with respect to the price of good Y: 2

   Would an increase in income and a decrease in the price of good Y unambiguously decrease the demand for good X? Why or why not?
8. Maria has decided always to spend one-third of her income on clothing.
   a. What is her income elasticity of clothing demand?
   b. What is her price elasticity of clothing demand?
   c. If Maria's tastes change and she decides to spend only one-fourth of her income on clothing, how does her demand curve change? What is her income elasticity and price elasticity now?

9. The *New York Times* reported (Feb. 17, 1996, p. 25) that subway ridership declined after a fare increase: "There were nearly four million fewer riders in December 1995, the first full month after the price of a token increased 25 cents to $1.50, than in the previous December, a 4.3 percent decline."
   a. Use these data to estimate the price elasticity of demand for subway rides.
   b. According to your estimate, what happens to the Transit Authority's revenue when the fare rises?
   c. Why might your estimate of the elasticity be unreliable?
10. Two drivers—Tom and Jerry—each drive up to a gas station. Before looking at the price, each places an order. Tom says, "I'd like 10 gallons of gas." Jerry says, "I'd like $10 worth of gas." What is each driver's price elasticity of demand?
11. Consider public policy aimed at smoking.
   a. Studies indicate that the price elasticity of demand for cigarettes is about 0.4. If a pack of cigarettes currently costs $2 and the government wants to reduce smoking by 20 percent, by how much should it increase the price?
   b. If the government permanently increases the price of cigarettes, will the policy have a larger effect on smoking 1 year from now or 5 years from now?
   c. Studies also find that teenagers have a higher price elasticity than do adults. Why might this be true?
12. You are the curator of a museum. The museum is running short of funds, so you decide to increase revenue. Should you increase or decrease the price of admission? Explain.
13. Pharmaceutical drugs have an inelastic demand, and computers have an elastic demand. Suppose that technological advance doubles the supply of both products (that is, the quantity supplied at each price is twice what it was).
   a. What happens to the equilibrium price and quantity in each market?
   b. Which product experiences a larger change in price?
   c. Which product experiences a larger change in quantity?
   d. What happens to total consumer spending on each product?
14. Beachfront resorts have an inelastic supply, and automobiles have an elastic supply. Suppose that a rise in population doubles the demand for both products (that is, the quantity demanded at each price is twice what it was).
   a. What happens to the equilibrium price and quantity in each market?
   b. Which product experiences a larger change in price?
   c. Which product experiences a larger change in quantity?
   d. What happens to total consumer spending on each product?
15. Several years ago, flooding along the Missouri and the Mississippi rivers destroyed thousands of acres of wheat.
   a. Farmers whose crops were destroyed by the floods were much worse off, but farmers whose crops were not destroyed benefited from the floods. Why?
   b. What information would you need about the market for wheat to assess whether farmers as a group were hurt or helped by the floods?
16. Explain why the following might be true: A drought around the world raises the total revenue that farmers receive from the sale of grain, but a drought only in Kansas reduces the total revenue that Kansas farmers receive.
17. Suppose the demand curve for a product is $Q = 60/P$. Compute the quantity demanded at prices of $1, $2, $3, $4, $5, and $6. Graph the demand curve. Use the midpoint method to calculate the price elasticity of demand between $1 and $2 and between $5 and $6. How does this demand curve compare to the linear demand curve?