section 9

Behind the Demand Curve: Consumer Choice

Panic was the only word to describe the situation at hospitals, clinics, and nursing homes across America in October 2004. Early that month, Chiron Corporation, one of only two suppliers of flu vaccine for the entire U.S. market, announced that contamination problems would force the closure of its manufacturing plant. With that closure, the U.S. supply of vaccine for the 2004–2005 flu season was suddenly cut in half, from 100 million to 50 million doses. Because making flu vaccine is a costly and time-consuming process, no more doses could be made to replace Chiron's lost output. And since every country jealously guards its supply of flu vaccine for its own citizens, none could be obtained from other countries.

If you've ever had a real case of the flu, you know just how unpleasant an experience it is. And it can be worse than unpleasant: every year the flu kills around 36,000 Americans and sends another 200,000 to the hospital. Victims are most commonly children, seniors, or those with compromised immune systems. In a normal flu season, this part of the population, along with health care workers, are immunized first.

But the flu vaccine shortfall of 2004 upended those plans. As news of it spread, there was a rush to get the shots. People lined up in the middle of the night at the few locations that had somehow obtained the vaccine and were offering it at a reasonable price: the crowds included seniors with oxygen tanks, parents with sleeping children, and others in wheelchairs. Meanwhile, some pharmaceutical distributors—the companies that obtain vaccine from manufacturers and then distribute it to hospitals and pharmacies—detected a profit-making opportunity in the frenzy. One company, Med-Stat, which normally charged $8.50 for a dose, began charging $90, more than 10 times the normal price. A survey of pharmacists found that price-gouging was fairly widespread.

AP Photo/Will Kincaid

Because consumers are relatively unresponsive to the price of flu vaccine, the price depends largely on availability.

Although many people refused or were unable to pay such a high price for the vaccine, many others undoubtedly did. Med-Stat judged, correctly, that consumers of the vaccine were relatively *unresponsive* to price; that is, the large increase in the price of the vaccine left the quantity demanded by consumers relatively unchanged.

Clearly, the demand for flu vaccine is unusual in this respect. For many, getting vaccinated meant the difference between life and death. Let's consider a very different and less urgent scenario. Suppose, for example, that the supply of a particular type of breakfast cereal was halved due to manufacturing problems. It would be extremely unlikely, if not impossible, to find a consumer willing to pay 10 times the original price for a box of this particular cereal. In other words, consumers of breakfast cereal are much more responsive to price than consumers of flu vaccine. But how do we define *responsiveness?* Economists measure consumers' responsiveness to price with a particular number, called the *price elasticity of demand.*

In this section we take a closer look at the supply and demand model developed in Section 2 and present several economic concepts used to evaluate market results. We will see how the price elasticity of demand is calculated and why it is the best measure of how the quantity demanded responds to changes in price. We will then discover that the price elasticity of demand is only one of a family of related concepts, including the *income elasticity of demand* and the *price elasticity of supply.* We will look at how the price and the quantity bought and sold in a market affect consumer, producer, and overall welfare. And we will consider how consumers make choices to maximize their individual *utility,* the term economists use to describe "satisfaction."

What you will learn in this **Module:**

- How the income and substitution effects explain the law of demand
- The definition of elasticity, a measure of responsiveness to changes in prices or incomes
- The importance of the price elasticity of demand, which measures the responsiveness of the quantity demanded to changes in price
- How to calculate the price elasticity of demand

Module 46 Income Effects, Substitution Effects, and Elasticity

Explaining the Law of Demand

In Section 2 we introduced the demand curve and the law of demand. To this point, we have accepted that the demand curve has a negative slope. And we have drawn demand curves that are somewhere in the middle between flat and steep (with a negative slope). In this module, we present more detail about why demand curves slope downward and what the slope of the demand curve tells us. We begin with the *income* and *substitution effects,* which explain why the demand curve has a negative slope.

The Substitution Effect

When the price of a good increases, an individual will normally consume less of that good and more of other goods. Correspondingly, when the price of a good decreases, an individual will normally consume more of that good and less of other goods. This explains why the individual demand curve, which relates an individual's consumption of a good to the price of that good, normally slopes downward—that is, it obeys the law of demand.

An alternative way to think about why demand curves slope downward is to focus on opportunity costs. For simplicity, let's suppose there are only two goods between which to choose. When the price of one good decreases, an individual doesn't have to give up as many units of the other good in order to buy one more unit of the first good. That makes it attractive to buy more of the good whose price has gone down. Conversely, when the price of one good increases, one must give up more units of the other good to buy one more unit of the first good, so consuming that good becomes less attractive and the consumer buys fewer. The change in the quantity demanded as the good that has become relatively cheaper is substituted for the good that has become relatively more expensive is known as the **substitution effect.** When a good absorbs only a small share of the typical consumer's income, as with pillow cases and swim

The **substitution effect** of a change in the price of a good is the change in the quantity of that good demanded as the consumer substitutes the good that has become relatively cheaper for the good that has become relatively more expensive.

goggles, the substitution effect is essentially the sole explanation of why the market demand curve slopes downward. There are, however, some goods, like food and housing, that account for a substantial share of many consumers' incomes. In such cases another effect, called the *income effect,* also comes into play.

The **income effect** of a change in the price of a good is the change in the quantity of that good demanded that results from a change in the consumer's purchasing power when the price of the good changes.

The Income Effect

Consider the case of a family that spends half of its income on rental housing. Now suppose that the price of housing increases everywhere. This will have a substitution effect on the family's demand: other things equal, the family will have an incentive to consume less housing—say, by moving to a smaller apartment—and more of other goods. But the family will also, in a real sense, be made poorer by that higher housing price—its income will buy less housing than before. When income is adjusted to reflect its true purchasing power, it is called *real income,* in contrast to *money income* or *nominal income,* which has not been adjusted. And this reduction in a consumer's real income will have an additional effect, beyond the substitution effect, on the family's consumption choices, including its consumption of housing. The **income effect** is the change in the quantity of a good demanded that results from a change in the overall purchasing power of the consumer's income due to a change in the price of that good.

It's possible to give more precise definitions of the substitution effect and the income effect of a price change, but for most purposes, there are only two things you need to know about the distinction between these two effects.

First, for the majority of goods and services, the income effect is not important and has no significant effect on individual consumption. Thus, most market demand curves slope downward solely because of the substitution effect—end of story.

Second, when it matters at all, the income effect usually reinforces the substitution effect. That is, when the price of a good that absorbs a substantial share of income rises, consumers of that good become a bit poorer because their purchasing power falls. And the vast majority of goods are *normal* goods, goods for which demand decreases when income falls. So this effective reduction in income leads to a reduction in the quantity demanded and reinforces the substitution effect.

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Giffen Goods

Back when Ireland was a desperately poor country—not the prosperous "Celtic Tiger" it has lately become—it was claimed that the Irish would eat *more* potatoes when the price of potatoes went up. That is, some observers claimed that Ireland's demand curve for potatoes sloped upward, not downward.

Can this happen? In theory, yes. If Irish demand for potatoes actually sloped upward, it would have been a real-life case of a "Giffen good," named after a nineteenth-century statistician who thought (probably wrongly) that he saw an upward-sloping demand curve in some data he was studying.

Here's the story. Suppose that there is some good that absorbs a large share of consumers' budgets and that this good is also *inferior*—people demand less of it when their income rises. The classic supposed example was, as you might guess, potatoes in Ireland, back when potatoes were an inferior good—they were what poor people ate—and when the Irish were very poor.

Now suppose that the price of potatoes increases. This would, *other things equal,* cause people to substitute other goods for potatoes. But other things are not equal: given the higher price of potatoes, people are poorer. And this *increases* the demand for potatoes, because potatoes are an inferior good.

If this income effect outweighs the substitution effect, a rise in the price of potatoes would increase the quantity demanded; the law of demand would not hold.

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In a way the point of this story—which has never been validated in any real situation, nineteenth-century Ireland included—is how unlikely such an event is. The law of demand really is a law, with few exceptions.

However, in the case of an *inferior* good, a good for which demand increases when income falls, the income and substitution effects work in opposite directions. Although the substitution effect decreases the quantity of any good demanded as its price increases, the income effect of a price increase for an inferior good is an *increase* in the quantity demanded. This makes sense because the price increase lowers the real income of the consumer, and as real income falls, the demand for an inferior good increases.

If a good were so inferior that the income effect exceeded the substitution effect, a price increase would lead to an increase in the quantity demanded. There is controversy over whether such goods, known as "Giffen goods," exist at all. If they do, they are very rare. You can generally assume that the income effect for an inferior good is smaller than the substitution effect, and so a price increase will lead to a decrease in the quantity demanded.

Defining and Measuring Elasticity

As we saw in Section 1, *dependent variables* respond to changes in *independent variables*. For example, if two variables are negatively related and the independent variable increases, the dependent variable will respond by decreasing. But often the important question is not whether the variables are negatively or positively related, but how responsive the dependent variable is to changes in the independent variable (that is, ***by how much*** will the dependent variable change?). If price increases, we know that quantity demanded will decrease (that is the *law of demand*). The question in this context is *by how much* will quantity demanded decrease if price goes up?

Economists use the concept of *elasticity* to measure the responsiveness of one variable to changes in another. For example, *price elasticity of demand* measures the responsiveness of quantity demanded to changes in price—something a firm considering changing its price would certainly want to know! Elasticity can be used to measure responsiveness using any two related variables. We will start by looking at the price elasticity of demand and then move on to other examples of elasticities commonly used by economists.

Think back to the opening example of the 2004 flu shot panic. In order for Flunomics, a hypothetical flu vaccine distributor, to know whether it could raise its revenue by significantly raising the price of its flu vaccine during the 2004 flu vaccine panic, it would have to know whether the price increase would decrease the quantity demanded by a lot or a little. That is, it would have to know the price elasticity of demand for flu vaccinations.

Calculating the Price Elasticity of Demand

Figure 46.1 shows a hypothetical demand curve for flu vaccinations. At a price of $20 per vaccination, consumers would demand 10 million vaccinations per year (point *A*); at a price of $21, the quantity demanded would fall to 9.9 million vaccinations per year (point *B*).

Figure 46.1, then, tells us the change in the quantity demanded for a particular change in the price. But how can we turn this into a measure of price responsiveness? The answer is to calculate the price elasticity of demand. The **price elasticity of demand** compares the *percent change in quantity demanded* to the *percent change in price* as we move along the demand curve. As we'll see later, the reason economists use percent changes is to get a measure that doesn't depend on the units in which a good is measured (say, a child-size dose versus an adult-size dose of vaccine). But before we get to that, let's look at how elasticity is calculated.

The **price elasticity of demand** is the ratio of the percent change in the quantity demanded to the percent change in the price as we move along the demand curve (dropping the minus sign).

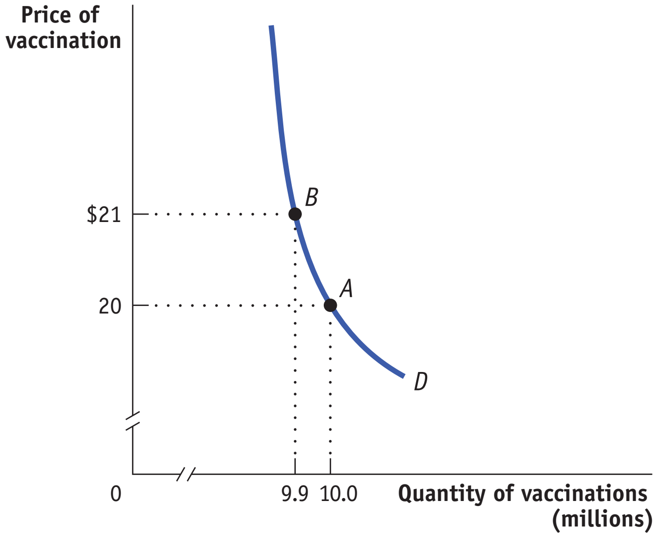
To calculate the price elasticity of demand, we first calculate the *percent change in the quantity demanded* and the corresponding *percent change in the price* as we move along the demand curve. These are defined as follows:

$$\textbf{(46-1)}\quad \%\text{ change in quantity demanded} = \frac{\text{Change in quantity demanded}}{\text{Initial quantity demanded}} \times 100$$

figure 46.1

The Demand for Vaccinations

At a price of $20 per vaccination, the quantity of vaccinations demanded is 10 million per year (point *A*). When price rises to $21 per vaccination, the quantity demanded falls to 9.9 million vaccinations per year (point *B*).



and

$$\textbf{(46-2)} \quad \text{\% change in price} = \frac{\text{Change in price}}{\text{Initial price}} \times 100$$

In Figure 46.1, we see that when the price rises from \$20 to \$21, the quantity demanded falls from 10 million to 9.9 million vaccinations, yielding a change in the quantity demanded of 0.1 million vaccinations. So the percent change in the quantity demanded is

$$\text{\% change in quantity demanded} = \frac{-0.1 \text{ million vaccinations}}{10 \text{ million vaccinations}} \times 100 = -1\%$$

The initial price is \$20 and the change in the price is \$1, so the percent change in the price is

$$\text{\% change in price} = \frac{\$1}{\$20} \times 100 = 5\%$$

To calculate the price elasticity of demand, we find the ratio of the percent change in the quantity demanded to the percent change in the price:

$$\textbf{(46-3)} \quad \text{Price elasticity of demand} = \frac{\text{\% change in quantity demanded}}{\text{\% change in price}}$$

In Figure 46.1, the price elasticity of demand is therefore

$$\text{Price elasticity of demand} = \frac{1\%}{5\%} = 0.2$$

The *law of demand* says that demand curves slope downward, so price and quantity demanded always move in opposite directions. In other words, a positive percent change in price (a rise in price) leads to a negative percent change in the quantity demanded; a negative percent change in price (a fall in price) leads to a positive percent change in the quantity demanded. This means that the price elasticity of demand is, in strictly mathematical terms, a negative number. However, it is inconvenient to repeatedly write a minus sign. So when economists talk about the price elasticity of demand, they usually drop the minus sign and report the absolute value of the price elasticity of demand. In this case, for example, economists would usually say "the price elasticity of demand is 0.2," taking it for granted that you understand they mean *minus* 0.2. We follow this convention here.

The larger the price elasticity of demand, the more responsive the quantity demanded is to the price. When the price elasticity of demand is large—when consumers change their quantity demanded by a large percentage compared with the percent change in the price—economists say that demand is highly elastic.

As we'll see shortly, a price elasticity of 0.2 indicates a small response of quantity demanded to price. That is, the quantity demanded will fall by a relatively small amount when price rises. This is what economists call *inelastic* demand. And inelastic demand was exactly what Flunomics needed for its strategy to increase revenue by raising the price of its flu vaccines.

An Alternative Way to Calculate Elasticities: The Midpoint Method

We've seen that price elasticity of demand compares the *percent change in quantity demanded* with the *percent change in price.* When we look at some other elasticities, which we will do shortly, we'll see why it is important to focus on percent changes. But at this point we need to discuss a technical issue that arises when you calculate percent changes in variables and how economists deal with it.

Ian Britton/Freefoto.com

The best way to understand the issue is with a real example. Suppose you were trying to estimate the price elasticity of demand for gasoline by comparing gasoline prices and consumption in different countries. Because of high taxes, gasoline usually costs about three times as much per gallon in Europe as it does in the United States. So what is the percent difference between American and European gas prices?

Well, it depends on which way you measure it. Because the price of gasoline in Europe is approximately three times higher than in the United States, it is 200 percent higher. Because the price of gasoline in the United States is one-third as high as in Europe, it is 66.7 percent lower.

This is a nuisance: we'd like to have a percent measure of the difference in prices that doesn't depend on which way you measure it. A good way to avoid computing different elasticities for rising and falling prices is to use the *midpoint method* (sometimes called the *arc method*).

The **midpoint method** replaces the usual definition of the percent change in a variable, *X,* with a slightly different definition:

$$\textbf{(46-4)} \quad \%\text{ change in } X = \frac{\text{Change in } X}{\text{Average value of } X} \times 100$$

where the average value of X is defined as

$$\text{Average value of } X = \frac{\text{Starting value of } X + \text{Final value of } X}{2}$$

When calculating the price elasticity of demand using the midpoint method, both the percent change in the price and the percent change in the quantity demanded are found using average values in this way. To see how this method works, suppose you have the following data for some good:

The **midpoint method** is a technique for calculating the percent change. In this approach, we calculate changes in a variable compared with the average, or midpoint, of the initial and final values.

	Price	Quantity demanded
Situation A	$0.90	1,100
Situation B	$1.10	900

To calculate the percent change in quantity going from situation A to situation B, we compare the change in the quantity demanded—a fall of 200 units—with the *average* of the quantity demanded in the two situations. So we calculate

$$\%\text{ change in quantity demanded} = \frac{-200}{(1{,}100 + 900)/2} \times 100 = \frac{-200}{1{,}000} \times 100 = -20\%$$

In the same way, we calculate the percentage change in price as

$$\%\text{ change in price} = \frac{\$0.20}{(\$0.90 + \$1.10)/2} \times 100 = \frac{\$0.20}{\$1.00} \times 100 = 20\%$$

So in this case we would calculate the price elasticity of demand to be

$$\text{Price elasticity of demand} = \frac{\%\text{ change in quantity demanded}}{\%\text{ change in price}} = \frac{20\%}{20\%} = 1$$

again dropping the minus sign.

The important point is that we would get the same result, a price elasticity of demand of 1, whether we went up the demand curve from situation A to situation B or down from situation B to situation A.

To arrive at a more general formula for price elasticity of demand, suppose that we have data for two points on a demand curve. At point 1 the quantity demanded and

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Estimating Elasticities

You might think it's easy to estimate price elasticities of demand from real-world data: just compare percent changes in prices with percent changes in quantities demanded. Unfortunately, it's rarely that simple because changes in price aren't the only thing affecting changes in the quantity demanded: other factors—such as changes in income, changes in population, and changes in the prices of other goods—shift the demand curve, thereby changing the quantity demanded at any given price. To estimate price elasticities of demand, economists must use careful statistical analysis to separate the influence of these different factors, holding other things equal.

The most comprehensive effort to estimate price elasticities of demand was a mammoth study by the economists Hendrik S. Houthakker and Lester D. Taylor. Some of their results are summarized in Table 46.1. These estimates show a wide range of price elasticities. There are some goods, like eggs, for which demand hardly responds at all to changes in the price; there are other goods, most notably foreign travel, for which the quantity demanded is very sensitive to the price.

Notice that Table 46.1 is divided into two parts: inelastic and elastic demand. We'll explain in the next section the significance of that division.

table **46.1**

Some Estimated Price Elasticities of Demand

Good	Price elasticity of demand
Inelastic demand	
Eggs	0.1
Beef	0.4
Stationery	0.5
Gasoline	0.5
Elastic demand	
Housing	1.2
Restaurant meals	2.3
Airline travel	2.4
Foreign travel	4.1

Source: Hendrick S. Houthakker and Lester D. Taylor, *Consumer Demand in the United States, 1929–1970* (Cambridge: Harvard University Press, 1970) price are (Q_1, P_1); at point 2 they are (Q_2, P_2). Then the formula for calculating the price elasticity of demand is:

$$\textbf{(46-5)} \quad \text{Price elasticity of demand} = \frac{\dfrac{Q_2 - Q_1}{(Q_1 + Q_2)/2}}{\dfrac{P_2 - P_1}{(P_1 + P_2)/2}}$$

As before, when reporting a price elasticity of demand calculated by the midpoint method, we drop the minus sign and report the absolute value.

Module 46 AP Review

Solutions appear at the back of the book.

Check Your Understanding

1. In each of the following cases, state whether the income effect, the substitution effect, or both are significant. In which cases do they move in the same direction? In opposite directions? Why?
   a. Orange juice represents a small share of Clare's spending. She buys more lemonade and less orange juice when the price of orange juice goes up. She does not change her spending on other goods.
   b. Apartment rents have risen dramatically this year. Since rent absorbs a major part of her income, Delia moves to a smaller apartment. Assume that rental housing is a normal good.
   c. The cost of a semester-long meal ticket at the student cafeteria rises, representing a significant increase in living costs. As a result, many students have less money to spend on weekend meals at restaurants and eat in the cafeteria instead. Assume that cafeteria meals are an inferior good.
2. The price of strawberries falls from \$1.50 to \$1.00 per carton, and the quantity demanded goes from 100,000 to 200,000 cartons. Use the midpoint method to find the price elasticity of demand.
3. At the present level of consumption, 4,000 movie tickets, and at the current price, \$5 per ticket, the price elasticity of demand for movie tickets is 1. Using the midpoint method, calculate the percentage by which the owners of movie theaters must reduce the price in order to sell 5,000 tickets.
4. The price elasticity of demand for ice-cream sandwiches is 1.2 at the current price of \$0.50 per sandwich and the current consumption level of 100,000 sandwiches. Calculate the change in the quantity demanded when price rises by \$0.05. Use Equations 46-1 and 46-2 to calculate percent changes and Equation 46-3 to relate price elasticity of demand to the percent changes.

Tackle the Test: Multiple-Choice Questions

1. Which of the following statements is true?
   I. When a good absorbs only a small share of consumer spending, the income effect explains the demand curve's negative slope.
   II. A change in consumption brought about by a change in purchasing power describes the income effect.
   III. In the case of an inferior good, the income and substitution effects work in opposite directions.
   a. I only
   b. II only
   c. III only
   d. II and III only
   e. I, II, and III
2. The income effect is most likely to come into play for which of the following goods?
   a. water
   b. clothing
   c. housing
   d. transportation
   e. entertainment
3. If a decrease in price from \$2 to \$1 causes an increase in quantity demanded from 100 to 120, using the midpoint method, price elasticity of demand equals
   a. 0.17.
   b. 0.27.
   c. 0.40.
   d. 2.5.
   e. 3.72.
4. Which of the following is likely to have the highest price elasticity of demand?
   a. eggs
   b. beef
   c. housing
   d. gasoline
   e. foreign travel

5. If a 2% change in the price of a good leads to a 10% change in the quantity demanded of a good, what is the value of price elasticity of demand?
   a. 0.02
   b. 0.2
   c. 5
   d. 10
   e. 20

Tackle the Test: Free-Response Questions

1. a. Define the price elasticity of demand and provide the formula for calculating the price elasticity of demand using the midpoint method.
   b. Refer to the table provided. Using the midpoint method, calculate the price elasticity of demand for good *X*.
   c. Based on your calculation of price elasticity of demand in part b, if price increases by 10%, in what direction and by what percentage will quantity demanded change?

	Good X
Price	*Quantity demanded*
$2	800
$4	500

Answer (5 points)

1 point: The price elasticity of demand measures the responsiveness of the quantity demanded to price changes.

1 point: (Change in quantity demanded/average quantity demanded)/(change in price/average price)

1 point: 0.69

1 point: Decrease

1 point: 6.9%

2. Assume the price of an inferior good increases.
   a. In what direction will the substitution effect change the quantity demanded? Explain.
   b. In what direction will the income effect change the quantity demanded? Explain.
   c. Given that the demand curve for the good slopes downward, what is true of the relative sizes of the income and substitution effects for the inferior good? Explain.

What you will learn in this Module:

- The difference between elastic and inelastic demand
- The relationship between elasticity and total revenue
- Changes in the price elasticity of demand along a demand curve
- The factors that determine price elasticity of demand

Module 47 Interpreting Price Elasticity of Demand

Interpreting the Price Elasticity of Demand

Med-Stat and other pharmaceutical distributors believed they could sharply drive up flu vaccine prices in the face of a shortage because the price elasticity of vaccine demand was low. But what does that mean? How low does a price elasticity have to be for us to classify it as low? How high does it have to be for us to consider it high? And what determines whether the price elasticity of demand is high or low, anyway? To answer these questions, we need to look more deeply at the price elasticity of demand.

How Elastic Is Elastic?

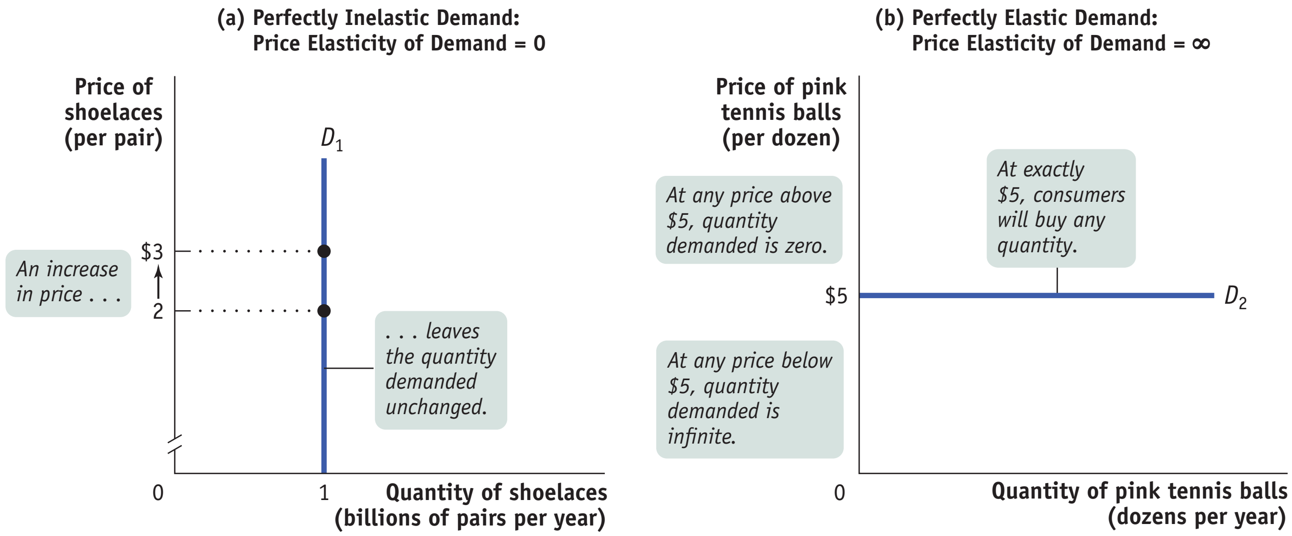
As a first step toward classifying price elasticities of demand, let's look at the extreme cases.

First, consider the demand for a good when people pay no attention to the price of, say, shoelaces. Suppose that consumers would buy 1 billion pairs of shoelaces per year regardless of the price. If that were true, the demand curve for shoelaces would look like the curve shown in panel (a) of Figure 47.1: it would be a vertical line at 1 billion pairs of shoelaces. Since the percent change in the quantity demanded is zero for *any* change in the price, the price elasticity of demand in this case is zero. The case of a zero price elasticity of demand is known as **perfectly inelastic** demand.

The opposite extreme occurs when even a tiny rise in the price will cause the quantity demanded to drop to zero or even a tiny fall in the price will cause the quantity demanded to get extremely large. Panel (b) of Figure 47.1 shows the case of pink tennis balls; we suppose that tennis players really don't care what color their balls are and that other colors, such as neon green and vivid yellow, are available at $5 per dozen balls. In this case, consumers will buy no pink balls if they cost more than $5 per dozen but will buy only pink balls if they cost less than $5. The demand curve will therefore be a horizontal line at a price of $5 per dozen balls. As you move back and forth along this line, there is a change in the quantity demanded but no change in the price. When you divide a number by zero, you get infinity, denoted by the symbol ∞.

Demand is **perfectly inelastic** when the quantity demanded does not respond at all to changes in the price. When demand is perfectly inelastic, the demand curve is a vertical line.

figure 47.1 Two Extreme Cases of Price Elasticity of Demand



Panel (a) shows a perfectly inelastic demand curve, which is a vertical line. The quantity of shoelaces demanded is always 1 billion pairs, regardless of price. As a result, the price elasticity of demand is zero—the quantity demanded is unaffected by the price. Panel (b) shows a perfectly elastic demand curve, which is a horizontal line. At a price of $5, consumers will buy any quantity of pink tennis balls, but will buy none at a price above $5. If the price falls below $5, they will buy an extremely large number of pink tennis balls and none of any other color.

So a horizontal demand curve implies an infinite price elasticity of demand. When the price elasticity of demand is infinite, economists say that demand is **perfectly elastic.**

The price elasticity of demand for the vast majority of goods is somewhere between these two extreme cases. Economists use one main criterion for classifying these intermediate cases: they ask whether the price elasticity of demand is greater or less than 1. When the price elasticity of demand is greater than 1, economists say that demand is **elastic.** When the price elasticity of demand is less than 1, they say that demand is **inelastic.** The borderline case is **unit-elastic** demand, where the price elasticity of demand is—surprise—exactly 1.

Demand is **perfectly elastic** when any price increase will cause the quantity demanded to drop to zero. When demand is perfectly elastic, the demand curve is a horizontal line.

Demand is **elastic** if the price elasticity of demand is greater than 1, **inelastic** if the price elasticity of demand is less than 1, and **unit-elastic** if the price elasticity of demand is exactly 1.

To see why a price elasticity of demand equal to 1 is a useful dividing line, let's consider a hypothetical example: a toll bridge operated by the state highway department. Other things equal, the number of drivers who use the bridge depends on the toll, the price the highway department charges for crossing the bridge: the higher the toll, the fewer the drivers who use the bridge.

Figure 47.2 on the next page shows three hypothetical demand curves—one in which demand is unit-elastic, one in which it is inelastic, and one in which it is elastic. In each case, point *A* shows the quantity demanded if the toll is $0.90 and point *B* shows the quantity demanded if the toll is $1.10. An increase in the toll from $0.90 to $1.10 is an increase of 20% if we use the midpoint method to calculate percent changes.

Panel (a) shows what happens when the toll is raised from $0.90 to $1.10 and the demand curve is unit-elastic. Here the 20% price rise leads to a fall in the quantity of cars using the bridge each day from 1,100 to 900, which is a 20% decline (again using the midpoint method). So the price elasticity of demand is 20%/20% = 1.

Panel (b) shows a case of inelastic demand when the toll is raised from $0.90 to $1.10. The same 20% price rise reduces the quantity demanded from 1,050 to 950. That's only a 10% decline, so in this case the price elasticity of demand is 10%/20% = 0.5.

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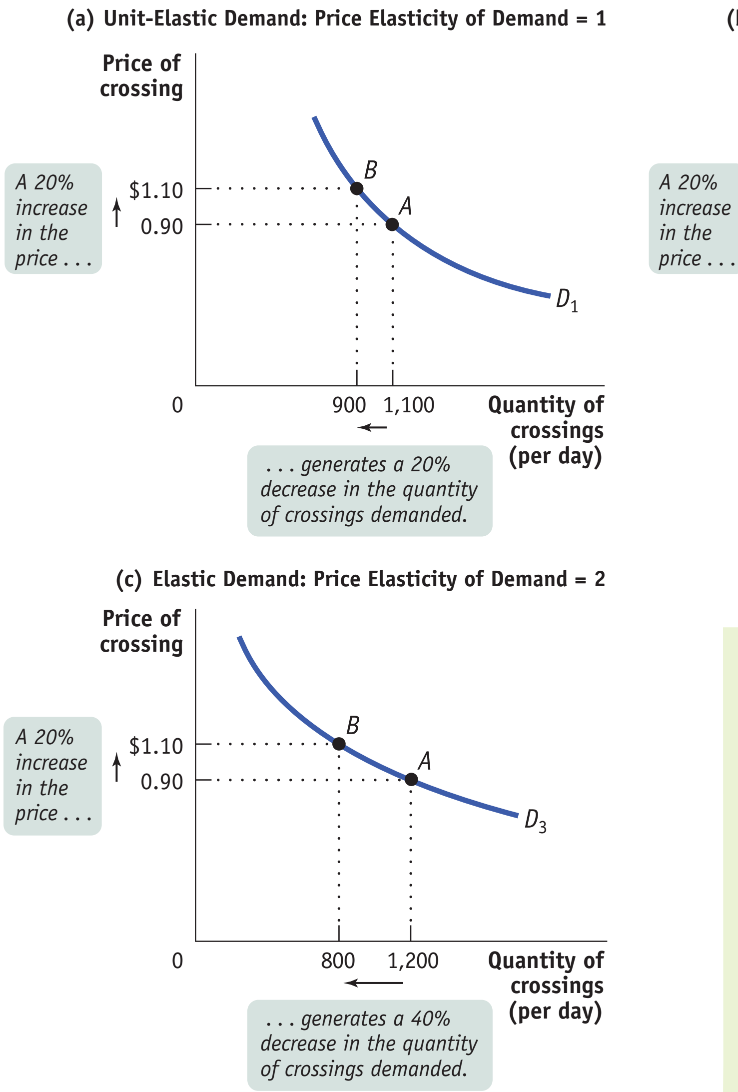
When the Bay Area Toll Authority deliberated a toll increase from $4 to $6 for San Francisco's Bay Bridge in 2010, at issue was the price elasticity of demand, which would determine the resulting drop in use.

figure 47.2 Unit-Elastic Demand, Inelastic Demand, and Elastic Demand



Panel (a) shows a case of unit-elastic demand: a 20% increase in price generates a 20% decline in quantity demanded, implying a price elasticity of demand of 1. Panel (b) shows a case of inelastic demand: a 20% increase in price generates a 10% decline in quantity demanded, implying a price elasticity of demand of 0.5. A case of elastic demand is shown in Panel (c): a 20% increase in price causes a 40% decline in quantity demanded, implying a price elasticity of demand of 2. All percentages are calculated using the midpoint method.

Panel (c) shows a case of elastic demand when the toll is raised from \$0.90 to \$1.10. The 20% price increase causes the quantity demanded to fall from 1,200 to 800, a 40% decline, so the price elasticity of demand is 40%/20% = 2.

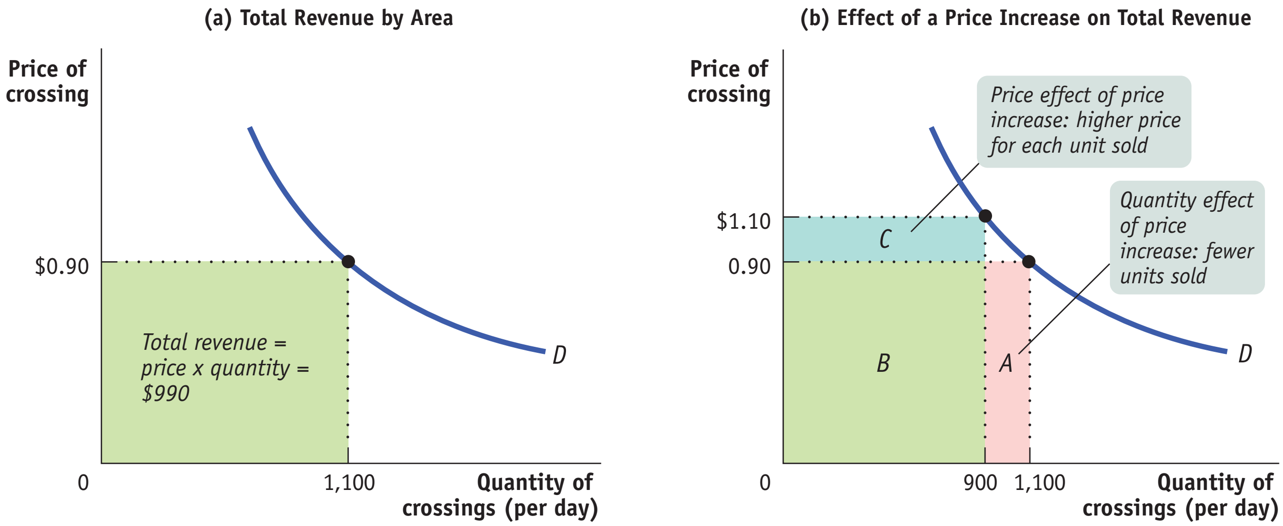
Why does it matter whether demand is unit-elastic, inelastic, or elastic? Because this classification predicts how changes in the price of a good will affect the *total revenue* earned by producers from the sale of that good. In many real-life situations, such as the one faced by Med-Stat, it is crucial to know how price changes affect total revenue. **Total revenue** is defined as the total value of sales of a good or service: the price multiplied by the quantity sold.

(47-1) Total revenue = Price × Quantity sold

Total revenue has a useful graphical representation that can help us understand why knowing the price elasticity of demand is crucial when we ask whether a price rise will increase or reduce total revenue. Panel (a) of Figure 47.3 shows the same demand curve as panel (a) of Figure 47.2. We see that 1,100 drivers will use the bridge if the toll

Total revenue is the total value of sales of a good or service. It is equal to the price multiplied by the quantity sold.

figure 47.3 Total Revenue



The green rectangle in panel (a) represents total revenue generated from 1,100 drivers who each pay a toll of $0.90. Panel (b) shows how total revenue is affected when the price increases from $0.90 to $1.10. Due to the quantity effect, total revenue falls by area *A*. Due to the price effect, total revenue increases by area *C*. In general, the overall effect can go either way, depending on the price elasticity of demand.

is $0.90. So the total revenue at a price of $0.90 is $0.90 × 1,100 = $990. This value is equal to the area of the green rectangle, which is drawn with the bottom left corner at the point (0, 0) and the top right corner at (1,100, 0.90). In general, the total revenue at any given price is equal to the area of a rectangle whose height is the price and whose width is the quantity demanded at that price.

To get an idea of why total revenue is important, consider the following scenario. Suppose that the toll on the bridge is currently $0.90 but that the highway department must raise extra money for road repairs. One way to do this is to raise the toll on the bridge. But this plan might backfire, since a higher toll will reduce the number of drivers who use the bridge. And if traffic on the bridge dropped a lot, a higher toll would actually reduce total revenue instead of increasing it. So it's important for the highway department to know how drivers will respond to a toll increase.

We can see graphically how the toll increase affects total bridge revenue by examining panel (b) of Figure 47.3. At a toll of $0.90, total revenue is given by the sum of the areas *A* and *B*. After the toll is raised to $1.10, total revenue is given by the sum of areas *B* and *C*. So when the toll is raised, revenue represented by area *A* is lost but revenue represented by area *C* is gained. These two areas have important interpretations. Area *C* represents the revenue gain that comes from the additional $0.20 paid by drivers who continue to use the bridge. That is, the 900 who continue to use the bridge contribute an additional $0.20 × 900 = $180 per day to total revenue, represented by area *C*. But 200 drivers who would have used the bridge at a price of $0.90 no longer do so, generating a loss to total revenue of $0.90 × 200 = $180 per day, represented by area *A*. (In this particular example, because demand is unit-elastic—the same as in panel (a) of Figure 47.2—the rise in the toll has no effect on total revenue; areas *A* and *B* are the same size.)

Except in the rare case of a good with perfectly elastic or perfectly inelastic demand, when a seller raises the price of a good, two countervailing effects are present:

- *A price effect.* After a price increase, each unit sold sells at a higher price, which tends to raise revenue.
- *A quantity effect.* After a price increase, fewer units are sold, which tends to lower revenue.

But then, you may ask, what is the net ultimate effect on total revenue: does it go up or down? The answer is that, in general, the effect on total revenue can go either way—a price rise may either increase total revenue or lower it. If the price effect, which tends to raise total revenue, is the stronger of the two effects, then total revenue goes up. If the quantity effect, which tends to reduce total revenue, is the stronger, then total revenue goes down. And if the strengths of the two effects are exactly equal—as in our toll bridge example, where a $180 gain offsets a $180 loss—total revenue is unchanged by the price increase.

The price elasticity of demand tells us what happens to total revenue when price changes: its size determines which effect—the price effect or the quantity effect—is stronger. Specifically:

- If demand for a good is *unit-elastic* (the price elasticity of demand is 1), an increase in price does not change total revenue. In this case, the quantity effect and the price effect exactly offset each other.
- If demand for a good is *inelastic* (the price elasticity of demand is less than 1), a higher price increases total revenue. In this case, the price effect is stronger than the quantity effect.
- If demand for a good is *elastic* (the price elasticity of demand is greater than 1), an increase in price reduces total revenue. In this case, the quantity effect is stronger than the price effect.

Table 47.1 shows how the effect of a price increase on total revenue depends on the price elasticity of demand, using the same data as in Figure 47.2. An increase in the price from $0.90 to $1.10 leaves total revenue unchanged at $990 when demand is unit-elastic. When demand is inelastic, the price effect dominates the quantity effect; the same price increase leads to an increase in total revenue from $945 to $1,045. And when demand is elastic, the quantity effect dominates the price effect; the price increase leads to a decline in total revenue from $1,080 to $880.

table 47.1

Price Elasticity of Demand and Total Revenue

	Price of crossing = $0.90	Price of crossing = $1.10
Unit-elastic demand (price elasticity of demand = 1)		
Quantity demanded	1,100	900
Total revenue	$990	$990
Inelastic demand (price elasticity of demand = 0.5)		
Quantity demanded	1,050	950
Total revenue	$945	$1,045
Elastic demand (price elasticity of demand = 2)		
Quantity demanded	1,200	800
Total revenue	$1,080	$880

The price elasticity of demand also predicts the effect of a *fall* in price on total revenue. When the price falls, the same two countervailing effects are present, but they work in the opposite directions as compared to the case of a price rise. There is the price effect of a lower price per unit sold, which tends to lower revenue. This is countered by the quantity effect of more units sold, which tends to raise revenue. Which effect dominates depends on the price elasticity. Here is a quick summary:

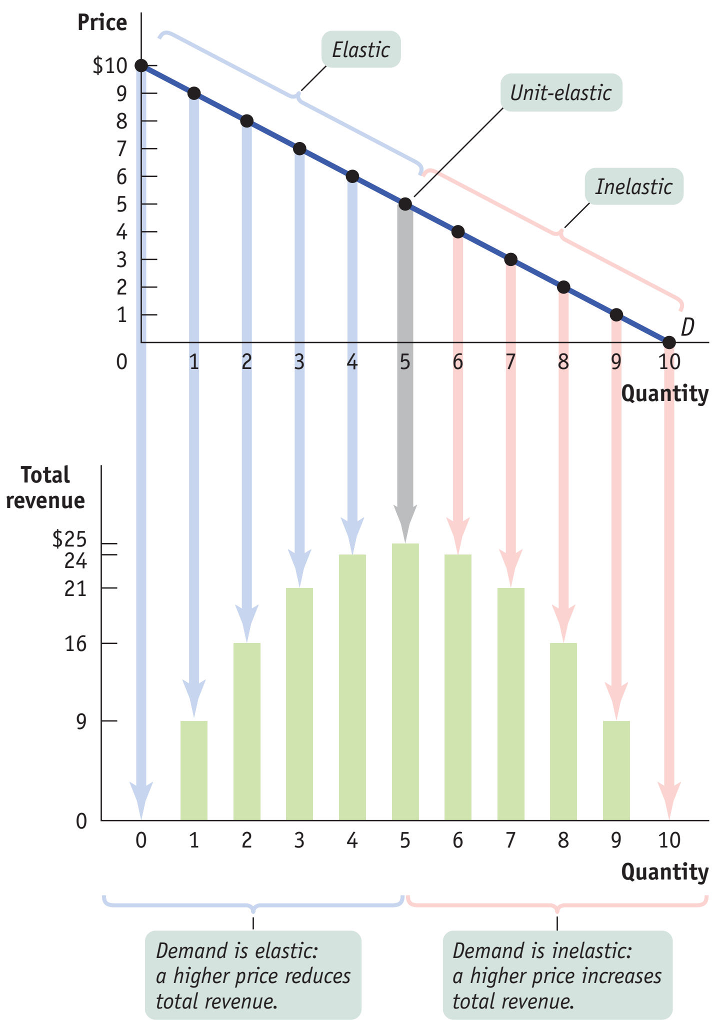
- When demand is *unit-elastic,* the two effects exactly balance each other out; so a fall in price has no effect on total revenue.
- When demand is *inelastic,* the price effect dominates the quantity effect; so a fall in price reduces total revenue.
- When demand is *elastic,* the quantity effect dominates the price effect; so a fall in price increases total revenue.

Price Elasticity Along the Demand Curve

Suppose an economist says that "the price elasticity of demand for coffee is 0.25." What he or she means is that *at the current price* the elasticity is 0.25. In the previous discussion of the toll bridge, what we were really describing was the elasticity *at the price* of $0.90. Why this qualification? Because for the vast majority of demand curves, the price elasticity of demand at one point along the curve is different from the price elasticity of demand at other points along the same curve.

To see this, consider the table in Figure 47.4, which shows a hypothetical demand schedule. It also shows in the last column the total revenue generated at each price and quantity combination in the demand schedule. The upper panel of the graph in Figure

figure 47.4 The Price Elasticity of Demand Changes Along the Demand Curve



Demand Schedule and Total Revenue for a Linear Demand Curve

Price	Quantity demanded	Total revenue
$0	10	$0
1	9	9
2	8	16
3	7	21
4	6	24
5	5	25
6	4	24
7	3	21
8	2	16
9	1	9
10	0	0

The upper panel shows a demand curve corresponding to the demand schedule in the table. The lower panel shows how total revenue changes along that demand curve: at each price and quantity combination, the height of the bar represents the total revenue generated. You can see that at a low price, raising the price increases total revenue. So demand is inelastic at low prices. At a high price, however, a rise in price reduces total revenue. So demand is elastic at high prices.

47.4 shows the corresponding demand curve. The lower panel illustrates the same data on total revenue: the height of a bar at each quantity demanded—which corresponds to a particular price—measures the total revenue generated at that price.

In Figure 47.4, you can see that when the price is low, raising the price increases total revenue: starting at a price of $1, raising the price to $2 increases total revenue from $9 to $16. This means that when the price is low, demand is inelastic. Moreover, you can see that demand is inelastic on the entire section of the demand curve from a price of $0 to a price of $5.

When the price is high, however, raising it further reduces total revenue: starting at a price of $8, for example, raising the price to $9 reduces total revenue, from $16 to $9. This means that when the price is high, demand is elastic. Furthermore, you can see that demand is elastic over the section of the demand curve from a price of $5 to $10.

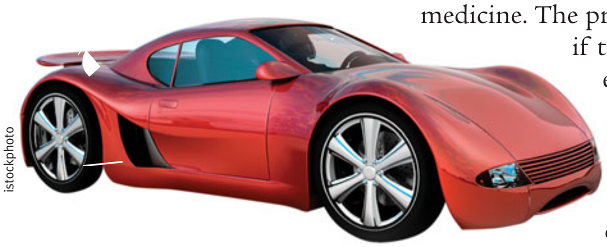
For the vast majority of goods, the price elasticity of demand changes along the demand curve. So whenever you measure a good's elasticity, you are really measuring it at a particular point or section of the good's demand curve.

What Factors Determine the Price Elasticity of Demand?

The flu vaccine shortfall of 2004–2005 allowed vaccine distributors to significantly raise their prices for two important reasons: there were no substitutes, and for many people the vaccine was a medical necessity. People responded in various ways. Some paid the high prices, and some traveled to Canada and other countries to get vaccinated. Some simply did without (and over time often changed their habits to avoid catching the flu, such as eating out less often and avoiding mass transit). This experience illustrates the four main factors that determine elasticity: whether close substitutes are available, whether the good is a necessity or a luxury, the share of income a consumer spends on the good, and how much time has elapsed since the price change. We'll briefly examine each of these factors.

Whether Close Substitutes Are Available The price elasticity of demand tends to be high if there are other goods that consumers regard as similar and would be willing to consume instead. The price elasticity of demand tends to be low if there are no close substitutes.

Whether the Good Is a Necessity or a Luxury The price elasticity of demand tends to be low if a good is something you must have, like a life-saving medicine. The price elasticity of demand tends to be high if the good is a luxury—something you can easily live without.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Share of Income Spent on the Good The price elasticity of demand tends to be low when spending on a good accounts for a small share of a consumer's income. In that case, a significant change in the price of the good has little impact on how much the consumer spends. In contrast, when a good accounts for a significant share of a consumer's spending, the consumer is likely to be very responsive to a change in price. In this case, the price elasticity of demand is high.

Time In general, the price elasticity of demand tends to increase as consumers have more time to adjust to a price change. This means that the long-run price elasticity of demand is often higher than the short-run elasticity.

A good illustration of the effect of time on the elasticity of demand is drawn from the 1970s, the first time gasoline prices increased dramatically in the United States. Initially, consumption fell very little because there were no close substitutes for gasoline and because driving their cars was necessary for people to carry out the ordinary tasks of life. Over time, however, Americans changed their habits in ways that enabled them to gradually reduce their gasoline consumption. The result was a steady decline in gasoline consumption over the next decade, even though the price of gasoline did not continue to rise, confirming that the long-run price elasticity of demand for gasoline was indeed much larger than the short-run elasticity.

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Responding to Your Tuition Bill

College costs more than ever—and not just because of overall inflation. Tuition has been rising faster than the overall cost of living for years. But does rising tuition keep people from going to college? Two studies found that the answer depends on the type of college. Both studies assessed how responsive the decision to go to college is to a change in tuition.

A 1988 study found that a 3% increase in tuition led to an approximately 2% fall in the number of students enrolled at four-year institutions, giving a price elasticity of demand of 0.67 (2%/3%). In the case of two-year institutions, the study found a significantly higher response: a 3% increase in tuition led to a 2.7% fall in enrollments, giving a price elasticity of demand of 0.9. In other words, the enrollment decision for students at two-year colleges was significantly more responsive to price than for students at four-year colleges. The result: students at two-year colleges are more likely to forgo getting a degree because of tuition costs than students at four-year colleges.

A 1999 study confirmed this pattern. In comparison to four-year colleges, it found that two-year college enrollment rates were significantly more responsive to changes in state financial aid (a decline in aid leading to a decline in enrollments), a predictable effect given these students' greater sensitivity to the cost of tuition. Another piece of evidence suggests that students at two-year colleges are more likely to be paying their own way and making a trade-off between attending college and working: the study found that enrollments at two-year colleges are much more responsive to changes in the unemployment rate (an increase in the unemployment rate leading to an increase in enrollments) than enrollments at four-year colleges. So is the cost of tuition a barrier to getting a college degree in the United States? Yes, but more so at two-year colleges than at four-year colleges.

Interestingly, the 1999 study found that for both two-year and four-year colleges, price sensitivity of demand had fallen somewhat since the 1988 study. One possible explanation is that because the value of a college education has risen considerably over time, fewer people forgo college, even if tuition goes up. (See source note on copyright page.)

Module 47 AP Review

Solutions appear at the back of the book.

Check Your Understanding

1. For each case, choose the condition that characterizes demand: elastic demand, inelastic demand, or unit-elastic demand.
   a. Total revenue decreases when price increases.
   b. When price falls, the additional revenue generated by the increase in the quantity sold is exactly offset by the revenue lost from the fall in the price received per unit.
   c. Total revenue falls when output increases.
   d. Producers in an industry find they can increase their total revenues by working together to reduce industry output.
2. For the following goods, is demand elastic, inelastic, or unit-elastic? Explain. What is the shape of the demand curve?
   a. demand by a snake-bite victim for an antidote
   b. demand by students for blue pencils

Tackle the Test: Multiple-Choice Questions

1. A perfectly elastic demand curve is
   a. upward sloping.
   b. vertical.
   c. not a straight line.
   d. horizontal.
   e. downward sloping.
2. Which of the following would cause the demand for a good to be relatively inelastic?
   a. The good has a large number of close substitutes.
   b. Expenditures on the good represent a large share of consumer income.
   c. There is ample time to adjust to price changes.
   d. The good is a necessity.
   e. The price of the good is in the upper left section of a linear demand curve.
3. Which of the following is true if the price elasticity of demand for a good is zero?
   a. The slope of the demand curve is zero.
   b. The slope of the demand curve is one.
   c. The demand curve is vertical.
   d. The demand curve is horizontal.
   e. The price of the good is high.
4. Which of the following is correct for a price increase? When demand is ____________, total revenue will ____________.

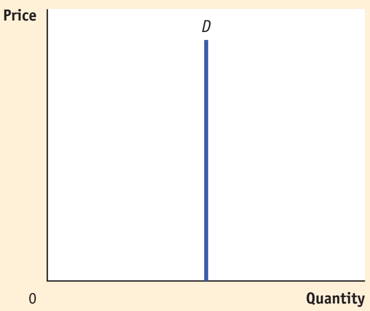
	Demand	*Total Revenue*
a.	inelastic	decrease
b.	elastic	decrease
c.	unit-elastic	increase
d.	unit-elastic	decrease
e.	elastic	increase

5. Total revenue is maximized when demand is
   a. elastic.
   b. inelastic.
   c. unit-elastic.
   d. zero.
   e. infinite.

Tackle the Test: Free-Response Questions

1. Draw a correctly labeled graph of a perfectly inelastic demand curve.
   a. What is the price elasticity of demand for this good?
   b. What is the slope of the demand curve for this good?
   c. Is this good more likely to be a luxury or a necessity? Explain.
2. Draw a correctly labeled graph illustrating a demand curve that is a straight line and is neither perfectly elastic nor perfectly inelastic.
   a. On your graph, indicate the half of the demand curve along which demand is elastic.
   b. In the elastic range, how will an increase in price affect total revenue? Explain.

Answer (5 points)



1 point: A graph with "Price" (or "*P*") on the vertical axis, "Quantity" (or "*Q*") on the horizontal axis, and a vertical line labeled "Demand" (or "*D*")

1 point: Zero

1 point: Infinite or undefined

1 point: Necessity

1 point: Since you have to have a necessity (such as a life-saving medicine), you do not change the quantity you purchase when price changes.

Module 48 Other Elasticities

What you will learn in this Module:

- How the cross-price elasticity of demand measures the responsiveness of demand for one good to changes in the price of another good
- The meaning and importance of the income elasticity of demand, a measure of the responsiveness of demand to changes in income
- The significance of the price elasticity of supply, which measures the responsiveness of the quantity supplied to changes in price
- The factors that influence the size of these various elasticities

Other Elasticities

We stated earlier that economists use the concept of *elasticity* to measure the responsiveness of one variable to changes in another. However, up to this point we have focused on the price elasticity of demand. Now that we have used elasticity to measure the responsiveness of quantity demanded to changes in price, we can go on to look at how elasticity is used to understand the relationship between other important variables in economics.

The quantity of a good demanded depends not only on the price of that good but also on other variables. In particular, demand curves shift because of changes in the prices of related goods and changes in consumers' incomes. It is often important to have a measure of these other effects, and the best measures are—you guessed it—elasticities. Specifically, we can best measure how the demand for a good is affected by prices of other goods using a measure called the *cross-price elasticity of demand,* and we can best measure how demand is affected by changes in income using the *income elasticity of demand.*

Finally, we can also use elasticity to measure supply responses. The *price elasticity of supply* measures the responsiveness of the quantity supplied to changes in price.

The Cross-Price Elasticity of Demand

The demand for a good is often affected by the prices of other, related goods—goods that are substitutes or complements. A change in the price of a related good shifts the demand curve of the original good, reflecting a change in the quantity demanded at any given price. The strength of such a "cross" effect on demand can be measured by the **cross-price elasticity of demand,** defined as the ratio of the percent change in the quantity demanded of one good to the percent change in the price of another.

(48-1) Cross-price elasticity of demand between goods A and B

$$= \frac{\text{\% change in quantity of A demanded}}{\text{\% change in price of B}}$$

When two goods are substitutes, like hot dogs and hamburgers, the cross-price elasticity of demand is positive: a rise in the price of hot dogs increases the demand for hamburgers—that is, it causes a rightward shift of the demand curve for hamburgers. If the goods are close substitutes, the cross-price elasticity will be positive and large;

The **cross-price elasticity of demand** between two goods measures the effect of the change in one good's price on the quantity demanded of the other good. It is equal to the percent change in the quantity demanded of one good divided by the percent change in the other good's price.

if they are not close substitutes, the cross-price elasticity will be positive and small. So when the cross-price elasticity of demand is positive, its size is a measure of how closely substitutable the two goods are.

When two goods are complements, like hot dogs and hot dog buns, the cross-price elasticity is negative: a rise in the price of hot dogs decreases the demand for hot dog buns—that is, it causes a leftward shift of the demand curve for hot dog buns. As with substitutes, the size of the cross-price elasticity of demand between two complements tells us how strongly complementary they are: if the cross-price elasticity is only slightly below zero, they are weak complements; if it is very negative, they are strong complements.

Note that in the case of the cross-price elasticity of demand, the sign (plus or minus) is very important: it tells us whether the two goods are complements or substitutes. So we cannot drop the minus sign as we did for the price elasticity of demand.

Our discussion of the cross-price elasticity of demand is a useful place to return to a point we made earlier: elasticity is a *unit-free* measure—that is, it doesn't depend on the units in which goods are measured.

To see the potential problem, suppose someone told you that "if the price of hot dog buns rises by $0.30, Americans will buy 10 million fewer hot dogs this year." If you've ever bought hot dog buns, you'll immediately wonder: is that a $0.30 increase in the price *per bun,* or is it a $0.30 increase in the price *per package* of buns? It makes a big difference what units we are talking about! However, if someone says that the cross-price elasticity of demand between buns and hot dogs is –0.3, it doesn't matter whether buns are sold individually or by the package. So elasticity is defined as a ratio of percent changes, which avoids confusion over units.

The Income Elasticity of Demand

The **income elasticity of demand** measures how changes in income affect the demand for a good. It indicates whether a good is normal or inferior and specifies how responsive demand for the good is to changes in income. Having learned the price and cross-price elasticity formulas, the income elasticity formula will look familiar:

$$\textbf{(48-2)}\quad \text{Income elasticity of demand} = \frac{\%\text{ change in quantity demanded}}{\%\text{ change in income}}$$

Just as the cross-price elasticity of demand between two goods can be either positive or negative, depending on whether the goods are substitutes or complements, the income elasticity of demand for a good can also be either positive or negative. Recall that goods can be either *normal goods,* for which demand increases when income rises, or *inferior goods,* for which demand decreases when income rises. These definitions relate directly to the sign of the income elasticity of demand:

- When the income elasticity of demand is positive, the good is a normal good—that is, the quantity demanded at any given price increases as income increases.
- When the income elasticity of demand is negative, the good is an inferior good—that is, the quantity demanded at any given price decreases as income increases.

Economists often use estimates of the income elasticity of demand to predict which industries will grow most rapidly as the incomes of consumers grow over time. In doing this, they often find it useful to make a further distinction among normal goods, identifying which are *income-elastic* and which are *income-inelastic.*

The demand for a good is **income-elastic** if the income elasticity of demand for that good is greater than 1. When income rises, the demand for income-elastic goods rises *faster* than income. Luxury goods such as second homes and international travel tend to be income-elastic. The demand for a good is **income-inelastic** if the income elasticity of demand for that good is positive but less than 1. When income rises, the demand for income-inelastic goods rises, but more slowly than income. Necessities such as food and clothing tend to be income-inelastic.

The **income elasticity of demand** is the percent change in the quantity of a good demanded when a consumer's income changes divided by the percent change in the consumer's income.

The demand for a good is **income-elastic** if the income elasticity of demand for that good is greater than 1.

The demand for a good is **income-inelastic** if the income elasticity of demand for that good is positive but less than 1.

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Where Have All the Farmers Gone?

What percentage of Americans live on farms? Sad to say, the U.S. government no longer publishes that number. In 1991 the official percentage was 1.9, but in that year the government decided it was no longer a meaningful indicator of the size of the agricultural sector because a large proportion of those who live on farms actually make their living doing something else. But in the days of the Founding Fathers, the great majority of Americans lived on farms. As recently as the 1940s, one American in six—or approximately 17%—still did.

Why do so few people now live and work on farms in the United States? There are two main reasons, both involving elasticities.

First, the income elasticity of demand for food is much less than 1—food demand is income-inelastic. As consumers grow richer, other things equal, spending on food rises less than in proportion to income. As a result, as the U.S. economy has grown, the share of income spent on food—and therefore the share of total U.S. income earned by farmers—has fallen.

Second, agriculture has been a technologically progressive sector for approximately 150 years in the United States, with steadily increasing yields over time. You might think that technological progress would be good for farmers. But competition among farmers means that technological progress leads to lower food prices. Meanwhile, the demand for food is price-inelastic, so falling prices of agricultural goods, other things equal, reduce the total revenue of farmers. That's right: progress in farming is good for consumers but bad for farmers.

The combination of these effects explains the relative decline of farming. Even if farming weren't such a technologically progressive sector, the low income elasticity of demand for food would ensure that the income of farmers grows more slowly than the economy as a whole. The combination of rapid technological progress in farming with price-inelastic demand for farm products reinforces this effect, further reducing the growth of farm income. In short, the U.S. farm sector has been a victim of success—the U.S. economy's success as a whole (which reduces the importance of spending on food) and its own success in increasing yields.


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The Price Elasticity of Supply

In the wake of the flu vaccine shortfall of 2004, attempts by vaccine distributors to drive up the price of vaccines would have been much less effective if a higher price had induced a large increase in the output of flu vaccines by flu vaccine manufacturers other than Chiron. In fact, if the rise in price had precipitated a significant increase in flu vaccine production, the price would have been pushed back down. But that didn't happen because, as we mentioned earlier, it would have been far too costly and technically difficult to produce more vaccine for the 2004–2005 flu season. (In reality, the production of flu vaccine is begun a year before it is to be distributed.) This was another critical element in the ability of some flu vaccine distributors, like Med-Stat, to get significantly higher prices for their product: a low responsiveness in the quantity of output supplied to the higher price of flu vaccine by flu vaccine producers. To measure the response of producers to price changes, we need a measure parallel to the price elasticity of demand—the *price elasticity of supply*.

Measuring the Price Elasticity of Supply

The **price elasticity of supply** is defined the same way as the price elasticity of demand (although there is no minus sign to be eliminated here):

$$\textbf{(48-3)} \quad \text{Price elasticity of supply} = \frac{\%\text{ change in quantity supplied}}{\%\text{ change in price}}$$

The **price elasticity of supply** is a measure of the responsiveness of the quantity of a good supplied to the price of that good. It is the ratio of the percent change in the quantity supplied to the percent change in the price as we move along the supply curve.

The only difference is that here we consider movements along the supply curve rather than movements along the demand curve.

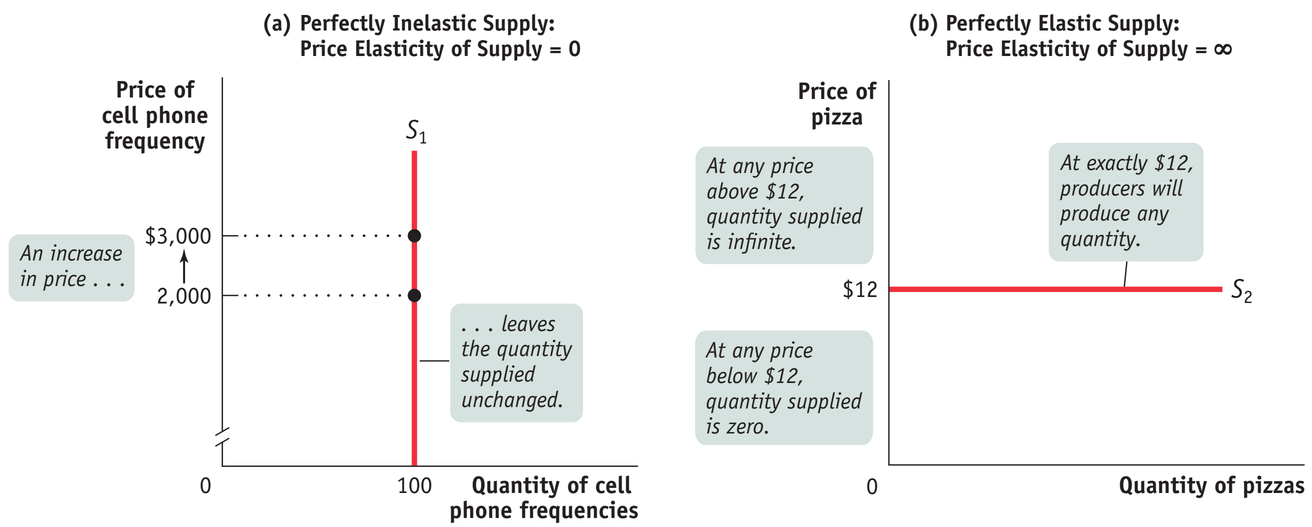
Suppose that the price of tomatoes rises by 10%. If the quantity of tomatoes supplied also increases by 10% in response, the price elasticity of supply of tomatoes is

There is **perfectly inelastic supply** when the price elasticity of supply is zero, so that changes in the price of the good have no effect on the quantity supplied. A perfectly inelastic supply curve is a vertical line.

1 (10%/10%) and supply is unit-elastic. If the quantity supplied increases by 5%, the price elasticity of supply is 0.5 and supply is inelastic; if the quantity increases by 20%, the price elasticity of supply is 2 and supply is elastic.

As in the case of demand, the extreme values of the price elasticity of supply have a simple graphical representation. Panel (a) of Figure 48.1 shows the supply of cell phone frequencies, the portion of the radio spectrum that is suitable for sending and receiving cell phone signals. Governments own the right to sell the use of this part of the radio spectrum to cell phone operators inside their borders. But governments can't increase or decrease the number of cell phone frequencies they have to offer—for technical reasons, the quantity of frequencies suitable for cell phone operation is fixed. So the supply curve for cell phone frequencies is a vertical line, which we have assumed is set at the quantity of 100 frequencies. As you move up and down that curve, the change in the quantity supplied by the government is zero, whatever the change in price. So panel (a) illustrates a case of **perfectly inelastic supply,** meaning that the price elasticity of supply is zero.

figure 48.1 Two Extreme Cases of Price Elasticity of Supply



Panel (a) shows a perfectly inelastic supply curve, which is a vertical line. The price elasticity of supply is zero: the quantity supplied is always the same, regardless of price. Panel (b) shows a perfectly elastic supply curve, which is a horizontal line. At a price of $12, producers will supply any quantity, but they will supply none at a price below $12. If the price rises above $12, they will supply an extremely large quantity.

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Panel (b) shows the supply curve for pizza. We suppose that it costs $12 to produce a pizza, including all opportunity costs. At any price below $12, it would be unprofitable to produce pizza and all the pizza parlors would go out of business. At a price of $12 or more, there are many producers who could operate pizza parlors. The ingredients—flour, tomatoes, cheese—are plentiful. And if necessary, more tomatoes could be grown, more milk could be produced to make mozzarella cheese, and so on. So by allowing profits, any price above $12 would elicit the supply of an extremely large quantity of pizzas. The implied supply curve is therefore a horizontal line at $12. Since even a tiny increase in the price would lead to an enormous increase in the quantity supplied, the price elasticity of supply would be virtually infinite. A horizontal supply curve such as this represents a case of **perfectly elastic supply.**

As our cell phone frequencies and pizza examples suggest, real-world instances of both perfectly inelastic and perfectly elastic supply are easier to find than their counterparts in demand.

There is **perfectly elastic supply** if the quantity supplied is zero below some price and infinite above that price. A perfectly elastic supply curve is a horizontal line.

What Factors Determine the Price Elasticity of Supply? Our examples tell us the main determinant of the price elasticity of supply: the availability of inputs. In addition, as with the price elasticity of demand, time may also play a role in the price elasticity of supply. Here we briefly summarize the two factors.

The Availability of Inputs The price elasticity of supply tends to be large when inputs are readily available and can be shifted into and out of production at a relatively low cost. It tends to be small when inputs are available only in a more-or-less fixed quantity or can be shifted into and out of production only at a relatively high cost.

Time The price elasticity of supply tends to grow larger as producers have more time to respond to a price change. This means that the long-run price elasticity of supply is often higher than the short-run elasticity. In the case of the flu vaccine shortfall, time was the crucial element because flu vaccine must be grown in cultures over many months.

The price elasticity of pizza supply is very high because the inputs needed to make more pizza are readily available. The price elasticity of cell phone frequencies is zero because an essential input—the radio spectrum—cannot be increased at all.

Many industries are like pizza and have large price elasticities of supply: they can be readily expanded because they don't require any special or unique resources. On the other hand, the price elasticity of supply is usually substantially less than perfectly elastic for goods that involve limited natural resources: minerals like gold or copper, agricultural products like coffee that flourish only on certain types of land, and renewable resources like ocean fish that can be exploited only up to a point without destroying the resource.

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But given enough time, producers are often able to significantly change the amount they produce in response to a price change, even when production involves a limited natural resource. For example, consider again the effects of a surge in flu vaccine prices, but this time focus on the supply response. If the price were to rise to $90 per vaccination and stay there for a number of years, there would almost certainly be a substantial increase in flu vaccine production. Producers such as Chiron would eventually respond by increasing the size of their manufacturing plants, hiring more lab technicians, and so on. But significantly enlarging the capacity of a biotech manufacturing lab takes several years, not weeks or months or even a single year.

For this reason, economists often make a distinction between the short-run elasticity of supply, usually referring to a few weeks or months, and the long-run elasticity of supply, usually referring to several years. In most industries, the long-run elasticity of supply is larger than the short-run elasticity.

An Elasticity Menagerie

We've just run through quite a few different types of elasticity. Keeping them all straight can be a challenge. So in Table 48.1 on the next page we provide a summary of all the types of elasticity we have discussed and their implications.

table **48.1**

An Elasticity Menagerie

Name	Possible values	Significance
Price elasticity of demand $= \dfrac{\text{\% change in quantity demanded}}{\text{\% change in price}}$ (dropping the minus sign)		
Perfectly inelastic demand	0	Price has no effect on quantity demanded (vertical demand curve).
Inelastic demand	Between 0 and 1	A rise in price increases total revenue.
Unit-elastic demand	Exactly 1	Changes in price have no effect on total revenue.
Elastic demand	Greater than 1, less than ∞	A rise in price reduces total revenue.
Perfectly elastic demand	∞	A rise in price causes quantity demanded to fall to 0. A fall in price leads to an infinite quantity demanded (horizontal demand curve).
Cross-price elasticity of demand $= \dfrac{\text{\% change in quantity } \textit{of one good} \text{ demanded}}{\text{\% change in price } \textit{of another good}}$		
Complements	Negative	Quantity demanded of one good falls when the price of another rises.
Substitutes	Positive	Quantity demanded of one good rises when the price of another rises.
Income elasticity of demand $= \dfrac{\text{\% change in quantity demanded}}{\text{\% change in income}}$		
Inferior good	Negative	Quantity demanded falls when income rises.
Normal good, income-inelastic	Positive, less than 1	Quantity demanded rises when income rises, but not as rapidly as income.
Normal good, income-elastic	Greater than 1	Quantity demanded rises when income rises, and more rapidly than income.
Price elasticity of supply $= \dfrac{\text{\% change in quantity supplied}}{\text{\% change in price}}$		
Perfectly inelastic supply	0	Price has no effect on quantity supplied (vertical supply curve).
	Greater than 0, less than ∞	Ordinary upward-sloping supply curve.
Perfectly elastic supply	∞	Any fall in price causes quantity supplied to fall to 0. Any rise in price elicits an infinite quantity supplied (horizontal supply curve).

Module 48 AP Review

Solutions appear at the back of the book.

Check Your Understanding

1. After Chelsea's income increased from \$12,000 to \$18,000 a year, her purchases of CDs increased from 10 to 40 CDs a year. Calculate Chelsea's income elasticity of demand for CDs using the midpoint method.

2. As the price of margarine rises by 20%, a manufacturer of baked goods increases its quantity of butter demanded by 5%. Calculate the cross-price elasticity of demand between butter and margarine. Are butter and margarine substitutes or complements for this manufacturer?

3. Using the midpoint method, calculate the price elasticity of supply for web-design services when the price per hour rises from \$100 to \$150 and the number of hours supplied increases from 300,000 hours to 500,000. Is supply elastic, inelastic, or unit-elastic?

Tackle the Test: Multiple-Choice Questions

1. If the cross-price elasticity between two goods is negative, this means that the two goods are
   a. substitutes.
   b. complements.
   c. normal.
   d. inferior.
   e. luxuries.
2. If Kylie buys 200 units of good X when her income is \$20,000 and 300 units of good X when her income increases to \$25,000, her income elasticity of demand, using the midpoint method, is
   a. 0.06.
   b. 0.5.
   c. 1.65.
   d. 1.8.
   e. 2.00.
3. The income elasticity of demand for a normal good is
   a. zero.
   b. 1.
   c. infinite.
   d. positive.
   e. negative.
4. A perfectly elastic supply curve is
   a. positively sloped.
   b. negatively sloped.
   c. vertical.
   d. horizontal.
   e. U-shaped
5. Which of the following leads to a more inelastic price elasticity of supply?
   I. the use of inputs that are easily obtained
   II. a high degree of substitutability between inputs
   III. a shorter time period in which to supply the good
   a. I only
   b. II only
   c. III only
   d. I and II only
   e. I, II, and III

Tackle the Test: Free-Response Questions

1. Refer to the table below to answer the following questions.

Price of Good A	*Quantity of Good A Demanded*	*Quantity of Good B Demanded*
\$10	100	5
8	110	10

   a. Using the midpoint method, calculate the price elasticity of demand for good A.
   b. Give the formula for calculating the cross-price elasticity of demand between good A and good B.
   c. Using the midpoint method, calculate the cross-price elasticity of demand between good A and good B.
   d. What does your answer for part c tell you about the relationship between the two goods? Explain.

Answer (5 points)

1 point: 0.43

1 point: % change in quantity of good B/% change in price of good A or (change in Q_B/average Q_B)/(change in P_A/average P_A)

1 point: –3

1 point: They are complements.

1 point: Cross-price elasticity is negative—when the price of good A goes down, in addition to buying more of good A, people buy more of good B to go along with it.

2. Assume the price of corn rises by 20% and this causes suppliers to increase the quantity of corn supplied by 40%.
   a. Calculate the price elasticity of supply.
   b. In this case, is supply elastic or inelastic?
   c. Draw a correctly labeled graph of a supply curve illustrating the most extreme case of the category of elasticity you found in part b (either perfectly elastic or perfectly inelastic supply).
   d. What would likely be true of the availability of inputs for a firm with the supply curve you drew in part c? Explain.

What you will learn in this **Module:**

- The meaning of consumer surplus and its relationship to the demand curve
- The meaning of producer surplus and its relationship to the supply curve

Module 49 Consumer and Producer Surplus

There is a lively market in second-hand college textbooks. At the end of each term, some students who took a course decide that the money they can make by selling their used books is worth more to them than keeping the books. And some students who are taking the course next term prefer to buy a somewhat battered but less expensive used textbook rather than pay full price for a new one.

Textbook publishers and authors are not happy about these transactions because they cut into sales of new books. But both the students who sell used books and those who buy them clearly benefit from the existence of the market. That is why many college bookstores facilitate their trade, buying used textbooks and selling them alongside the new books.

But can we put a number on what used textbook buyers and sellers gain from these transactions? Can we answer the question "*How much* do the buyers and sellers of textbooks gain from the existence of the used-book market?"

Yes, we can. In this module we will see how to measure benefits, such as those to buyers of used textbooks, from being able to purchase a good—known as *consumer surplus*. And we will see that there is a corresponding measure, *producer surplus,* of the benefits sellers receive from being able to sell a good.

The concepts of consumer surplus and producer surplus are useful for analyzing a wide variety of economic issues. They let us calculate how much benefit producers and consumers receive from the existence of a market. They also allow us to calculate how the welfare of consumers and producers is affected by changes in market prices. Such calculations play a crucial role in evaluating many economic policies.

What information do we need to calculate consumer and producer surplus? Surprisingly, all we need are the demand and supply curves for a good. That is, the supply and demand model isn't just a model of how a competitive market works—it's also a model of how much consumers and producers gain from participating in that market. So our first step will be to learn how consumer and producer surplus can be derived from the demand and supply curves. We will then see how these concepts can be applied to actual economic issues.

Consumer Surplus and the Demand Curve

First-year college students are often surprised by the prices of the textbooks required for their classes. The College Board estimates that in 2006-2007 students at four-year schools spent, on average, $942 for books and supplies. But at the end of the semester, students might again be surprised to find out that they can sell back at least some of the textbooks they used for the semester for a percentage of the purchase price (offsetting some of the cost of textbooks). The ability to purchase used textbooks at the start of the semester and to sell back used textbooks at the end of the semester is beneficial to students on a budget. In fact, the market for used textbooks is a big business in terms of dollars and cents—approximately $1.9 billion in 2004–2005. This market provides a convenient starting point for us to develop the concepts of consumer and producer surplus. We'll use the concepts of consumer and producer surplus to understand exactly how buyers and sellers benefit from a competitive market and how big those benefits are. In addition, these concepts assist in the analysis of what happens when competitive markets don't work well or there is interference in the market.

So let's begin by looking at the market for used textbooks, starting with the buyers. The key point, as we'll see in a minute, is that the demand curve is derived from their tastes or preferences—and that those same preferences also determine how much they gain from the opportunity to buy used books.

Willingness to Pay and the Demand Curve

A used book is not as good as a new book—it will be battered and coffee-stained, may include someone else's highlighting, and may not be completely up to date. How much this bothers you depends on your preferences. Some potential buyers would prefer to buy the used book even if it is only slightly cheaper than a new one, while others would buy the used book only if it is considerably cheaper. Let's define a potential buyer's **willingness to pay** as the maximum price at which he or she would buy a good, in this case a used textbook. An individual won't buy the good if it costs more than this amount but is eager to do so if it costs less. If the price is just equal to an individual's willingness to pay, he or she is indifferent between buying and not buying. For the sake of simplicity, we'll assume that the individual buys the good in this case.

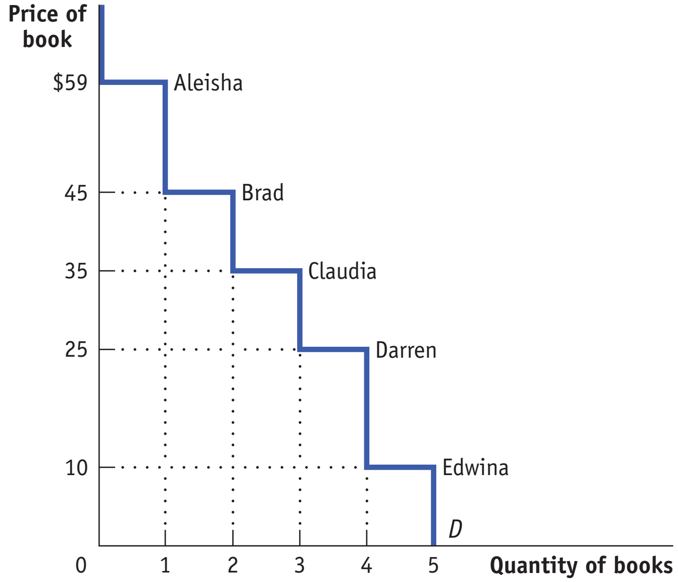
The table in Figure 49.1 on the next page shows five potential buyers of a used book that costs $100 new, listed in order of their willingness to pay. At one extreme is Aleisha, who will buy a second-hand book even if the price is as high as $59. Brad is less willing to have a used book and will buy one only if the price is $45 or less. Claudia is willing to pay only $35 and Darren, only $25. Edwina, who really doesn't like the idea of a used book, will buy one only if it costs no more than $10.

How many of these five students will actually buy a used book? It depends on the price. If the price of a used book is $55, only Aleisha buys one; if the price is $40, Aleisha and Brad both buy used books, and so on. So the information in the table can be used to construct the *demand schedule* for used textbooks.

We can use this demand schedule to derive the market demand curve shown in Figure 49.1. Because we are considering only a small number of consumers, this curve doesn't look like the smooth demand curves we have seen previously, for markets that contained hundreds or thousands of consumers. This demand curve is step-shaped, with alternating horizontal and vertical segments. Each horizontal segment—each step—corresponds to one potential buyer's willingness to pay. However, we'll see shortly that for the analysis of consumer surplus it doesn't matter whether the demand curve is step-shaped, as in this figure, or whether there are many consumers, making the curve smooth.

A consumer's **willingness to pay** for a good is the maximum price at which he or she would buy that good.

figure 49.1 The Demand Curve for Used Textbooks



Potential buyers	Willingness to pay
Aleisha	$59
Brad	45
Claudia	35
Darren	25
Edwina	10

With only five potential consumers in this market, the demand curve is step-shaped. Each step represents one consumer, and its height indicates that consumer's willingness to pay—the maximum price at which each will buy a used textbook—as indicated in the table. Aleisha has the highest willingness to pay at $59, Brad has the next highest at $45, and so on down to Edwina with the lowest willingness to pay at $10. At a price of $59, the quantity demanded is one (Aleisha); at a price of $45, the quantity demanded is two (Aleisha and Brad); and so on until you reach a price of $10, at which all five students are willing to purchase a book.

Willingness to Pay and Consumer Surplus

Suppose that the campus bookstore makes used textbooks available at a price of $30. In that case Aleisha, Brad, and Claudia will buy books. Do they gain from their purchases, and if so, how much?

The answer, shown in Table 49.1, is that each student who purchases a book does achieve a net gain but that the amount of the gain differs among students.

Aleisha would have been willing to pay $59, so her net gain is $59 – $30 = $29. Brad would have been willing to pay $45, so his net gain is $45 – $30 = $15. Claudia would

table 49.1

Consumer Surplus When the Price of a Used Textbook Is $30

Potential buyer	Willingness to pay	Price paid	Individual consumer surplus = Willingness to pay – Price paid
Aleisha	$59	$30	$29
Brad	45	30	15
Claudia	35	30	5
Darren	25	—	—
Edwina	10	—	—
All buyers			Total consumer surplus = $49

have been willing to pay $35, so her net gain is $35 – $30 = $5. Darren and Edwina, however, won't be willing to buy a used book at a price of $30, so they neither gain nor lose.

The net gain that a buyer achieves from the purchase of a good is called that buyer's **individual consumer surplus.** What we learn from this example is that whenever a buyer pays a price less than his or her willingness to pay, the buyer achieves some individual consumer surplus.

The sum of the individual consumer surpluses achieved by all the buyers of a good is known as the **total consumer surplus** achieved in the market. In Table 49.1, the total consumer surplus is the sum of the individual consumer surpluses achieved by Aleisha, Brad, and Claudia: $29 + $15 + $5 = $49.

Economists often use the term **consumer surplus** to refer to both individual and total consumer surplus. We will follow this practice; it will always be clear in context whether we are referring to the consumer surplus achieved by an individual or by all buyers.

Total consumer surplus can be represented graphically. Figure 49.2 reproduces the demand curve from Figure 49.1. Each step in that demand curve is one book wide and represents one consumer. For example, the height of Aleisha's step is $59, her willingness to pay. This step forms the top of a rectangle, with $30—the price she actually pays for a book—forming the bottom. The area of Aleisha's rectangle, ($59 – $30) × 1 = $29, is her consumer surplus from purchasing one book at $30. So the individual consumer surplus Aleisha gains is the *area of the dark blue rectangle* shown in Figure 49.2.

In addition to Aleisha, Brad and Claudia will also each buy a book when the price is $30. Like Aleisha, they benefit from their purchases, though not as much, because they each have a lower willingness to pay. Figure 49.2 also shows the consumer surplus gained by Brad and Claudia; again, this can be measured by the areas of the appropriate rectangles. Darren and Edwina, because they do not buy books at a price of $30, receive no consumer surplus.

The total consumer surplus achieved in this market is just the sum of the individual consumer surpluses received by Aleisha, Brad, and Claudia. So total consumer surplus is equal to the combined area of the three rectangles—the entire shaded area in Figure 49.2. Another way to say this is that total consumer surplus is equal to the area below the demand curve but above the price.

Individual consumer surplus is the net gain to an individual buyer from the purchase of a good. It is equal to the difference between the buyer's willingness to pay and the price paid.

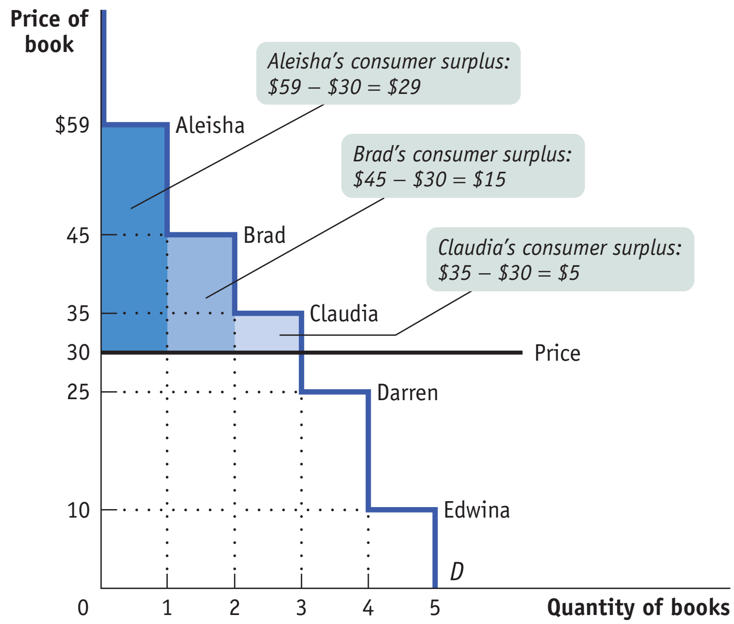
Total consumer surplus is the sum of the individual consumer surpluses of all the buyers of a good in a market.

The term **consumer surplus** is often used to refer to both individual and to total consumer surplus.

figure 49.2

Consumer Surplus in the Used-Textbook Market

At a price of $30, Aleisha, Brad, and Claudia each buy a book but Darren and Edwina do not. Aleisha, Brad, and Claudia get individual consumer surpluses equal to the difference between their willingness to pay and the price, illustrated by the areas of the shaded rectangles. Both Darren and Edwina have a willingness to pay less than $30, so they are unwilling to buy a book in this market; they receive zero consumer surplus. The total consumer surplus is given by the entire shaded area—the sum of the individual consumer surpluses of Aleisha, Brad, and Claudia—equal to $29 + $15 + $5 = $49.



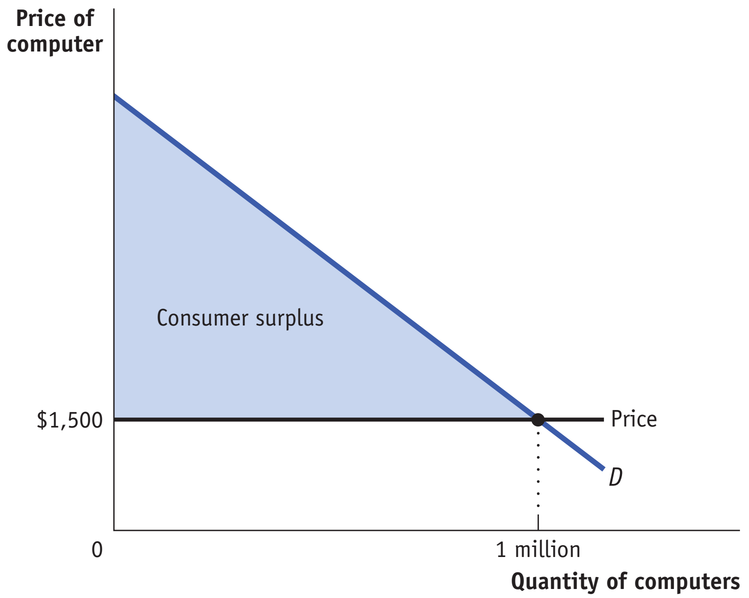
This is worth repeating as a general principle: *The total consumer surplus generated by purchases of a good at a given price is equal to the area below the demand curve but above that price*. The same principle applies regardless of the number of consumers.

When we consider large markets, this graphical representation becomes particularly helpful. Consider, for example, the sales of personal computers to millions of potential buyers. Each potential buyer has a maximum price that he or she is willing to pay. With so many potential buyers, the demand curve will be smooth, like the one shown in Figure 49.3.

figure 49.3

Consumer Surplus

The demand curve for computers is smooth because there are many potential buyers. At a price of $1,500, 1 million computers are demanded. The consumer surplus at this price is equal to the shaded area: the area below the demand curve but above the price. This is the total net gain to consumers generated from buying and consuming computers when the price is $1,500.



Suppose that at a price of $1,500, a total of 1 million computers are purchased. How much do consumers gain from being able to buy those 1 million computers? We could answer that question by calculating the individual consumer surplus of each buyer and then adding these numbers up to arrive at a total. But it is much easier just to look at Figure 49.3 and use the fact that total consumer surplus is equal to the shaded area below the demand curve but above the price.

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How Changing Prices Affect Consumer Surplus

It is often important to know how price *changes* affect consumer surplus. For example, we may want to know the harm to consumers from a frost in Florida that drives up orange prices or consumers' gain from the introduction of fish farming that makes salmon steaks less expensive. The same approach we have used to derive consumer surplus can be used to answer questions about how changes in prices affect consumers.

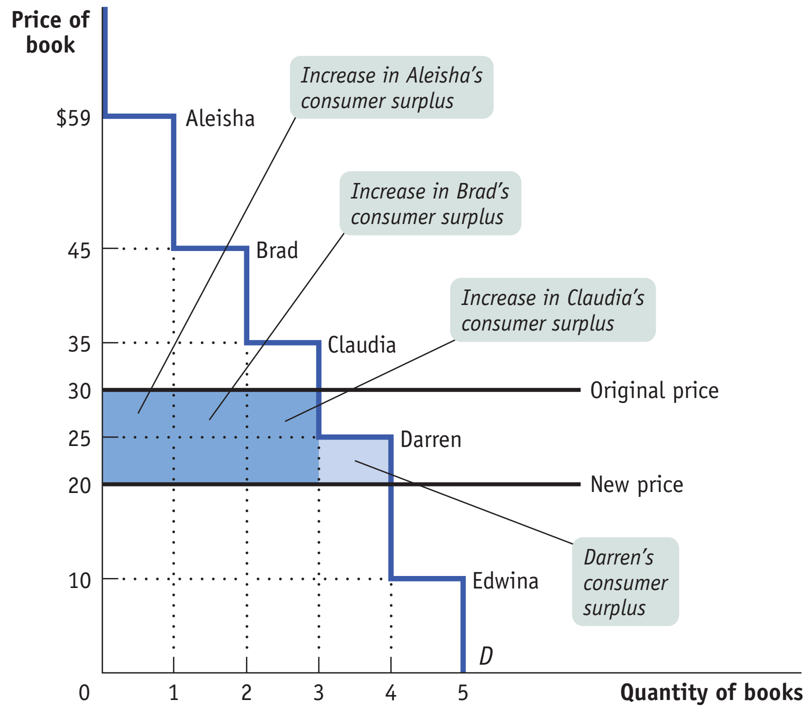
Let's return to the example of the market for used textbooks. Suppose that the bookstore decided to sell used textbooks for $20 instead of $30. By how much would this fall in price increase consumer surplus?

The answer is illustrated in Figure 49.4. As shown in the figure, there are two parts to the increase in consumer surplus. The first part, shaded dark blue, is the gain of those who would have bought books even at the higher price of $30. Each of the students who would have bought books at $30—Aleisha, Brad, and Claudia—now pays $10 less, and therefore each gains $10 in consumer surplus from the fall in price to $20. So

figure 49.4

Consumer Surplus and a Fall in the Price of Used Textbooks

There are two parts to the increase in consumer surplus generated by a fall in price from $30 to $20. The first is given by the dark blue rectangle: each person who would have bought at the original price of $30—Aleisha, Brad, and Claudia—receives an increase in consumer surplus equal to the total reduction in price, $10. So the area of the dark blue rectangle corresponds to an amount equal to 3 × $10 = $30. The second part is given by the light blue area: the increase in consumer surplus for those who would *not* have bought at the original price of $30 but who buy at the new price of $20—namely, Darren. Darren's willingness to pay is $25, so he now receives consumer surplus of $5. The total increase in consumer surplus is 3 × $10 + $5 = $35, represented by the sum of the shaded areas. Likewise, a rise in price from $20 to $30 would decrease consumer surplus by an amount equal to the sum of the shaded areas.



the dark blue area represents the $10 × 3 = $30 increase in consumer surplus to those three buyers. The second part, shaded light blue, is the gain to those who would not have bought a book at $30 but are willing to pay more than $20. In this case that gain goes to Darren, who would not have bought a book at $30 but does buy one at $20. He gains $5—the difference between his willingness to pay of $25 and the new price of $20. So the light blue area represents a further $5 gain in consumer surplus. The total increase in consumer surplus is the sum of the shaded areas, $35. Likewise, a rise in price from $20 to $30 would decrease consumer surplus by an amount equal to the sum of the shaded areas.

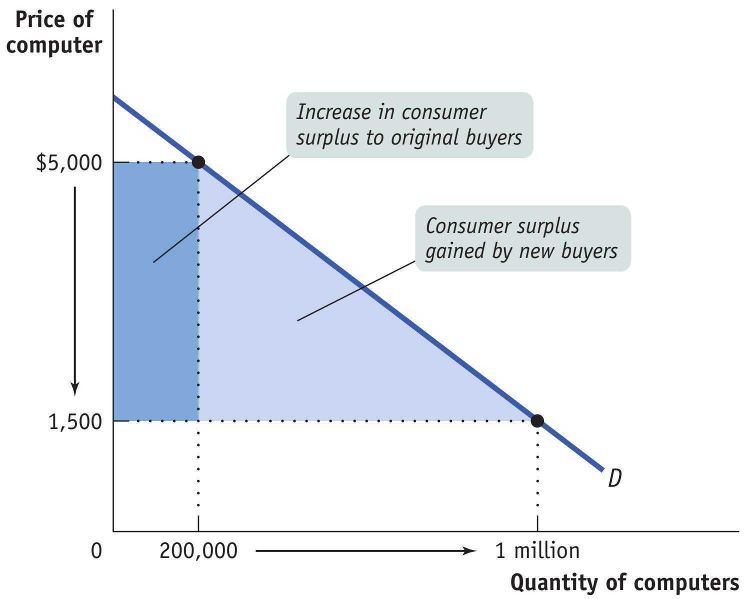
Figure 49.4 illustrates that when the price of a good falls, the area under the demand curve but above the price—the total consumer surplus—increases. Figure 49.5 on the next page shows the same result for the case of a smooth demand curve for personal computers. Here we assume that the price of computers falls from $5,000 to $1,500, leading to an increase in the quantity demanded from 200,000 to 1 million units. As in the used-textbook example, we divide the gain in consumer surplus into two parts. The dark blue rectangle in Figure 49.5 corresponds to the dark blue area in Figure 49.4: it is the gain to the 200,000 people who would have bought computers even at the higher price of $5,000. As a result of the price reduction, each receives additional surplus of $3,500. The light blue triangle in Figure 49.5 corresponds to the light blue area in Figure 49.4: it is the gain to people who would not have bought the good at the higher price but are willing to do so at a price of $1,500. For example, the light blue triangle includes the gain to someone who would have been willing to pay $2,000 for a computer and therefore gains $500 in consumer surplus when it is possible to buy a computer for only $1,500. As before, the total gain in consumer surplus is the sum of the shaded areas, the increase in the area under the demand curve but above the price.

What would happen if the price of a good were to rise instead of fall? We would do the same analysis in reverse. Suppose, for example, that for some reason the price of

figure 49.5

A Fall in the Price Increases Consumer Surplus

A fall in the price of a computer from $5,000 to $1,500 leads to an increase in the quantity demanded and an increase in consumer surplus. The change in total consumer surplus is given by the sum of the shaded areas: the total area below the demand curve and between the old and new prices. Here, the dark blue area represents the increase in consumer surplus for the 200,000 consumers who would have bought a computer at the original price of $5,000; they each receive an increase in consumer surplus of $3,500. The light blue area represents the increase in consumer surplus for those willing to buy at a price equal to or greater than $1,500 but less than $5,000. Similarly, a rise in the price of a computer from $1,500 to $5,000 generates a decrease in consumer surplus equal to the sum of the two shaded areas.



computers rises from $1,500 to $5,000. This would lead to a fall in consumer surplus equal to the sum of the shaded areas in Figure 49.5. This loss consists of two parts. The dark blue rectangle represents the loss to consumers who would still buy a computer, even at a price of $5,000. The light blue triangle represents the loss to consumers who decide not to buy a computer at the higher price.

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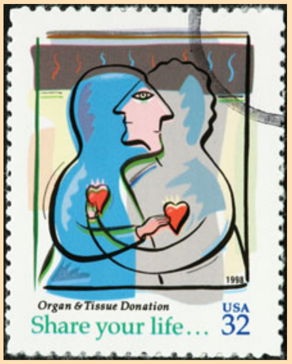
A Matter of Life and Death

Each year about 4,000 people in the United States die while waiting for a kidney transplant. In 2009, some 80,000 were on the waiting list. Since the number of those in need of a kidney far exceeds availability, what is the best way to allocate available organs? A market isn't feasible. For understandable reasons, the sale of human body parts is illegal in this country. So the task of establishing a protocol for these situations has fallen to the nonprofit group United Network for Organ Sharing (UNOS).

Under current UNOS guidelines, a donated kidney goes to the person who has been waiting the longest. According to this system, an available kidney would go to a 75-year-old who has been waiting for 2 years instead of to a 25-year-old who has been waiting 6 months, even though the 25-year-old will likely live longer and benefit from the transplanted organ for a longer period of time.

To address this issue, UNOS is devising a new set of guidelines based on a concept it calls "net benefit." According to these new guidelines, kidneys would be allocated on the basis of who will receive the greatest net benefit, where net benefit is measured as the expected increase in lifespan from the transplant. And age is by far the biggest predictor of how long someone will live after a transplant. For example, a typical 25-year-old diabetic will gain an extra 8.7 years of life from a transplant, but a typical 55-year-old diabetic will gain only 3.6 extra years. Under the current system, based on waiting times, transplants lead to about 44,000 extra years of life for recipients; under the new system, that number would jump to 55,000 extra years. The share of kidneys going to those in their 20s would triple; the share going to those 60 and older would be halved.

What does this have to do with consumer surplus? As you may have guessed, the UNOS concept of "net benefit" is a lot like individual consumer surplus—the individual consumer surplus generated from getting a new kidney. In essence, UNOS has devised a system that allocates donated kidneys according to who gets the greatest individual consumer surplus. In terms of results, then, its proposed "net benefit" system operates a lot like a competitive market.



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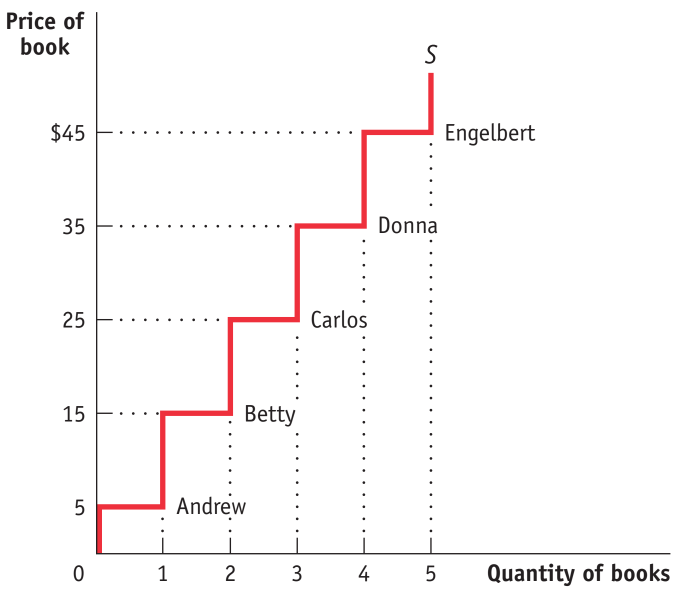
Producer Surplus and the Supply Curve

Just as some buyers of a good would have been willing to pay more for their purchase than the price they actually pay, some sellers of a good would have been willing to sell it for less than the price they actually receive. We can therefore carry out an analysis of producer surplus and the supply curve that is almost exactly parallel to that of consumer surplus and the demand curve.

Cost and Producer Surplus

Consider a group of students who are potential sellers of used textbooks. Because they have different preferences, the various potential sellers differ in the price at which they are willing to sell their books. The table in Figure 49.6 shows the prices at which several different students would be willing to sell. Andrew is willing to sell the book as long as he can get at least $5; Betty won't sell unless she can get at least $15; Carlos requires $25; Donna requires $35; Engelbert $45.

figure 49.6 The Supply Curve for Used Textbooks



Potential sellers	Cost
Andrew	$5
Betty	15
Carlos	25
Donna	35
Engelbert	45

The supply curve illustrates sellers' cost, the lowest price at which a potential seller is willing to sell the good, and the quantity supplied at that price. Each of the five students has one book to sell and each has a different cost, as indicated in the accompanying table. At a price of $5 the quantity supplied is one (Andrew), at $15 it is two (Andrew and Betty), and so on until you reach $45, the price at which all five students are willing to sell.

The lowest price at which a potential seller is willing to sell is called the seller's **cost.** So Andrew's cost is $5, Betty's is $15, and so on.

Using the term *cost,* which people normally associate with the monetary cost of producing a good, may sound a little strange when applied to sellers of used textbooks. The students don't have to manufacture the books, so it doesn't cost the student who sells a book anything to make that book available for sale, does it?

Yes, it does. A student who sells a book won't have it later, as part of his or her personal collection. So there is an *opportunity cost* to selling a textbook, even if the owner has completed the course for which it was required. And remember that one of the basic principles of economics is that the true measure of the cost of doing something is

A seller's **cost** is the lowest price at which he or she is willing to sell a good.

Individual producer surplus is the net gain to an individual seller from selling a good. It is equal to the difference between the price received and the seller's cost.

Total producer surplus in a market is the sum of the individual producer surpluses of all the sellers of a good in a market. Economists use the term **producer surplus** to refer both to individual and to total producer surplus.

always its opportunity cost. That is, the real cost of something is what you must give up to get it.

So it is good economics to talk of the minimum price at which someone will sell a good as the "cost" of selling that good, even if he or she doesn't spend any money to make the good available for sale. Of course, in most real-world markets the sellers are also those who produce the good and therefore *do* spend money to make the good available for sale. In this case the cost of making the good available for sale *includes* monetary costs, but it may also include other opportunity costs.

Getting back to the example, suppose that Andrew sells his book for $30. Clearly he has gained from the transaction: he would have been willing to sell for only $5, so he has gained $25. This net gain, the difference between the price he actually gets and his cost—the minimum price at which he would have been willing to sell—is known as his **individual producer surplus.**

Just as we derived the demand curve from the willingness to pay of different consumers, we can derive the supply curve from the cost of different producers. The step-shaped curve in Figure 49.6 shows the supply curve implied by the costs shown in the accompanying table. At a price less than $5, none of the students are willing to sell; at a price between $5 and $15, only Andrew is willing to sell, and so on.

As in the case of consumer surplus, we can add the individual producer surpluses of sellers to calculate the **total producer surplus,** the total net gain to all sellers in the market. Economists use the term **producer surplus** to refer to either total or individual producer surplus. Table 49.2 shows the net gain to each of the students who would sell a used book at a price of $30: $25 for Andrew, $15 for Betty, and $5 for Carlos. The total producer surplus is $25 + $15 + $5 = $45.

table 49.2

Producer Surplus When the Price of a Used Textbook Is $30

Potential seller	Cost	Price received	Individual producer surplus = Price received − Cost
Andrew	$5	$30	$25
Betty	15	30	15
Carlos	25	30	5
Donna	35	—	—
Engelbert	45	—	—
All sellers			Total producer surplus = $45

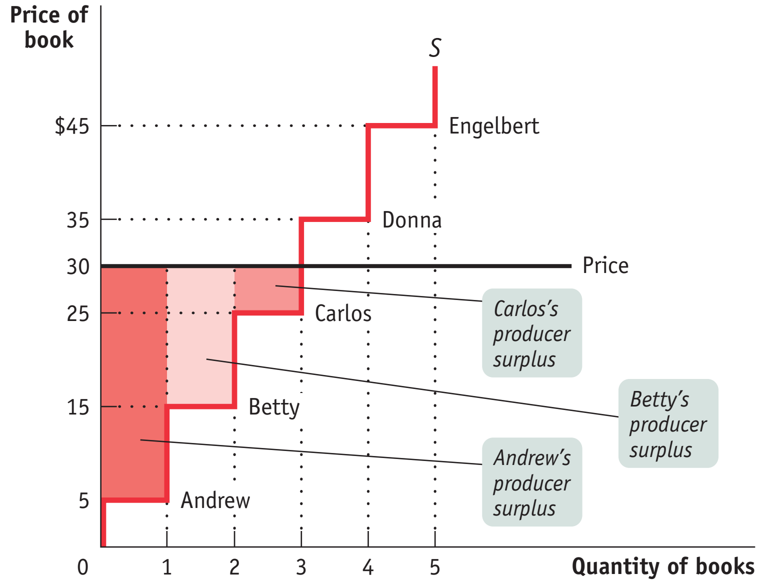
As with consumer surplus, the producer surplus gained by those who sell books can be represented graphically. Figure 49.7 reproduces the supply curve from Figure 49.6. Each step in that supply curve is one book wide and represents one seller. The height of Andrew's step is $5, his cost. This forms the bottom of a rectangle, with $30, the price he actually receives for his book, forming the top. The area of this rectangle, ($30 − $5) × 1 = $25, is his producer surplus. So the producer surplus Andrew gains from selling his book is the *area of the dark red rectangle* shown in the figure.

Let's assume that the campus bookstore is willing to buy all the used copies of this book that students are willing to sell at a price of $30. Then, in addition to Andrew, Betty and Carlos will also sell their books. They will also benefit from their sales, though not as much as Andrew, because they have higher costs. Andrew, as we have seen, gains $25. Betty gains a smaller amount: since her cost is $15, she gains only $15. Carlos gains even less, only $5.

figure 49.7

Producer Surplus in the Used-Textbook Market

At a price of $30, Andrew, Betty, and Carlos each sell a book but Donna and Engelbert do not. Andrew, Betty, and Carlos get individual producer surpluses equal to the difference between the price and their cost, illustrated here by the shaded rectangles. Donna and Engelbert each have a cost that is greater than the price of $30, so they are unwilling to sell a book and so receive zero producer surplus. The total producer surplus is given by the entire shaded area, the sum of the individual producer surpluses of Andrew, Betty, and Carlos, equal to $25 + $15 + $5 = $45.



Again, as with consumer surplus, we have a general rule for determining the total producer surplus from sales of a good: *The total producer surplus from sales of a good at a given price is the area above the supply curve but below that price.*

This rule applies both to examples like the one shown in Figure 49.7, where there are a small number of producers and a step-shaped supply curve, and to more realistic examples, where there are many producers and the supply curve is more or less smooth.

Consider, for example, the supply of wheat. Figure 49.8 shows how producer surplus depends on the price per bushel. Suppose that, as shown in


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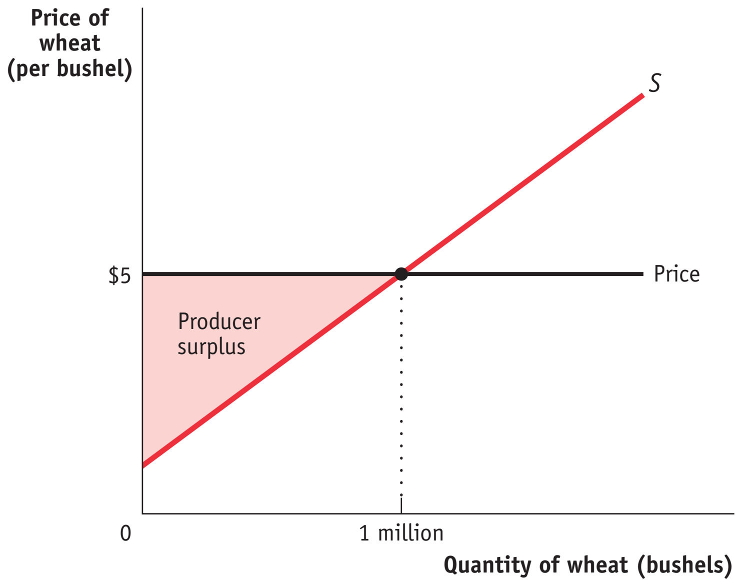
figure 49.8

Producer Surplus

Here is the supply curve for wheat. At a price of $5 per bushel, farmers supply 1 million bushels. The producer surplus at this price is equal to the shaded area: the area above the supply curve but below the price. This is the total gain to producers—farmers in this case—from supplying their product when the price is $5.



the figure, the price is $5 per bushel and farmers supply 1 million bushels. What is the benefit to the farmers from selling their wheat at a price of $5? Their producer surplus is equal to the shaded area in the figure—the area above the supply curve but below the price of $5 per bushel.

How Changing Prices Affect Producer Surplus

As in the case of consumer surplus, a change in price alters producer surplus. However, although a fall in price increases consumer surplus, it reduces producer surplus. Similarly, a rise in price reduces consumer surplus but increases producer surplus.

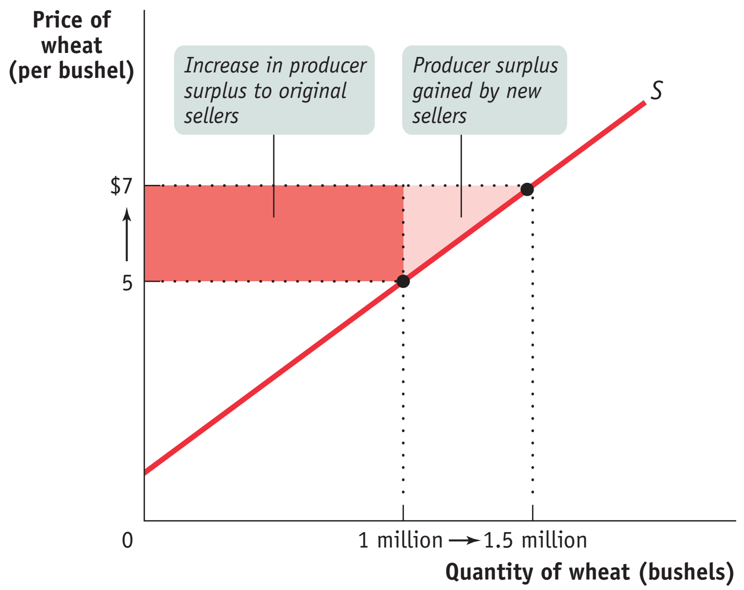
To see this, let's first consider a rise in the price of the good. Producers of the good will experience an increase in producer surplus, though not all producers gain the same amount. Some producers would have produced the good even at the original price; they will gain the entire price increase on every unit they produce. Other producers will enter the market because of the higher price; they will gain only the difference between the new price and their cost.

Figure 49.9 is the supply counterpart of Figure 49.5. It shows the effect on producer surplus of a rise in the price of wheat from $5 to $7 per bushel. The increase in producer surplus is the sum of the shaded areas, which consists of two parts. First, there is a dark red rectangle corresponding to the gains to those farmers who would have supplied wheat even at the original $5 price. Second, there is an additional light red triangle that corresponds to the gains to those farmers who would not have supplied wheat at the original price but are drawn into the market by the higher price.

figure 49.9

A Rise in the Price Increases Producer Surplus

A rise in the price of wheat from $5 to $7 leads to an increase in the quantity supplied and an increase in producer surplus. The change in total producer surplus is given by the sum of the shaded areas: the total area above the supply curve but between the old and new prices. The dark red area represents the gain to the farmers who would have supplied 1 million bushels at the original price of $5; they each receive an increase in producer surplus of $2 for each of those bushels. The triangular light red area represents the increase in producer surplus achieved by the farmers who supply the additional 500,000 bushels because of the higher price. Similarly, a fall in the price of wheat generates a reduction in producer surplus equal to the sum of the shaded areas.



If the price were to fall from $7 to $5 per bushel, the story would run in reverse. The sum of the shaded areas would now be the decline in producer surplus, the decrease in the area above the supply curve but below the price. The loss would consist of two parts, the loss to farmers who would still grow wheat at a price of $5 (the dark red rectangle) and the loss to farmers who decide to no longer grow wheat because of the lower price (the light red triangle).

Module 49 AP Review

Solutions appear at the back of the book.

Check Your Understanding

1. Consider the market for cheese-stuffed jalapeno peppers. There are two consumers, Casey and Josey, and their willingness to pay for each pepper is given in the accompanying table. (Neither is willing to consume more than 4 peppers at any price.) Use the table (i) to construct the demand schedule for peppers for prices of $0.00, $0.10, and so on, up to $0.90, and (ii) to calculate the total consumer surplus when the price of a pepper is $0.40.

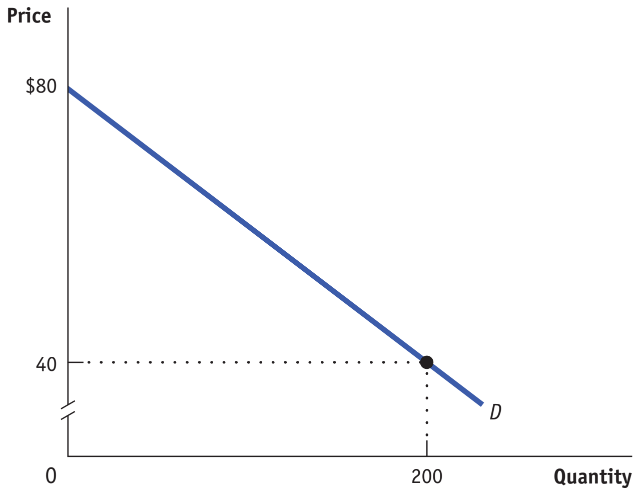
Quantity of peppers	*Casey's willingness to pay*	*Josey's willingness to pay*
1st pepper	$0.90	$0.80
2nd pepper	0.70	0.60
3rd pepper	0.50	0.40
4th pepper	0.30	0.30

2. Again consider the market for cheese-stuffed jalapeno peppers. There are two producers, Cara and Jamie, and their costs of producing each pepper are given in the accompanying table. (Neither is willing to produce more than 4 peppers at any price.) Use the table (i) to construct the supply schedule for peppers for prices of $0.00, $0.10, and so on, up to $0.90, and (ii) to calculate the total producer surplus when the price of a pepper is $0.70.

Quantity of peppers	*Cara's cost*	*Jamie's cost*
1st pepper	$0.10	$0.30
2nd pepper	0.10	0.50
3rd pepper	0.40	0.70
4th pepper	0.60	0.90

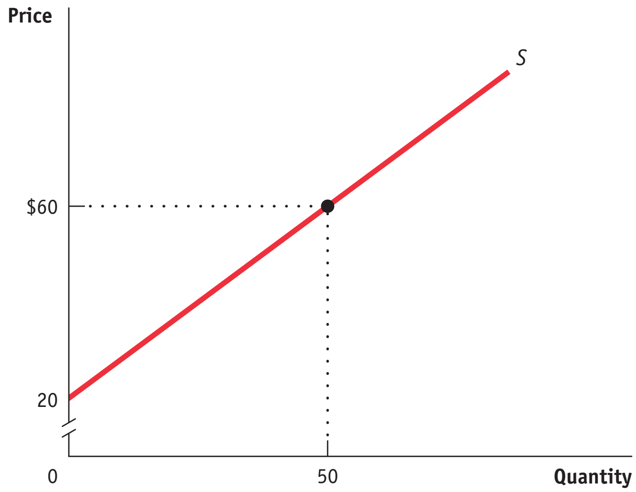
Tackle the Test: Multiple-Choice Questions

1. Refer to the graph below. What is the value of consumer surplus when the market price is $40?



a. $400
b. $800
c. $4,000
d. $8,000
e. $16,000

2. Refer to the graph below. What is the value of producer surplus when the market price is $60?



a. $100
b. $150
c. $1,000
d. $1,500
e. $3,000

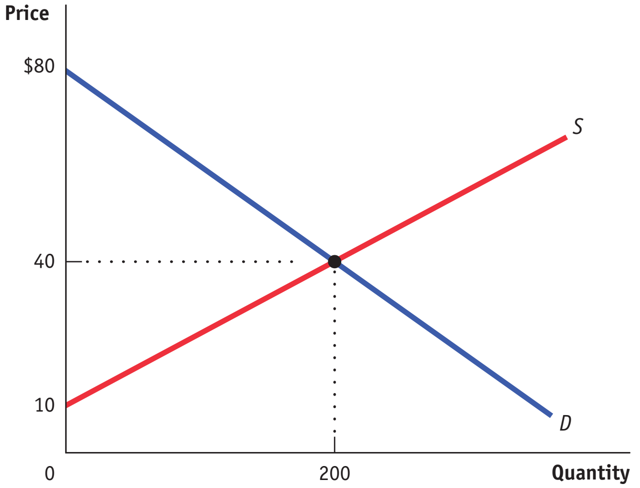
3. Other things equal, a rise in price will result in which of the following?
   a. Producer surplus will rise; consumer surplus will rise.
   b. Producer surplus will fall; consumer surplus will fall.
   c. Producer surplus will rise; consumer surplus will fall.
   d. Producer surplus will fall; consumer surplus will rise.
   e. Producer surplus will not change; consumer surplus will rise.

4. Consumer surplus is found as the area
   a. above the supply curve and below the price.
   b. below the demand curve and above the price.
   c. above the demand curve and below the price.
   d. below the supply curve and above the price.
   e. below the supply curve and above the demand curve.

5. Allocating kidneys to those with the highest net benefit (where net benefit is measured as the expected increase in lifespan from a transplant) is an attempt to maximize
   a. consumer surplus.
   b. producer surplus.
   c. profit.
   d. equity.
   e. respect for elders.

Tackle the Test: Free-Response Questions

1. Refer to the graph provided.



   a. Calculate consumer surplus.
   b. Calculate producer surplus.
   c. If supply increases, what will happen to consumer surplus? Explain.
   d. If demand decreases, what will happen to producer surplus? Explain.

Answer (6 points)

1 point: $4,000

1 point: $3,000

1 point: Consumer surplus will increase.

1 point: An increase in supply lowers the equilibrium price, which causes consumer surplus to increase.

1 point: Producer surplus will decrease.

1 point: A decrease in demand decreases the equilibrium price, which causes producer surplus to decrease.

2. Draw a correctly labeled graph showing a competitive market in equilibrium. On your graph, clearly indicate and label the area of consumer surplus and the area of producer surplus.

Module 50 Efficiency and Deadweight Loss

What you will learn in this Module:

- The meaning and importance of total surplus and how it can be used to illustrate efficiency in markets
- How taxes affect total surplus and can create deadweight loss

Consumer Surplus, Producer Surplus, and Efficiency

Markets are a remarkably effective way to organize economic activity: under the right conditions, they can make society as well off as possible given the available resources. The concepts of consumer and producer surplus can help us deepen our understanding of why this is so.

The Gains from Trade

Let's return to the market for used textbooks, but now consider a much bigger market—say, one at a large state university. There are many potential buyers and sellers, so the market is competitive. Let's line up incoming students who are potential buyers of a book in order of their willingness to pay, so that the entering student with the highest willingness to pay is potential buyer number 1, the student with the next highest willingness to pay is number 2, and so on. Then we can use their willingness to pay to derive a demand curve like the one in Figure 50.1 on the next page. Similarly, we can line up outgoing students, who are potential sellers of the book, in order of their cost, starting with the student with the lowest cost, then the student with the next lowest cost, and so on, to derive a supply curve like the one shown in the same figure.

As we have drawn the curves, the market reaches equilibrium at a price of $30 per book, and 1,000 books are bought and sold at that price. The two shaded triangles show the consumer surplus (blue) and the producer surplus (red) generated by this market. The sum of consumer and producer surplus is known as **total surplus.**

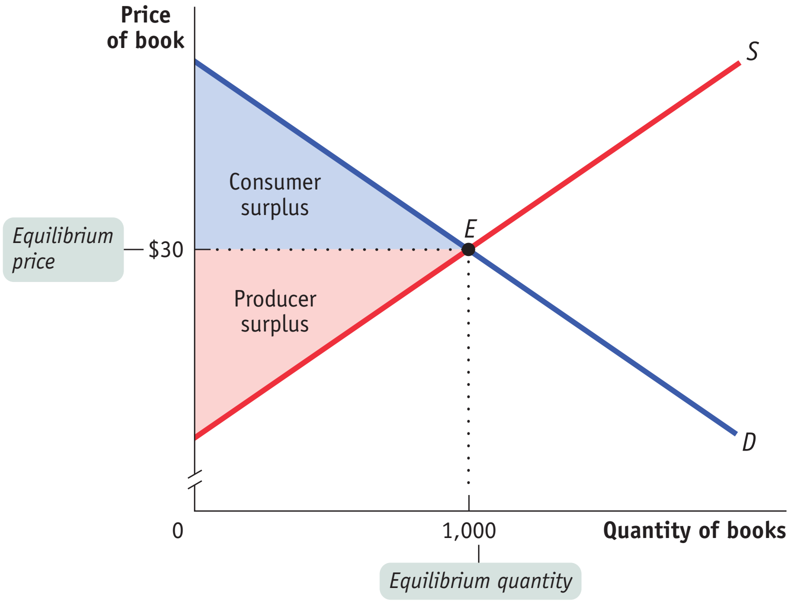
The striking thing about this picture is that both consumers and producers gain—that is, both consumers and producers are better off because there is a market in this good. But this should come as no surprise—it illustrates another core principle of economics: *There are gains from trade*. These gains from trade are the reason everyone is better off participating in a market economy than they would be if each individual tried to be self-sufficient.

Total surplus is the total net gain to consumers and producers from trading in a market. It is the sum of producer and consumer surplus.

figure 50.1

Total Surplus

In the market for used textbooks, the equilibrium price is $30 and the equilibrium quantity is 1,000 books. Consumer surplus is given by the blue area, the area below the demand curve but above the price. Producer surplus is given by the red area, the area above the supply curve but below the price. The sum of the blue and the red areas is total surplus, the total benefit to society from the production and consumption of the good.



But are we as well off as we could be? This brings us to the question of the efficiency of markets.

The Efficiency of Markets

A market is *efficient* if, once the market has produced its gains from trade, there is no way to make some people better off without making other people worse off. Note that market equilibrium is just *one* way of deciding who consumes a good and who sells a good. To better understand how markets promote efficiency, let's examine some alternatives. Consider the example of kidney transplants discussed earlier in an FYI box. There is not a market for kidneys, and available kidneys currently go to whoever has been on the waiting list the longest. Of course, those who have been waiting the longest aren't necessarily those who would benefit the most from a new kidney.

Similarly, imagine a committee charged with improving on the market equilibrium by deciding who gets and who gives up a used textbook. The committee's ultimate goal would be to bypass the market outcome and come up with another arrangement that would increase total surplus.

Let's consider three approaches the committee could take:

1. It could reallocate consumption among consumers.
2. It could reallocate sales among sellers.
3. It could change the quantity traded.

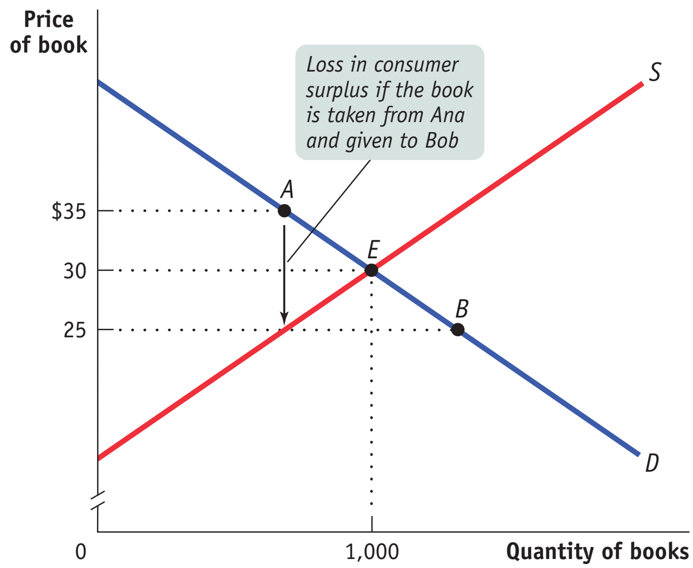
The Reallocation of Consumption Among Consumers The committee might try to increase total surplus by selling books to different consumers. Figure 50.2 shows why this will result in lower surplus compared to the market equilibrium outcome. Points *A* and *B* show the positions on the demand curve of two potential buyers of used books, Ana and Bob. As we can see from the figure, Ana is willing to pay $35 for a book, but Bob is willing to pay only $25. Since the market equilibrium price is $30, under the market outcome Ana gets a book and Bob does not.

Now suppose the committee reallocates consumption. This would mean taking the book away from Ana and giving it to Bob. Since the book is worth $35 to Ana but only $25 to Bob, this change *reduces total consumer surplus* by $35 − $25 = $10. Moreover, this result

figure 50.2

Reallocating Consumption Lowers Consumer Surplus

Ana (point *A*) has a willingness to pay of $35. Bob (point *B*) has a willingness to pay of only $25. At the market equilibrium price of $30, Ana purchases a book but Bob does not. If we rearrange consumption by taking a book from Ana and giving it to Bob, consumer surplus declines by $10 and, as a result, total surplus declines by $10. The market equilibrium generates the highest possible consumer surplus by ensuring that those who consume the good are those who most value it.



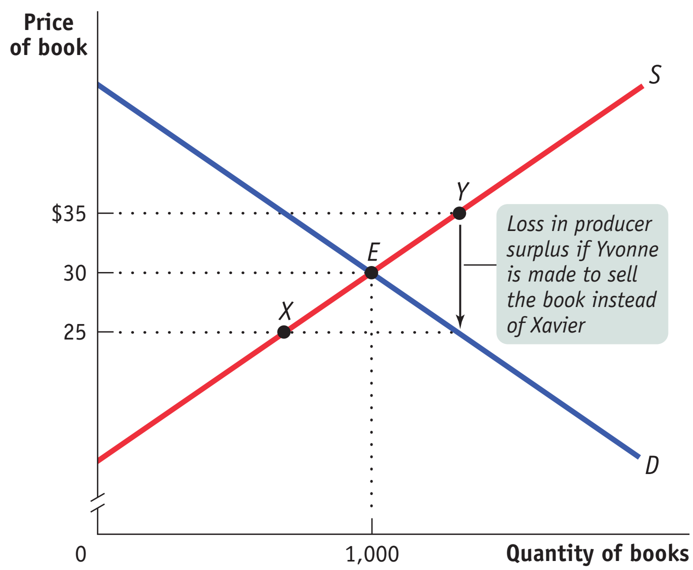
doesn't depend on which two students we pick. Every student who buys a book at the market equilibrium price has a willingness to pay of $30 or more, and every student who doesn't buy a book has a willingness to pay of less than $30. So reallocating the good among consumers always means taking a book away from a student who values it more and giving it to one who values it less. This necessarily reduces total consumer surplus.

The Reallocation of Sales Among Sellers The committee might try to increase total surplus by altering who sells their books, taking sales away from sellers who would have sold their books in the market equilibrium and instead compelling those who would not have sold their books in the market equilibrium to sell them. Figure 50.3 shows why this will result in lower surplus. Here points *X* and *Y* show the positions on the supply

figure 50.3

Reallocating Sales Lowers Producer Surplus

Yvonne (point *Y*) has a cost of $35, $10 more than Xavier (point *X*), who has a cost of $25. At the market equilibrium price of $30, Xavier sells a book but Yvonne does not. If we rearrange sales by preventing Xavier from selling his book and compelling Yvonne to sell hers, producer surplus declines by $10 and, as a result, total surplus declines by $10. The market equilibrium generates the highest possible producer surplus by assuring that those who sell the good are those who most value the right to sell it.



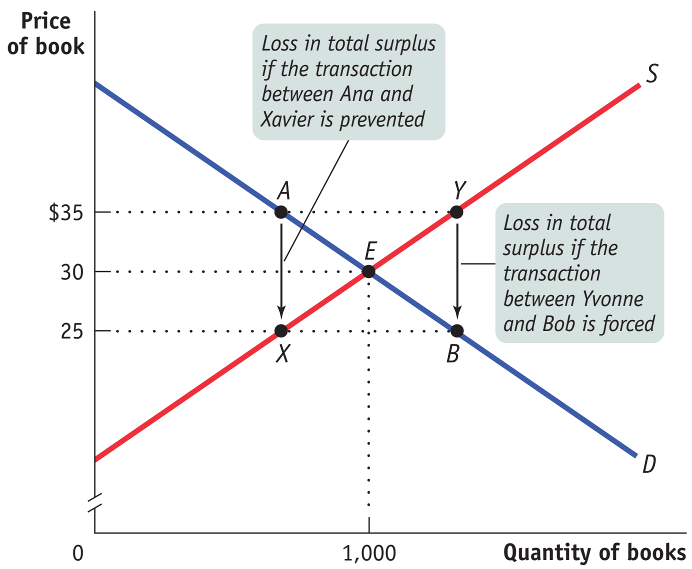
curve of Xavier, who has a cost of \$25, and Yvonne, who has a cost of \$35. At the equilibrium market price of \$30, Xavier would sell his book but Yvonne would not sell hers. If the committee reallocated sales, forcing Xavier to keep his book and Yvonne to sell hers, total producer surplus would be reduced by \$35 – \$25 = \$10. Again, it doesn't matter which two students we choose. Any student who sells a book at the market equilibrium price has a lower cost than any student who keeps a book. So reallocating sales among sellers necessarily increases total cost and reduces total producer surplus.

Changes in the Quantity Traded The committee might try to increase total surplus by compelling students to trade either more books or fewer books than the market equilibrium quantity. Figure 50.4 shows why this will result in lower surplus. It shows all four students: potential buyers Ana and Bob, and potential sellers Xavier and Yvonne. To reduce sales, the committee will have to prevent a transaction that would have occurred in the market equilibrium—that is, prevent Xavier from selling to Ana. Since Ana is willing to pay \$35 and Xavier's cost is \$25, preventing this transaction reduces total surplus by \$35 – \$25 = \$10. Once again, this result doesn't depend on which two students we pick: any student who would have sold the book in the market equilibrium has a cost of \$30 or less, and any student who would have purchased the book in the market equilibrium has a willingness to pay of \$30 or more. So preventing any sale that would have occurred in the market equilibrium necessarily reduces total surplus.

figure 50.4

Changing the Quantity Lowers Total Surplus

If Xavier (point *X*) were prevented from selling his book to someone like Ana (point *A*), total surplus would fall by \$10, the difference between Ana's willingness to pay (\$35) and Xavier's cost (\$25). This means that total surplus falls whenever fewer than 1,000 books—the equilibrium quantity—are transacted. Likewise, if Yvonne (point *Y*) were compelled to sell her book to someone like Bob (point *B*), total surplus would also fall by \$10, the difference between Yvonne's cost (\$35) and Bob's willingness to pay (\$25). This means that total surplus falls whenever more than 1,000 books are transacted. These two examples show that at market equilibrium, all mutually beneficial transactions—and only mutually beneficial transactions—occur.



Finally, the committee might try to increase sales by forcing Yvonne, who would not have sold her book in the market equilibrium, to sell it to someone like Bob, who would not have bought a book in the market equilibrium. Because Yvonne's cost is \$35, but Bob is only willing to pay \$25, this transaction reduces total surplus by \$10. And once again it doesn't matter which two students we pick—anyone who wouldn't have bought the book has a willingness to pay of less than \$30, and anyone who wouldn't have sold has a cost of more than \$30.

The key point to remember is that once this market is in equilibrium, there is no way to increase the gains from trade. Any other outcome reduces total surplus. We can summarize our results by stating that an efficient market performs four important functions:

1. It allocates consumption of the good to the potential buyers who most value it, as indicated by the fact that they have the highest willingness to pay.
2. It allocates sales to the potential sellers who most value the right to sell the good, as indicated by the fact that they have the lowest cost.
3. It ensures that every consumer who makes a purchase values the good more than every seller who makes a sale, so that all transactions are mutually beneficial.
4. It ensures that every potential buyer who doesn't make a purchase values the good less than every potential seller who doesn't make a sale, so that no mutually beneficial transactions are missed.

There are three caveats, however. First, although a market may be efficient, it isn't necessarily *fair.* In fact, fairness, or *equity,* is often in conflict with efficiency. We'll discuss this next.

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The second caveat is that markets sometimes *fail.* Under some well-defined conditions, markets can fail to deliver efficiency. When this occurs, markets no longer maximize total surplus. We'll take a closer look at market failures in later modules.

Third, even when the market equilibrium maximizes total surplus, this does not mean that it results in the best outcome for every *individual* consumer and producer. Other things equal, each buyer would like to pay a lower price and each seller would like to receive a higher price. So if the government were to intervene in the market—say, by lowering the price below the equilibrium price to make consumers happy or by raising the price above the equilibrium price to make producers happy—the outcome would no longer be efficient. Although some people would be happier, society as a whole would be worse off because total surplus would be lower.

Equity and Efficiency

It's easy to get carried away with the idea that markets are always good and that economic policies that interfere with efficiency are bad. But that would be misguided because there is another factor to consider: society cares about equity, or what's "fair." There is often a trade-off between equity and efficiency: policies that promote equity often come at the cost of decreased efficiency, and policies that promote efficiency often result in decreased equity. So it's important to realize that a society's choice to sacrifice some efficiency for the sake of equity, however it defines equity, may well be a valid one. And it's important to understand that fairness, unlike efficiency, can be very hard to define. Fairness is a concept about which well-intentioned people often disagree.

In fact, the debate about equity and efficiency is at the core of most debates about taxation. Proponents of taxes that redistribute income from the rich to the poor often argue for the fairness of such redistributive taxes. Opponents of taxation often argue that phasing out certain taxes would make the economy more efficient.

Because taxes are ultimately paid out of income, economists classify taxes according to how they vary with the income of individuals. A tax that rises more than in proportion to income, so that high-income taxpayers pay a larger percentage of their income than low-income taxpayers, is a **progressive tax.** A tax that rises less than in proportion to income, so that high-income taxpayers pay a smaller percentage of their income than low-income taxpayers, is a **regressive tax.** A tax that rises in proportion to income, so that all taxpayers pay the same percentage of their income, is a **proportional tax.** The U.S. tax system contains a mixture of progressive and regressive taxes, though it is somewhat progressive overall.

A **progressive tax** rises more than in proportion to income. A **regressive tax** rises less than in proportion to income. A **proportional tax** rises in proportion to income.

An **excise tax** is a tax on sales of a particular good or service.

The Effects of Taxes on Total Surplus

To understand the economics of taxes, it's helpful to look at a simple type of tax known as an **excise tax**—a tax charged on each unit of a good or service that is sold. Most tax revenue in the United States comes from other kinds of taxes, but excise taxes are common. For example, there are excise taxes on gasoline, cigarettes, and foreign-made trucks, and many local governments impose excise taxes on services such as hotel room rentals. The lessons we'll learn from studying excise taxes apply to other, more complex taxes as well.

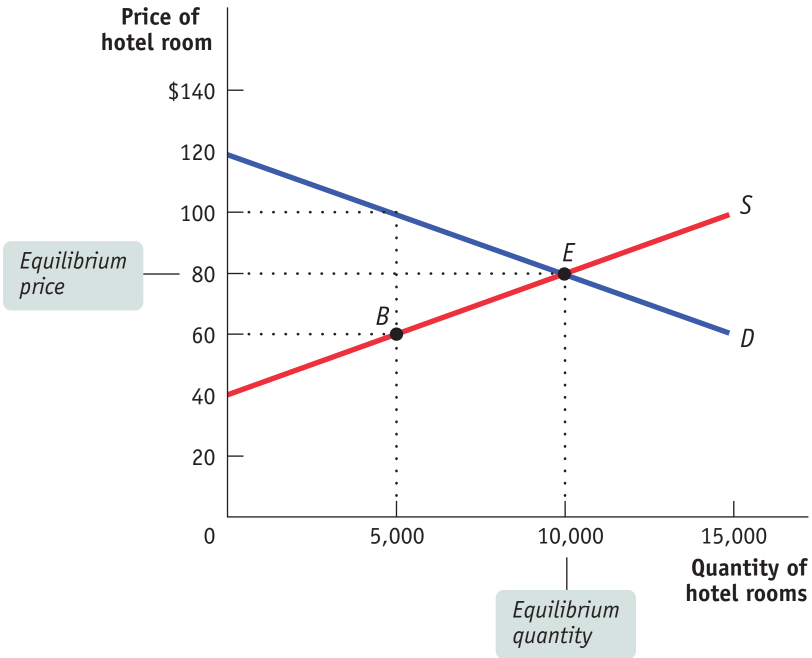
The Effect of an Excise Tax on Quantities and Prices

Suppose that the supply and demand for hotel rooms in the city of Potterville are as shown in Figure 50.5. We'll make the simplifying assumption that all hotel rooms are the same. In the absence of taxes, the equilibrium price of a room is $80 per night and the equilibrium quantity of hotel rooms rented is 10,000 per night.

figure 50.5

The Supply and Demand for Hotel Rooms in Potterville

In the absence of taxes, the equilibrium price of hotel rooms is $80 a night, and the equilibrium number of rooms rented is 10,000 per night, as shown by point *E*. The supply curve, *S*, shows the quantity supplied at any given price, pre-tax. At a price of $60 a night, hotel owners are willing to supply 5,000 rooms, as shown by point *B*. But post-tax, hotel owners are willing to supply the same quantity only at a price of $100: $60 for themselves plus $40 paid to the city as tax.



Now suppose that Potterville's government imposes an excise tax of $40 per night on hotel rooms—that is, every time a room is rented for the night, the owner of the hotel must pay the city $40. For example, if a customer pays $80, $40 is collected as a tax, leaving the hotel owner with only $40. As a result, hotel owners are less willing to supply rooms at any given price.

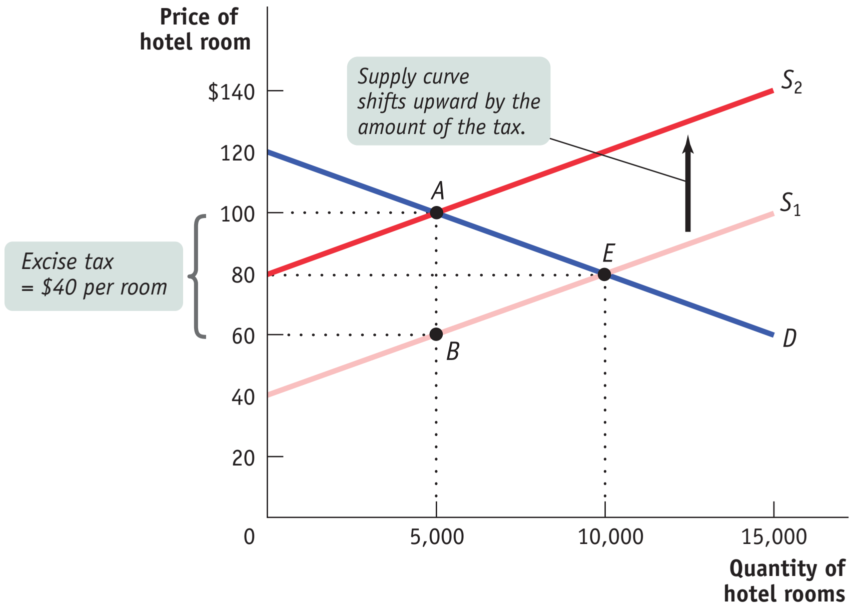
What does this imply about the supply curve for hotel rooms in Potterville? To answer this question, we must compare the incentives of hotel owners *pre-tax* (before the tax is levied) to their incentives *post-tax* (after the tax is levied). From Figure 50.5 we know that pre-tax, hotel owners are willing to supply 5,000 rooms per night at a price of $60 per room. But after the $40 tax per room is levied, they are willing to supply the same amount, 5,000 rooms, only if they receive $100 per room—$60 for themselves plus $40 paid to the city as tax. In other words, in order for hotel owners to be willing to supply the same quantity post-tax as they would have pre-tax, they must receive an additional $40 per room, the amount of the tax. This implies that the post-tax supply curve shifts up by the amount of the tax compared to the pre-tax supply curve. At every quantity supplied, the supply price—the price that producers must receive to produce a given quantity—has increased by $40.

The upward shift of the supply curve caused by the tax is shown in Figure 50.6, where S_1 is the pre-tax supply curve and S_2 is the post-tax supply curve. As you can see, the market equilibrium moves from *E,* at the equilibrium price of \$80 per room and 10,000 rooms rented each night, to *A,* at a market price of \$100 per room and only 5,000 rooms rented each night. *A* is, of course, on both the demand curve *D* and the new supply curve S_2. In this case, \$100 is the demand price of 5,000 rooms—but in effect hotel owners receive only \$60, when you account for the fact that they have to pay the \$40 tax. From the point of view of hotel owners, it is as if they were on their original supply curve at point *B*.

figure 50.6

An Excise Tax Imposed on Hotel Owners

A \$40 per room tax imposed on hotel owners shifts the supply curve from S_1 to S_2, an upward shift of \$40. The equilibrium price of hotel rooms rises from \$80 to \$100 a night, and the equilibrium quantity of rooms rented falls from 10,000 to 5,000. Although hotel owners pay the tax, they actually bear only half the burden: the price they receive net of tax falls only \$20, from \$80 to \$60. Guests who rent rooms bear the other half of the burden because the price they pay rises by \$20, from \$80 to \$100.



Let's check this again. How do we know that 5,000 rooms will be supplied at a price of \$100? Because the price *net of tax* is \$60, and according to the original supply curve, 5,000 rooms will be supplied at a price of \$60, as shown by point *B* in Figure 50.6.

An excise tax *drives a wedge* between the price paid by consumers and the price received by producers. As a result of this wedge, consumers pay more and producers receive less. In our example, consumers—people who rent hotel rooms—end up paying \$100 a night, \$20 more than the pre-tax price of \$80. At the same time, producers—the hotel owners—receive a price net of tax of \$60 per room, \$20 less than the pre-tax price. In addition, the tax creates missed opportunities: 5,000 potential consumers who would have rented hotel rooms—those willing to pay \$80 but not \$100 per night—are discouraged from renting rooms. Correspondingly, 5,000 rooms that would have been made available by hotel owners when they receive \$80 are not offered when they receive only \$60. Like a quota on sales as discussed in Module 9, this tax leads to inefficiency by distorting incentives and creating missed opportunities for mutually beneficial transactions.

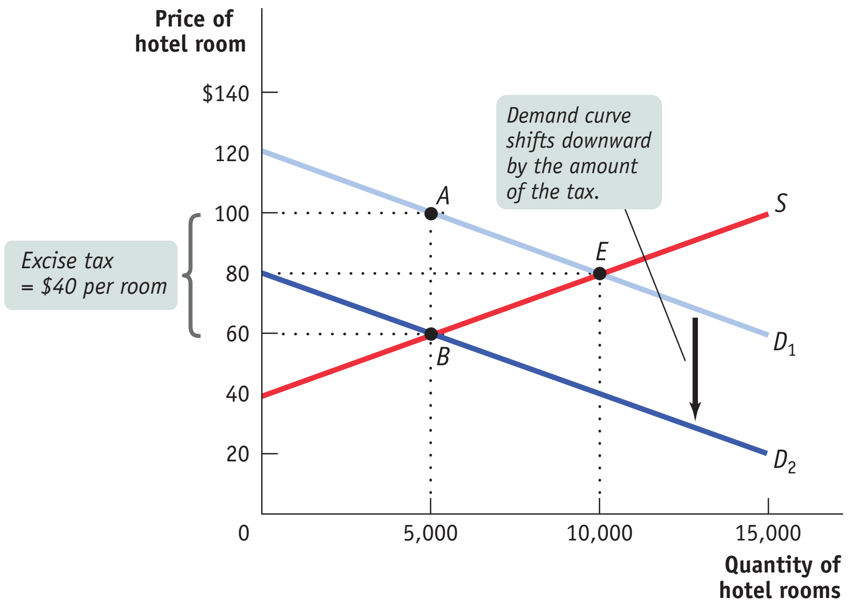
It's important to recognize that as we've described it, Potterville's hotel tax is a tax on the hotel owners, not their guests—it's a tax on the producers, not the consumers. Yet the price received by producers, net of tax, is down by only \$20, half the amount of the tax, and the price paid by consumers is up by \$20. In effect, half the tax is being paid by consumers.

What would happen if the city levied a tax on consumers instead of producers? That is, suppose that instead of requiring hotel owners to pay $40 a night for each room they rent, the city required hotel *guests* to pay $40 for each night they stayed in a hotel. The answer is shown in Figure 50.7. If a hotel guest must pay a tax of $40 per night, then the price for a room paid by that guest must be reduced by $40 in order for the quantity of hotel rooms demanded post-tax to be the same as that demanded pre-tax. So the demand curve shifts *downward,* from D_1 to D_2, by the amount of the tax. At every quantity demanded, the demand price—the price that consumers must be offered to demand a given quantity—has fallen by $40. This shifts the equilibrium from *E* to *B,* where the market price of hotel rooms is $60 and 5,000 hotel rooms are bought and sold. In effect, hotel guests pay $100 when you include the tax. So from the point of view of guests, it is as if they were on their original demand curve at point *A*.

figure 50.7

An Excise Tax Imposed on Hotel Guests

A $40 per room tax imposed on hotel guests shifts the demand curve from D_1 to D_2, a downward shift of $40. The equilibrium price of hotel rooms falls from $80 to $60 a night, and the quantity of rooms rented falls from 10,000 to 5,000. Although in this case the tax is officially paid by consumers, while in Figure 50.6 the tax was paid by producers, the outcome is the same: after taxes, hotel owners receive $60 per room but guests pay $100. This illustrates a general principle: *The incidence of an excise tax doesn't depend on whether consumers or producers officially pay the tax.*



If you compare Figures 50.6 and 50.7, you will notice that the effects of the tax are the same even though different curves are shifted. In each case, consumers pay $100 per unit (including the tax, if it is their responsibility), producers receive $60 per unit (after paying the tax, if it is their responsibility), and 5,000 hotel rooms are bought and sold. *In fact, it doesn't matter who officially pays the tax—the equilibrium outcome is the same.*

This example illustrates a general principle of **tax incidence,** a measure of who really pays a tax: the burden of a tax cannot be determined by looking at who writes the check to the government. In this particular case, a $40 tax on hotel rooms brings about a $20 increase in the price paid by consumers and a $20 decrease in the price received by producers. Regardless of whether the tax is levied on consumers or producers, the incidence of the tax is the same. As we will see next, the burden of a tax depends on the price elasticities of supply and demand.

Price Elasticities and Tax Incidence

Tax incidence is the distribution of the tax burden.

We've just learned that the incidence of an excise tax doesn't depend on who officially pays it. In the example shown in Figures 50.5 through 50.7, a tax on hotel rooms falls equally on consumers and producers, no matter on whom the tax is levied. But it's important to note that this 50–50 split between consumers and producers is a result of our assumptions in this example. In the real world, the incidence of an excise tax usually falls unevenly between consumers and producers: one group bears more of the burden than the other.

What determines how the burden of an excise tax is allocated between consumers and producers? The answer depends on the shapes of the supply and the demand curves. *More specifically, the incidence of an excise tax depends on the price elasticity of supply and the price elasticity of demand.* We can see this by looking first at a case in which consumers pay most of an excise tax, and then at a case in which producers pay most of the tax.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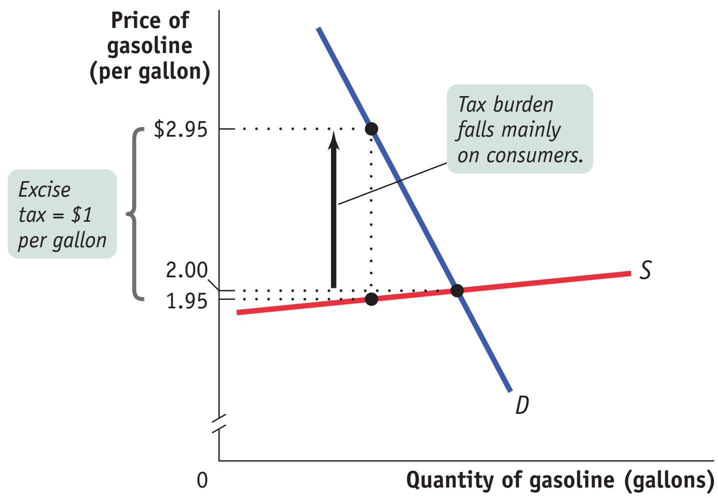
When an Excise Tax Is Paid Mainly by Consumers Figure 50.8 shows an excise tax that falls mainly on consumers: an excise tax on gasoline, which we set at $1 per gallon. (There really is a federal excise tax on gasoline, though it is actually only about $0.18 per gallon in the United States. In addition, states impose excise taxes between $0.08 and $0.37 per gallon.) According to Figure 50.8, in the absence of the tax, gasoline would sell for $2 per gallon.

figure 50.8

An Excise Tax Paid Mainly by Consumers

The relatively steep demand curve here reflects a low price elasticity of demand for gasoline. The relatively flat supply curve reflects a high price elasticity of supply. The pretax price of a gallon of gasoline is $2.00, and a tax of $1.00 per gallon is imposed. The price paid by consumers rises by $0.95 to $2.95, reflecting the fact that most of the burden of the tax falls on consumers. Only a small portion of the tax is borne by producers: the price they receive falls by only $0.05 to $1.95.



Two key assumptions are reflected in the shapes of the supply and demand curves in Figure 50.8. First, the price elasticity of demand for gasoline is assumed to be very low, so the demand curve is relatively steep. Recall that a low price elasticity of demand means that the quantity demanded changes little in response to a change in price. Second, the price elasticity of supply of gasoline is assumed to be very high, so the supply curve is relatively flat. A high price elasticity of supply means that the quantity supplied changes a lot in response to a change in price.

We have just learned that an excise tax drives a wedge, equal to the size of the tax, between the price paid by consumers and the price received by producers. This wedge drives the price paid by consumers up and the price received by producers down. But as we can see from Figure 50.8, in this case those two effects are very unequal in size. The price received by producers falls only slightly, from $2.00 to $1.95, but the price paid by consumers rises by a lot, from $2.00 to $2.95. This means that consumers bear the greater share of the tax burden.

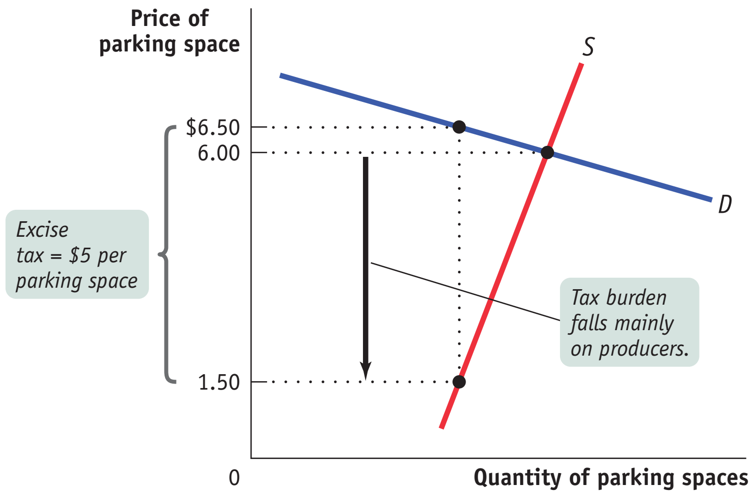
This example illustrates another general principle of taxation: *When the price elasticity of demand is low and the price elasticity of supply is high, the burden of an excise tax falls* *mainly on consumers.* Why? A low price elasticity of demand means that consumers have few substitutes and so little alternative to buying higher-priced gasoline. In contrast, a high price elasticity of supply results from the fact that producers have many production substitutes for their gasoline (that is, other uses for the crude oil from which gasoline is refined). This gives producers much greater flexibility in refusing to accept lower prices for their gasoline. And, not surprisingly, the party with the least flexibility—in this case, consumers—gets stuck paying most of the tax. This is a good description of how the burden of the main excise taxes actually collected in the United States today, such as those on cigarettes and alcoholic beverages, is allocated between consumers and producers.

When an Excise Tax Is Paid Mainly by Producers Figure 50.9 shows an example of an excise tax paid mainly by producers, a $5.00 per day tax on downtown parking in a small city. In the absence of the tax, the market equilibrium price of parking is $6.00 per day.

figure 50.9

An Excise Tax Paid Mainly by Producers

The relatively flat demand curve here reflects a high price elasticity of demand for downtown parking, and the relatively steep supply curve results from a low price elasticity of supply. The pre-tax price of a daily parking space is $6.00 and a tax of $5.00 is imposed. The price received by producers falls a lot, to $1.50, reflecting the fact that they bear most of the tax burden. The price paid by consumers rises a small amount, $0.50, to $6.50, so they bear very little of the burden.



We've assumed in this case that the price elasticity of supply is very low because the lots used for parking have very few alternative uses. This makes the supply curve for parking spaces relatively steep. The price elasticity of demand, however, is assumed to be high: consumers can easily switch from the downtown spaces to other parking spaces a few minutes' walk from downtown, spaces that are not subject to the tax. This makes the demand curve relatively flat.

The tax drives a wedge between the price paid by consumers and the price received by producers. In this example, however, the tax causes the price paid by consumers to rise only slightly, from $6.00 to $6.50, but the price received by producers falls a lot, from $6.00 to $1.50. In the end, a consumer bears only $0.50 of the $5 tax burden, with a producer bearing the remaining $4.50.

Again, this example illustrates a general principle: *When the price elasticity of demand is high and the price elasticity of supply is low, the burden of an excise tax falls mainly on producers.* A real-world example is a tax on purchases of existing houses. In many American towns, house prices in desirable locations have risen as well-off outsiders have moved in and purchased homes from the less well-off original occupants, a phenomenon called gentrification. Some of these towns have imposed taxes on house sales intended to extract money from the new arrivals. But this ignores the fact that the price elasticity of demand for houses in a particular town is often high because potential buyers can choose to move to other towns. Furthermore, the price elasticity of supply is often low because most sellers must sell their houses due to job transfers or to provide funds for their retirement. So taxes on home purchases are actually paid mainly by the less well-off sellers—not, as town officials imagine, by wealthy buyers.

The Benefits and Costs of Taxation

When a government is considering whether to impose a tax or how to design a tax system, it has to weigh the benefits of a tax against its costs. We may not think of a tax as something that provides benefits, but governments need money to provide things people want, such as streets, schools, national defense, and health care for those unable to afford it. The benefit of a tax is the revenue it raises for the government to pay for these services. Unfortunately, this benefit comes at a cost—a cost that is normally larger than the amount consumers and producers pay. Let's look first at what determines how much money a tax raises and then at the costs a tax imposes.

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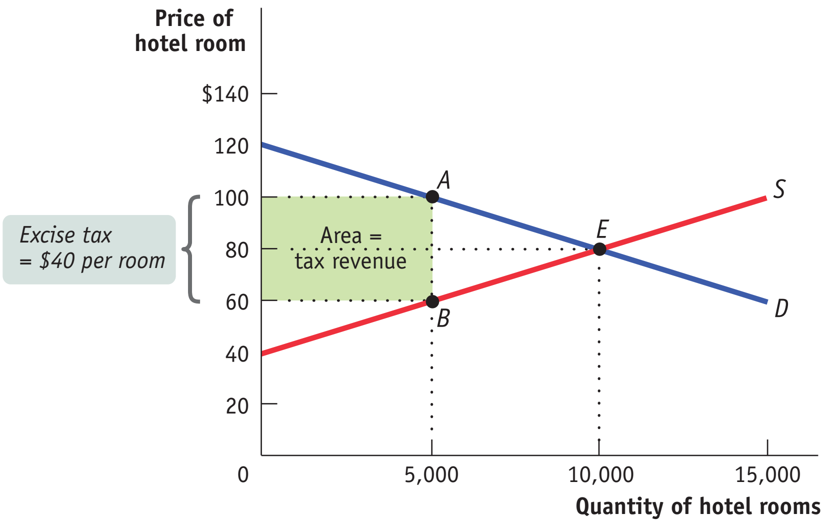
The Revenue from an Excise Tax

How much revenue does the government collect from an excise tax? In our hotel tax example, the revenue is equal to the area of the shaded rectangle in Figure 50.10.

figure 50.10

The Revenue from an Excise Tax

The revenue from a $40 excise tax on hotel rooms is $200,000, equal to the tax rate, $40—the size of the wedge that the tax drives between the supply price and the demand price—multiplied by the number of rooms rented, 5,000. This is equal to the area of the shaded rectangle.



To see why this area represents the revenue collected by a $40 tax on hotel rooms, notice that the *height* of the rectangle is $40, equal to the tax per room. It is also, as we've seen, the size of the wedge that the tax drives between the supply price (the price received by producers) and the demand price (the price paid by consumers). Meanwhile, the *width* of the rectangle is 5,000 rooms, equal to the equilibrium quantity of rooms given the $40 tax. With that information, we can make the following calculations.

The tax revenue collected is:

$$\text{Tax revenue} = \$40 \text{ per room} \times 5{,}000 \text{ rooms} = \$200{,}000$$

The area of the shaded rectangle is:

$$\text{Area} = \text{Height} \times \text{Width} = \$40 \text{ per room} \times 5{,}000 \text{ rooms} = \$200{,}000,$$

or

$$\text{Tax revenue} = \text{Area of shaded rectangle}$$

This is a general principle: *The revenue collected by an excise tax is equal to the area of a rectangle with the height of the tax wedge between the supply price and the demand price and the width of the quantity sold under the tax.*

The Costs of Taxation

What is the cost of a tax? You might be inclined to answer that it is the amount of money taxpayers pay to the government—the tax revenue collected. But suppose the government uses the tax revenue to provide services that taxpayers want. Or suppose that the government simply hands the tax revenue back to taxpayers. Would we say in those cases that the tax didn't actually cost anything?

No—because a tax, like a quota, prevents mutually beneficial transactions from occurring. Consider Figure 50.10 once more. Here, with a $40 tax on hotel rooms, guests pay $100 per room but hotel owners receive only $60 per room. Because of the wedge created by the tax, we know that some transactions didn't occur that would have occurred without the tax. More specifically, we know from the supply and demand curves that there are some potential guests who would be willing to pay up to $90 per night and some hotel owners who would be willing to supply rooms if they received at least $70 per night. If these two sets of people were allowed to trade with each other without the tax, they would engage in mutually beneficial transactions—hotel rooms would be rented. But such deals would be illegal because the $40 tax would not be paid. In our example, 5,000 potential hotel room rentals that would have occurred in the absence of the tax, to the mutual benefit of guests and hotel owners, do not take place because of the tax.

So an excise tax imposes costs over and above the tax revenue collected in the form of inefficiency, which occurs because the tax discourages mutually beneficial transactions. You may recall from Module 9 that the cost to society of this kind of inefficiency—the value of the forgone mutually beneficial transactions—is called the **deadweight loss.** While all real-world taxes impose some deadweight loss, a badly designed tax imposes a larger deadweight loss than a well-designed one.

To measure the deadweight loss from a tax, we turn to the concepts of producer and consumer surplus. Figure 50.11 shows the effects of an excise tax on consumer and producer surplus. In the absence of the tax, the equilibrium is at E and the equilibrium price and quantity are P_E and Q_E, respectively. An excise tax drives a wedge equal to the amount of the tax between the price received by producers and the price paid by consumers, reducing the quantity sold. In this case, with a tax of T dollars per unit, the quantity sold falls to Q_T. The price paid by consumers rises to P_C, the demand price of the reduced quantity, Q_T, and the price received by producers falls to P_P, the supply price of that quantity. The difference between these prices, $P_C - P_P$, is equal to the excise tax, T.

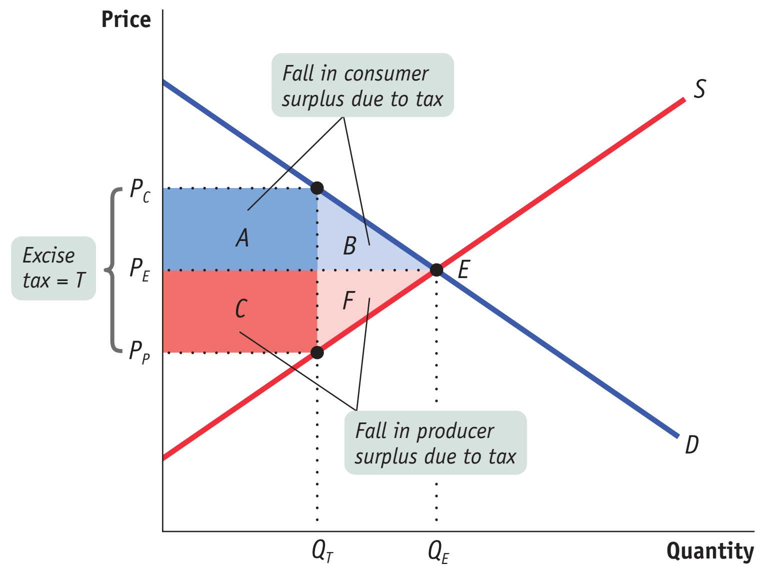
Using the concepts of producer and consumer surplus, we can show exactly how much surplus producers and consumers lose as a result of the tax. We learned previously that a fall in the price of a good generates a gain in consumer surplus that is equal to the sum of the areas of a rectangle and a triangle. Similarly, a price increase causes a loss to consumers that is represented by the sum of the areas of a rectangle and a triangle. So it's not surprising that in the case of an excise tax, the rise in the price paid by consumers causes a loss equal to the sum of the areas of a rectangle and a triangle: the dark blue rectangle labeled A and the area of the light blue triangle labeled B in Figure 50.11.

The **deadweight loss** (from a tax) is the decrease in total surplus resulting from the tax, minus the tax revenues generated.

figure 50.11

A Tax Reduces Consumer and Producer Surplus

Before the tax, the equilibrium price and quantity are P_E and Q_E, respectively. After an excise tax of T per unit is imposed, the price to consumers rises to P_C and consumer surplus falls by the sum of the dark blue rectangle, labeled *A*, and the light blue triangle, labeled *B*. The tax also causes the price to producers to fall to P_P; producer surplus falls by the sum of the dark red rectangle, labeled *C*, and the light red triangle, labeled *F*. The government receives revenue from the tax, $Q_T \times T$, which is given by the sum of the areas *A* and *C*. Areas *B* and *F* represent the losses to consumer and producer surplus that are not collected by the government as revenue; they are the deadweight loss to society of the tax.



Meanwhile, the fall in the price received by producers leads to a fall in producer surplus. This, too, is equal to the sum of the areas of a rectangle and a triangle. The loss in producer surplus is the sum of the areas of the dark red rectangle labeled *C* and the light red triangle labeled *F* in Figure 50.11.

Of course, although consumers and producers are hurt by the tax, the government gains revenue. The revenue the government collects is equal to the tax per unit sold, *T*, multiplied by the quantity sold, Q_T. This revenue is equal to the area of a rectangle Q_T wide and *T* high. And we already have that rectangle in the figure: it is the sum of rectangles *A* and *C*. So the government gains part of what consumers and producers lose from an excise tax.

But a portion of the loss to producers and consumers from the tax is not offset by a gain to the government—specifically, the two triangles *B* and *F*. The deadweight loss caused by the tax is equal to the combined area of these two triangles. It represents the total surplus lost to society because of the tax—that is, the amount of surplus that would have been generated by transactions that now do not take place because of the tax.

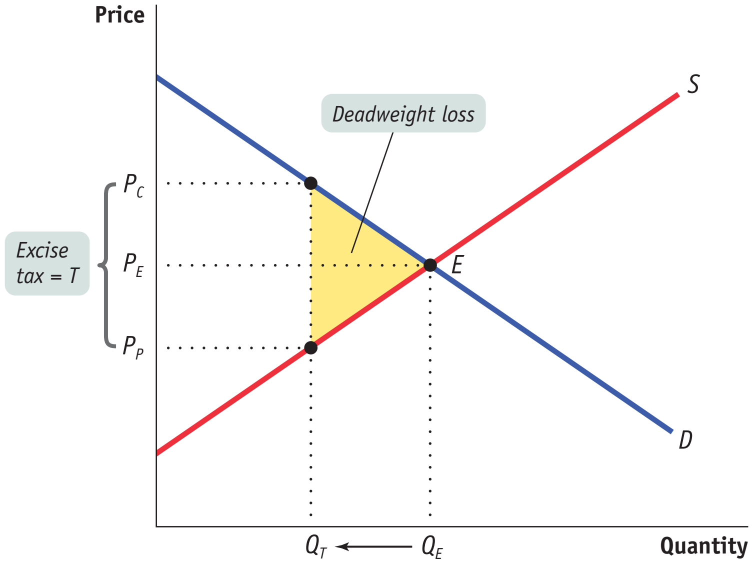
Figure 50.12 on the next page is a version of Figure 50.11 that leaves out rectangles *A* (the surplus shifted from consumers to the government) and *C* (the surplus shifted from producers to the government) and shows only the deadweight loss, drawn here as a triangle shaded yellow. The base of that triangle is equal to the tax wedge, *T*; the height of the triangle is equal to the reduction in the quantity transacted due to the tax, $Q_E - Q_T$. Clearly, the larger the tax wedge and the larger the reduction in the quantity transacted, the greater the inefficiency from the tax. But also note an important, contrasting point: if the excise tax somehow *didn't* reduce the quantity bought and sold in this market—if Q_T remained equal to Q_E after the tax was levied—the yellow triangle would disappear and the deadweight loss from the tax would be zero. So if a tax does *not* discourage transactions, it causes no deadweight loss. In this case, the tax simply shifts surplus straight from consumers and producers to the government.

Using a triangle to measure deadweight loss is a technique used in many economic applications. For example, triangles are used to measure the deadweight loss produced by types of taxes other than excise taxes. They are also used to measure the deadweight loss produced by monopoly, another kind of market distortion. And deadweight-loss triangles are often used to evaluate the benefits and costs of public policies besides taxation—such as whether to impose stricter safety standards on a product.

figure 50.12

The Deadweight Loss of a Tax

A tax leads to a deadweight loss because it creates inefficiency: some mutually beneficial transactions never take place because of the tax, namely the transactions $Q_E - Q_T$. The yellow area here represents the value of the deadweight loss: it is the total surplus that would have been gained from the $Q_E - Q_T$ transactions. If the tax had not discouraged transactions—had the number of transactions remained at Q_E—no deadweight loss would have been incurred.



In considering the total amount of inefficiency caused by a tax, we must also take into account something not shown in Figure 50.12: the resources actually used by the government to collect the tax, and by taxpayers to pay it, over and above the amount of the tax. These lost resources are called the **administrative costs** of the tax. The most familiar administrative cost of the U.S. tax system is the time individuals spend filling out their income tax forms or the money they spend on accountants to prepare their tax forms for them. (The latter is considered an inefficiency from the point of view of society because accountants could instead be performing other, non-tax-related services.) Included in the administrative costs that taxpayers incur are resources used to evade the tax, both legally and illegally. The costs of operating the Internal Revenue Service, the arm of the federal government tasked with collecting the federal income tax, are actually quite small in comparison to the administrative costs paid by taxpayers. The total inefficiency caused by a tax is the sum of its deadweight loss and its administrative costs.

Some extreme forms of taxation, such as the *poll tax* instituted by the government of British Prime Minister Margaret Thatcher in 1989, are notably unfair but very efficient. A poll tax is an example of a **lump-sum tax,** a tax that is the same for everyone regardless of any actions people take. The poll tax in Britain was widely perceived as much less fair than the tax structure it replaced, in which local taxes were proportional to property values.

Under the old system, the highest local taxes were paid by the people with the most expensive houses. Because these people tended to be wealthy, they were also best able to bear the burden. But the old system definitely distorted incentives to engage in mutually beneficial transactions and created deadweight loss. People who were considering home improvements knew that such improvements, by making their property more valuable, would increase their tax bills. The result, surely, was that some home improvements that would have taken place without the tax did not take place because of it. In contrast, a lump-sum tax does not distort incentives. Because under a lump-sum tax people have to pay the same amount of tax regardless of their actions, it does not cause them to substitute untaxed goods for a good whose price has been artificially inflated by a tax, as occurs with an excise tax. So lump-sum taxes, although unfair, are better than other taxes at promoting economic efficiency.

The **administrative costs** of a tax are the resources used by government to collect the tax, and by taxpayers to pay (or to evade) it, over and above the amount collected.

A **lump-sum tax** is a tax of a fixed amount paid by all taxpayers.

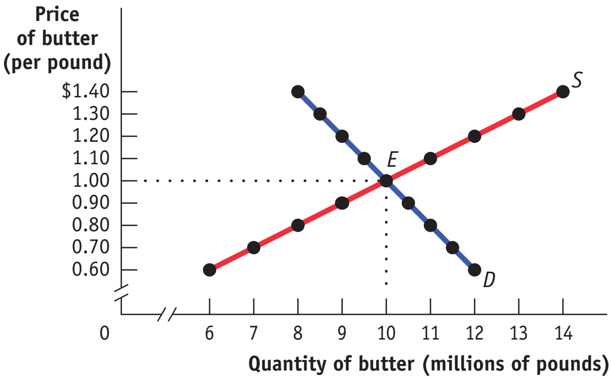
Module 50 AP Review

Solutions appear at the back of the book.

Check Your Understanding

1. Using the tables in Check Your Understanding Module 49, find the equilibrium price and quantity in the market for cheese-stuffed jalapeno peppers. What is the total surplus in the equilibrium in this market, and who receives it?

2. Consider the market for butter, shown in the accompanying figure. The government imposes an excise tax of $0.30 per pound of butter. What is the price paid by consumers post-tax? What is the price received by producers post-tax? What is the quantity of butter sold? How is the incidence of the tax allocated between consumers and producers? Show this on the figure.



3. The accompanying table shows five consumers' willingness to pay for one can of diet soda each as well as five producers' costs of selling one can of diet soda each. Each consumer buys at most one can of soda; each producer sells at most one can of soda. The government asks your advice about the effects of an excise tax of $0.40 per can of diet soda. Assume that there are no administrative costs from the tax.

	Consumer Willingness to Pay		*Producer Cost*
Ana	$0.70	Zhang	$0.10
Bernice	0.60	Yves	0.20
Chizuko	0.50	Xavier	0.30
Dagmar	0.40	Walter	0.40
Ella	0.30	Vern	0.50

a. Without the excise tax, what is the equilibrium price and the equilibrium quantity of soda?
b. The excise tax raises the price paid by consumers post-tax to $0.60 and lowers the price received by producers post-tax to $0.20. With the excise tax, what is the quantity of soda sold?
c. Without the excise tax, how much individual consumer surplus does each of the consumers gain? How much individual consumer surplus does each consumer gain with the tax? How much total consumer surplus is lost as a result of the tax?
d. Without the excise tax, how much individual producer surplus does each of the producers gain? How much individual producer surplus does each producer gain with the tax? How much total producer surplus is lost as a result of the tax?
e. How much government revenue does the excise tax create?
f. What is the deadweight loss from the imposition of this excise tax?

Tackle the Test: Multiple-Choice Questions

1. At market equilibrium in a competitive market, which of the following is necessarily true?
   I. Consumer surplus is maximized.
   II. Producer surplus is maximized.
   III. Total surplus is maximized.
   a. I only
   b. II only
   c. III only
   d. I and II only
   e. I, II, and III

2. When a competitive market is in equilibrium, total surplus can be increased by
   I. reallocating consumption among consumers.
   II. reallocating sales among sellers.
   III. changing the quantity traded.
   a. I only
   b. II only
   c. III only
   d. I, II, and III
   e. None of the above

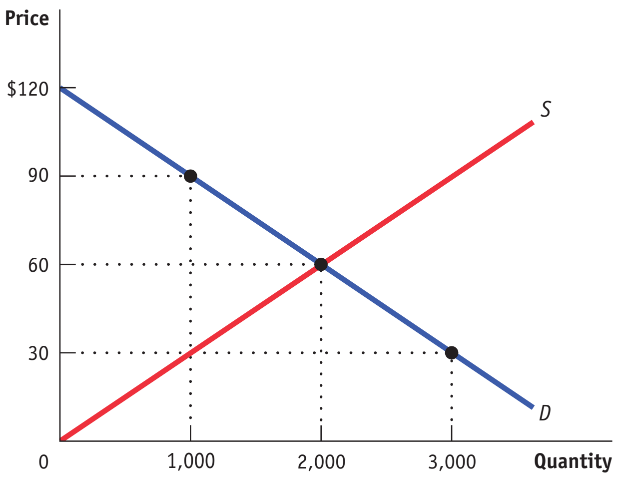
3. Which of the following is true regarding equity and efficiency in competitive markets?
   a. Competitive markets ensure equity and efficiency.
   b. There is often a trade-off between equity and efficiency.
   c. Competitive markets lead to neither equity nor efficiency.
   d. There is generally agreement about the level of equity and efficiency in a market.
   e. None of the above.

4. An excise tax imposed on sellers in a market will result in which of the following?
   I. an upward shift of the supply curve
   II. a downward shift of the demand curve
   III. deadweight loss
   a. I only
   b. II only
   c. III only
   d. I and III only
   e. I, II, and III

5. An excise tax will be paid mainly by producers when
   a. it is imposed on producers.
   b. it is imposed on consumers.
   c. the price elasticity of supply is low and the price elasticity of demand is high.
   d. the price elasticity of supply is high and the price elasticity of demand is low.
   e. the price elasticity of supply is perfectly elastic.

Tackle the Test: Free-Response Questions

1. Refer to the graph provided. Assume the government has imposed an excise tax of $60 on producers in this market.



   a. What quantity will be sold in the market?
   b. What price will consumers pay in the market?
   c. By how much will consumer surplus change as a result of the tax?
   d. By how much will producer surplus change as a result of the tax?
   e. How much revenue will the government collect from this excise tax?
   f. Calculate the deadweight loss created by the tax.

Answer (8 points)

1 point: 1,000

1 point: $90

1 point: Consumer surplus will decrease by $45,000, from $60,000 before the tax to $15,000 after the tax.

1 point: Producer surplus will decrease by $45,000, from $60,000 before the tax to $15,000 after the tax.

1 point: $60 × 1,000 = $60,000

1 point: $30,000

2. Draw a correctly labeled graph of a competitive market in equilibrium. Use your graph to illustrate the effect of an excise tax imposed on consumers. Indicate each of the following on your graph:
   a. the equilibrium price and quantity without the tax, labeled P_E and Q_E
   b. the quantity sold in the market post-tax, labeled Q_T
   c. the price paid by consumers post-tax, labeled P_C
   d. the price received by producers post-tax, labeled P_P
   e. the tax revenue generated by the tax, labeled “Tax revenue”
   f. The deadweight loss resulting from the tax, labeled “DWL.”

What you will learn in this Module:

- How consumers make choices about the purchase of goods and services
- Why consumers' general goal is to maximize utility
- Why the principle of diminishing marginal utility applies to the consumption of most goods and services
- How to use marginal analysis to find the optimal consumption bundle

Module 51 Utility Maximization

We have used the demand curve to study consumer responsiveness to changes in prices and discovered its usefulness in predicting how consumers will gain from the availability of goods and services in a market. But where does the demand curve come from? In other words, what lies behind the demand curve? The demand curve represents the tastes, preferences, and resulting choices of individual consumers. Its shape reflects the additional satisfaction, or *utility,* people receive from consuming more and more of a good or service.

Utility: It's All About Getting Satisfaction

When analyzing consumer behavior, we're looking into how people pursue their needs and wants and the subjective feelings that motivate purchases. Yet there is no simple way to measure subjective feelings. How much satisfaction do I get from my third cookie? Is it less or more than the satisfaction you receive from your third cookie? Does it even make sense to ask that question?

Luckily, we don't need to make comparisons between your feelings and mine. The analysis of consumer behavior that follows requires only the assumption that individuals try to maximize some personal measure of the satisfaction gained from consumption. That measure of satisfaction is known as **utility,** a concept we use to understand behavior but don't expect to measure in practice.

Utility is a measure of personal satisfaction.

Utility and Consumption

We can think of consumers as using consumption to "produce" utility, much in the same way that producers use inputs to produce output. As consumers, we do not make explicit calculations of the utility generated by consumption choices, but we must make choices, and we usually base them on at least a rough attempt to achieve greater satisfaction. I can have either soup or salad with my dinner. Which will I enjoy more? I can go to Disney World this year or put the money toward buying a new car. Which will make me happier? These are the types of questions that go into utility maximization.

The concept of utility offers a way to study choices that are made in a more or less rational way.

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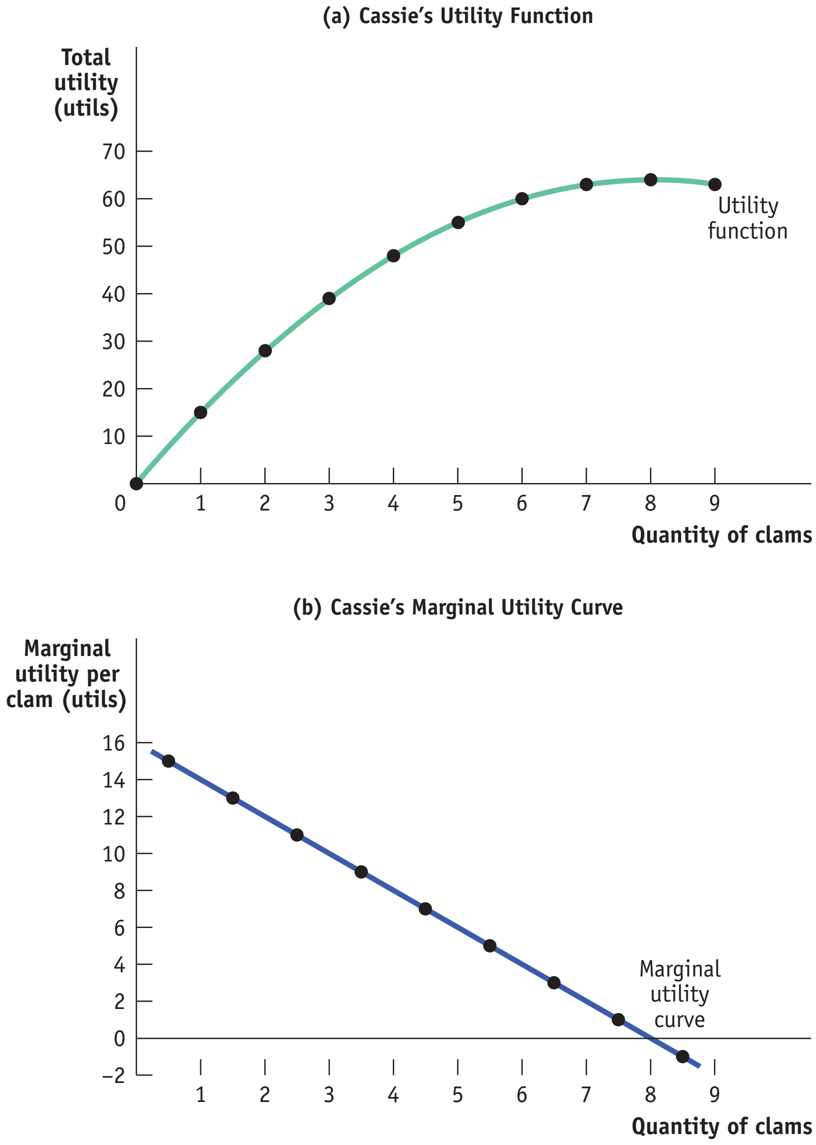
A **util** is a unit of utility.

How do we measure utility? For the sake of simplicity, it is useful to suppose that we can measure utility in hypothetical units called—what else?—**utils.** A *utility function* shows the relationship between a consumer's utility and the combination of goods and services—the *consumption bundle*—he or she consumes.

Figure 51.1 illustrates a utility function. It shows the total utility that Cassie, who likes fried clams, gets from an all-you-can-eat clam dinner. We suppose that her consumption bundle consists of a side of coleslaw, which comes with the meal, plus a number of clams to be determined. The table that accompanies the figure shows how Cassie's total utility depends on the number of clams; the curve in panel (a) of the figure shows that same information graphically.

Cassie's utility function slopes upward over most of the range shown, but it gets flatter as the number of clams consumed increases. And in this example it eventually turns downward. According to the information in the table in Figure 51.1, nine clams is a clam too far. Adding that additional clam actually makes Cassie worse off: it would lower her total utility. If she's rational, of course, Cassie will realize that and not consume the ninth clam.

figure 51.1 Cassie's Total Utility and Marginal Utility



Quantity of clams	Total utility (utils)	Marginal utility per clam (utils)
0	0	
		15
1	15	
		13
2	28	
		11
3	39	
		9
4	48	
		7
5	55	
		5
6	60	
		3
7	63	
		1
8	64	
		−1
9	63	

Panel (a) shows how Cassie's total utility depends on her consumption of fried clams. It increases until it reaches its maximum utility level of 64 utils at 8 clams consumed and decreases after that. Marginal utility is calculated in the table. Panel (b) shows the marginal utility curve, which slopes downward due to diminishing marginal utility. That is, each additional clam gives Cassie less utility than the previous clam.

So when Cassie chooses how many clams to consume, she will make this decision by considering the *change* in her total utility from consuming one more clam. This illustrates the general point: to maximize *total* utility, consumers must focus on *marginal* utility.

The **marginal utility** of a good or service is the change in total utility generated by consuming one additional unit of that good or service. The **marginal utility curve** shows how marginal utility depends on the quantity of a good or service consumed.

According to the **principle of diminishing marginal utility,** each successive unit of a good or service consumed adds less to total utility than does the previous unit.

The Principle of Diminishing Marginal Utility

In addition to showing how Cassie's total utility depends on the number of clams she consumes, the table in Figure 51.1 also shows the **marginal utility** generated by consuming each additional clam—that is, the *change* in total utility from consuming one additional clam. The **marginal utility curve** is constructed by plotting points at the midpoint between the numbered quantities since marginal utility is found as consumption levels change. For example, when consumption rises from 1 to 2 clams, marginal utility is 13. Therefore, we place the point corresponding to marginal utility of 13 halfway between 1 and 2 clams.

The marginal utility curve slopes downward because each successive clam adds less to total utility than the previous clam. This is reflected in the table: marginal utility falls from a high of 15 utils for the first clam consumed to −1 for the ninth clam consumed. The fact that the ninth clam has negative marginal utility means that consuming it actually reduces total utility. (Restaurants that offer all-you-can-eat meals depend on the proposition that you can have too much of a good thing.) Not all marginal utility curves eventually become negative. But it is generally accepted that marginal utility curves do slope downward—that consumption of most goods and services is subject to *diminishing marginal utility*.

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The basic idea behind the **principle of diminishing marginal utility** is that the additional satisfaction a consumer gets from one more unit of a good or service declines as the amount of that good or service consumed rises. Or, to put it slightly differently, the more of a good or service you consume, the closer you are to being satiated—reaching a point at which an additional unit of the good adds nothing to your satisfaction. For someone who almost never gets to eat a banana, the occasional banana is a marvelous treat (as it was in Eastern Europe before the fall of communism, when bananas were very hard to find). For someone who eats them all the time, a banana is just, well, a banana.

fyi

Is Marginal Utility Really Diminishing?

Are all goods really subject to diminishing marginal utility? Of course not; there are a number of goods for which, at least over some range, marginal utility is surely *increasing.*

For example, there are goods that require some experience to enjoy. The first time you do it, downhill skiing involves a lot more fear than enjoyment—or so they say: two of the authors have never tried it! It only becomes a pleasurable activity if you do it enough to become reasonably competent. And even some less strenuous forms of consumption take practice; people who are not accustomed to drinking coffee say it has a bitter taste and can't understand its appeal. (The authors, on the other hand, regard coffee as one of the basic food groups.)

Another example would be goods that only deliver positive utility if you buy enough. The great Victorian economist Alfred Marshall, who more or less invented the supply and demand model, gave the example of wallpaper: buying only enough to do half a room is worse than useless. If you need two rolls of wallpaper to finish a room, the marginal utility of the second roll is larger than the marginal utility of the first roll.

So why does it make sense to assume diminishing marginal utility? For one thing, most goods don't suffer from these qualifications: nobody needs to learn to like ice cream. Also, although most people don't ski and some people don't drink coffee, those who do ski or drink coffee do enough of it that the marginal utility of one more ski run or one more cup is less than that of the last. So *in the relevant range* of consumption, marginal utility is still diminishing.

The principle of diminishing marginal utility doesn't always apply, but it does apply in the great majority of cases, enough to serve as a foundation for our analysis of consumer behavior.

Budgets and Optimal Consumption

The principle of diminishing marginal utility explains why most people eventually reach a limit, even at an all-you-can-eat buffet where the cost of another clam is measured only in future indigestion. Under ordinary circumstances, however, it costs some additional resources to consume more of a good, and consumers must take that cost into account when making choices.

What do we mean by cost? As always, the fundamental measure of cost is *opportunity cost.* Because the amount of money a consumer can spend is limited, a decision to consume more of one good is also a decision to consume less of some other good.

Budget Constraints and Budget Lines

Consider Sammy, whose appetite is exclusively for clams and potatoes. (There's no accounting for tastes.) He has a weekly income of $20 and since, given his appetite, more of either good is better than less, he spends all of it on clams and potatoes. We will assume that clams cost $4 per pound and potatoes cost $2 per pound. What are his possible choices?

Whatever Sammy chooses, we know that the cost of his consumption bundle cannot exceed the amount of money he has to spend. That is,

(51-1) Expenditure on clams + Expenditure on potatoes ≤ Total income

Consumers always have limited income, which constrains how much they can consume. So the requirement illustrated by Equation 51-1—that a consumer must choose a consumption bundle that costs no more than his or her income—is known as the consumer's **budget constraint.** It's a simple way of saying that a consumer can't spend more than the total amount of income available to him or her. In other words, consumption bundles are affordable when they obey the budget constraint. We call the set of all of Sammy's affordable consumption bundles his **consumption possibilities.** In general, whether or not a particular consumption bundle is included in a consumer's consumption possibilities depends on the consumer's income and the prices of goods and services.

Figure 51.2 shows Sammy's consumption possibilities. The quantity of clams in his consumption bundle is measured on the horizontal axis and the quantity of potatoes on the vertical axis. The downward-sloping line connecting points *A* through *F* shows which consumption bundles are affordable and which are not. Every bundle on or inside this line (the shaded area) is affordable; every bundle outside this line is unaffordable. As an example of one of the points, let's look at point *C,* representing 2 pounds of clams and 6 pounds of potatoes, and check whether it satisfies Sammy's budget constraint. The cost of bundle *C* is 6 pounds of potatoes × $2 per pound + 2 pounds of clams × $4 per pound = $12 + $8 = $20. So bundle *C* does indeed satisfy Sammy's budget constraint: it costs no more than his weekly income of $20. In fact, bundle *C* costs exactly as much as Sammy's income. By doing the arithmetic, you can check that all the other points lying on the downward-sloping line are also bundles at which Sammy spends all of his income.

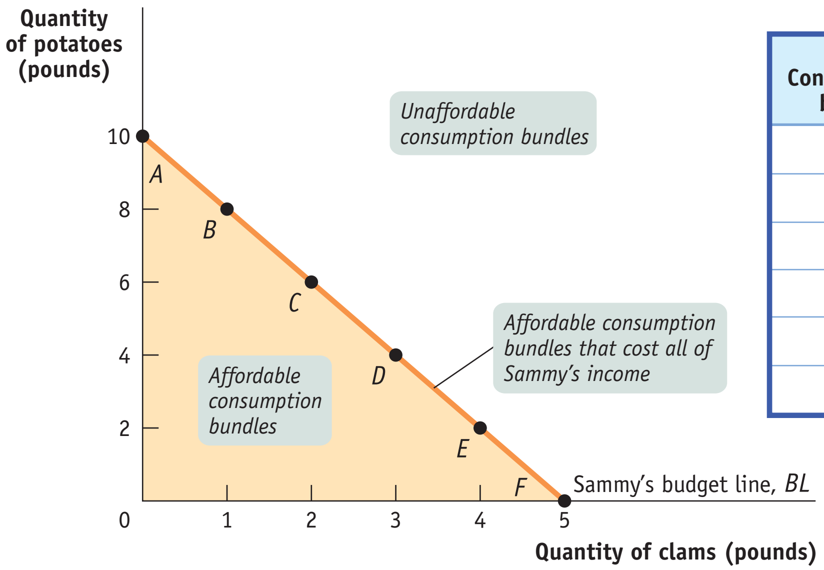
The downward-sloping line has a special name, the **budget line.** It shows all the consumption bundles available to Sammy when he spends all of his income. It's downward-sloping because when Sammy is spending all of his income, say by consuming at point *A* on the budget line, then in order to consume more clams he must consume fewer potatoes—that is, he must move to a point like *B*. In other words, when

A **budget constraint** limits the cost of a consumer's consumption bundle to no more than the consumer's income.

A consumer's **consumption possibilities** is the set of all consumption bundles that are affordable, given the consumer's income and prevailing prices.

A consumer's **budget line** shows the consumption bundles available to a consumer who spends all of his or her income.

figure 51.2 The Budget Line



Consumption bundle	Quantity of clams (pounds)	Quantity of potatoes (pounds)
A	0	10
B	1	8
C	2	6
D	3	4
E	4	2
F	5	0

The *budget line* represents all the possible combinations of quantities of potatoes and clams that Sammy can purchase if he spends all of his income. Also, it is the boundary between the set of affordable consumption bundles (the *consumption possibilities*) and the unaffordable ones. Given that clams cost $4 per pound and potatoes cost $2 per pound, if Sammy spends all of his income on clams (bundle *F*), he can purchase 5 pounds of clams; if he spends all of his income on potatoes (bundle *A*), he can purchase 10 pounds of potatoes.

Sammy is on his budget line, the opportunity cost of consuming more clams is consuming fewer potatoes, and vice versa. As Figure 51.2 indicates, any consumption bundle that lies above the budget line is unaffordable.

Do we need to consider the other bundles in Sammy's consumption possibilities, the ones that lie *within* the shaded region in Figure 51.2 bounded by the budget line? The answer is, for all practical situations, no: as long as Sammy doesn't get satiated—that is, as long as his marginal utility from consuming either good is always positive—and he doesn't get any utility from saving income rather than spending it, then he will always choose to consume a bundle that lies on his budget line.

Given that $20 per week budget, next we can consider the culinary dilemma of what point on his budget line Sammy will choose.

The Optimal Consumption Bundle

Because Sammy's budget constrains him to a consumption bundle somewhere along the budget line, a choice to consume a given quantity of clams also determines his potato consumption, and vice versa. We want to find the consumption bundle—represented by a point on the budget line—that maximizes Sammy's total utility. This bundle is Sammy's **optimal consumption bundle.**

Table 51.1 on the next page shows how much utility Sammy gets from different levels of consumption of clams and potatoes, respectively. According to the table, Sammy has a healthy appetite; the more of either good he consumes, the higher his utility. But because he has a limited budget, he must make a trade-off: the more pounds of clams he consumes, the fewer pounds of potatoes, and vice versa. That is, he must choose a point on his budget line.

A consumer's **optimal consumption bundle** is the consumption bundle that maximizes the consumer's total utility given his or her budget constraint.

table 51.1

Sammy's Utility from Clam and Potato Consumption

Utility from clam consumption		Utility from potato consumption	
Quantity of clams (pounds)	Utility from clams (utils)	Quantity of potatoes (pounds)	Utility from potatoes (utils)
0	0	0	0
1	15	1	11.5
2	25	2	21.4
3	31	3	29.8
4	34	4	36.8
5	36	5	42.5
		6	47.0
		7	50.5
		8	53.2
		9	55.2
		10	56.7

Table 51.2 shows how his total utility varies for the different consumption bundles along his budget line. Each of six possible consumption bundles, *A* through *F* from Figure 51.2, is given in the first column. The second column shows the level of clam consumption corresponding to each choice. The third column shows the utility Sammy gets from consuming those clams. The fourth column shows the quantity of potatoes Sammy can afford *given* the level of clam consumption; this quantity goes down as his clam consumption goes up because he is sliding down the budget line. The fifth column shows the utility he gets from consuming those potatoes. And the final column shows his *total utility*. In this example, Sammy's total utility is the sum of the utility he gets from clams and the utility he gets from potatoes.

Figure 51.3 gives a visual representation of the data shown in Table 51.2. Panel (a) shows Sammy's budget line, to remind us that when he decides to consume more clams he is also deciding to consume fewer potatoes. Panel (b) then shows how his total utility depends on that choice. The horizontal axis in panel (b) has two sets of labels: it shows both the quantity of clams, increasing from left to right, and the quantity of

table 51.2

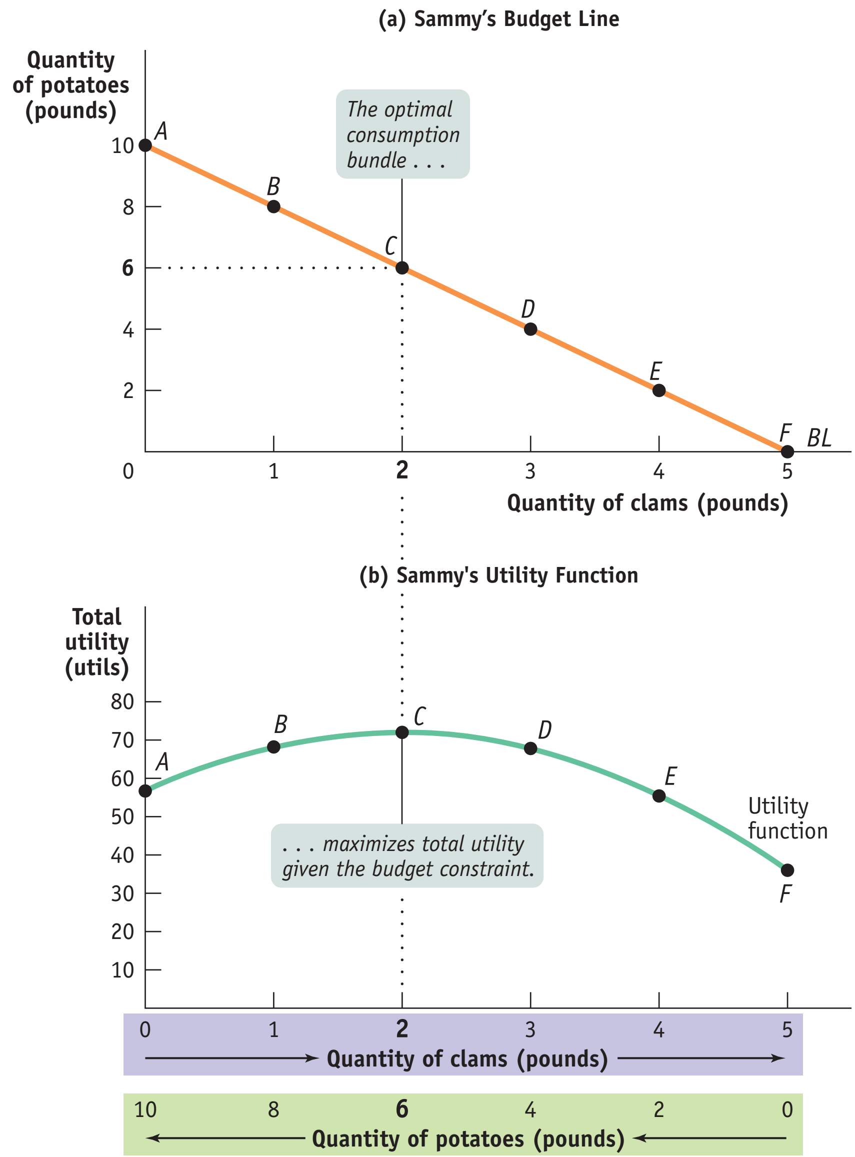
Sammy's Budget and Total Utility

Consumption bundle	Quantity of clams (pounds)	Utility from clams (utils)	Quantity of potatoes (pounds)	Utility from potatoes (utils)	Total utility (utils)
A	0	0	10	56.7	56.7
B	1	15	8	53.2	68.2
C	2	25	6	47.0	72.0
D	3	31	4	36.8	67.8
E	4	34	2	21.4	55.4
F	5	36	0	0	36.0

figure 51.3

Optimal Consumption Bundle

Panel (a) shows Sammy's budget line and his six possible consumption bundles. Panel (b) shows how his total utility is affected by his consumption bundle, which must lie on his budget line. The quantity of clams is measured from left to right on the horizontal axis, and the quantity of potatoes is measured from right to left. His total utility is maximized at bundle *C*, where he consumes 2 pounds of clams and 6 pounds of potatoes. This is Sammy's *optimal consumption bundle.*



potatoes, increasing from right to left. The reason we can use the same axis to represent consumption of both goods is, of course, that he is constrained by the budget line: the more pounds of clams Sammy consumes, the fewer pounds of potatoes he can afford, and vice versa.

Clearly, the consumption bundle that makes the best of the trade-off between clam consumption and potato consumption, the optimal consumption bundle, is the one that maximizes Sammy's total utility. That is, Sammy's optimal consumption bundle puts him at the top of the total utility curve.

As always, we can find the top of the curve by direct observation. We can see from Figure 51.3 that Sammy's total utility is maximized at point C—that his optimal consumption bundle contains 2 pounds of clams and 6 pounds of potatoes. But we know that we usually gain more insight into "how much" problems when we use marginal analysis. So in the next section we turn to representing and solving the optimal consumption choice problem with marginal analysis.

The **marginal utility per dollar** spent on a good or service is the additional utility from spending one more dollar on that good or service.

Spending the Marginal Dollar

As we've just seen, we can find Sammy's optimal consumption choice by finding the total utility he receives from each consumption bundle on his budget line and then choosing the bundle at which total utility is maximized. But we can use marginal analysis instead, turning Sammy's problem of finding his optimal consumption choice into a "how much" problem. How do we do this? By thinking about choosing an optimal consumption bundle as a problem of *how much to spend on each good.* That is, to find the optimal consumption bundle with marginal analysis we ask the question of whether Sammy can make himself better off by spending a little bit more of his income on clams and less on potatoes, or by doing the opposite—spending a little bit more on potatoes and less on clams. In other words, the marginal decision is a question of how to *spend the marginal dollar*—how to allocate an additional dollar between clams and potatoes in a way that maximizes utility.

Our first step in applying marginal analysis is to ask if Sammy is made better off by spending an additional dollar on either good; and if so, by how much is he better off. To answer this question we must calculate the **marginal utility per dollar** spent on either clams or potatoes—how much additional utility Sammy gets from spending an additional dollar on either good.

Marginal Utility per Dollar

We've already introduced the concept of marginal utility, the additional utility a consumer gets from consuming one more unit of a good or service; now let's see how this concept can be used to derive the related measure of marginal utility per dollar.

Table 51.3 shows how to calculate the marginal utility per dollar spent on clams and potatoes, respectively.

table **51.3**

Sammy's Marginal Utility per Dollar

(a) Clams (price of clams = $4 per pound)

Quantity of clams (pounds)	Utility from clams (utils)	Marginal utility per pound of clams (utils)	Marginal utility per dollar (utils)
0	0		
1	15	15	3.75
2	25	10	2.50
3	31	6	1.50
4	34	3	0.75
5	36	2	0.50

(b) Potatoes (price of potatoes = $2 per pound)

Quantity of potatoes (pounds)	Utility from potatoes (utils)	Marginal utility per pound of potatoes (utils)	Marginal utility per dollar (utils)
0	0		
1	11.5	11.5	5.75
2	21.4	9.9	4.95
3	29.8	8.4	4.20
4	36.8	7.0	3.50
5	42.5	5.7	2.85
6	47.0	4.5	2.25
7	50.5	3.5	1.75
8	53.2	2.7	1.35
9	55.2	2.0	1.00
10	56.7	1.5	0.75

In panel (a) of the table, the first column shows different possible amounts of clam consumption. The second column shows the utility Sammy derives from each amount of clam consumption; the third column then shows the marginal utility, the increase in utility Sammy gets from consuming an additional pound of clams. Panel (b) provides the same information for potatoes. The next step is to derive marginal utility *per dollar* for each good. To do this, we just divide the marginal utility of the good by its price in dollars.

To see why we divide by the price, compare the third and fourth columns of panel (a). Consider what happens if Sammy increases his clam consumption from 2 pounds to 3 pounds. This raises his total utility by 6 utils. But he must spend $4 for that additional pound, so the increase in his utility per additional dollar spent on clams is 6 utils/$4 = 1.5 utils per dollar. Similarly, if he increases his clam consumption from 3 pounds to 4 pounds, his marginal utility is 3 utils but his marginal utility per dollar is 3 utils/$4 = 0.75 utils per dollar. Notice that because of diminishing marginal utility, Sammy's marginal utility per pound of clams falls as the quantity of clams he consumes rises. As a result, his marginal utility per dollar spent on clams also falls as the quantity of clams he consumes rises.

So the last column of panel (a) shows how Sammy's marginal utility per dollar spent on clams depends on the quantity of clams he consumes. Similarly, the last column of panel (b) shows how his marginal utility per dollar spent on potatoes depends on the quantity of potatoes he consumes. Again, marginal utility per dollar spent on each good declines as the quantity of that good consumed rises because of diminishing marginal utility.

We will use the symbols MU_C and MU_P to represent the marginal utility per pound of clams and potatoes, respectively. And we will use the symbols P_C and P_P to represent the price of clams (per pound) and the price of potatoes (per pound). Then the marginal utility per dollar spent on clams is MU_C/P_C and the marginal utility per dollar spent on potatoes is MU_P/P_P. In general, the additional utility generated from an additional dollar spent on a good is equal to:

(51-2) Marginal utility per dollar spent on a good
= Marginal utility of one unit of the good/Price of one unit of the good
$= MU_{good}/P_{good}$

Next we'll see how this concept helps us determine a consumer's optimal consumption bundle using marginal analysis.

Optimal Consumption

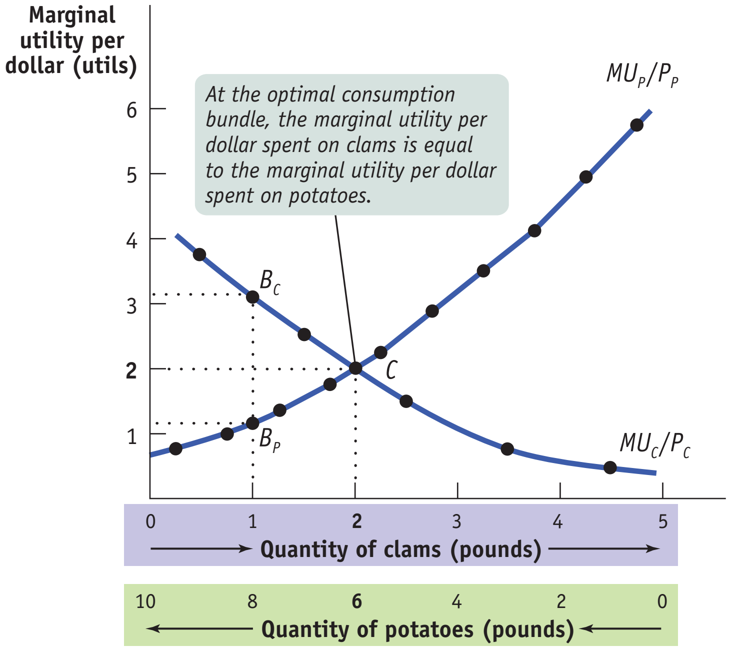
Let's consider Figure 51.4 on the next page. As in Figure 51.3, we can measure both the quantity of clams and the quantity of potatoes on the horizontal axis due to the budget constraint. Along the horizontal axis of Figure 51.4—also as in Figure 51.3—the quantity of clams increases as you move from left to right, and the quantity of potatoes increases as you move from right to left. The curve labeled MU_C/P_C in Figure 51.4 shows Sammy's marginal utility per dollar spent on clams as derived in Table 51.3. Likewise, the curve labeled MU_P/P_P shows his marginal utility per dollar spent on potatoes. Notice that the two curves, MU_C/P_C and MU_P/P_P, cross at the optimal consumption bundle, point *C*, consisting of 2 pounds of clams and 6 pounds of potatoes. Moreover, Figure 51.4 illustrates an important feature of Sammy's optimal consumption bundle: when Sammy consumes 2 pounds of clams and 6 pounds of potatoes, his marginal utility per dollar spent is the same, 2, for both goods. That is, at the optimal consumption bundle, $MU_C/P_C = MU_P/P_P = 2$.

This isn't an accident. Consider another one of Sammy's possible consumption bundles—say, *B* in Figure 51.3, at which he consumes 1 pound of clams and 8 pounds of potatoes. The marginal utility per dollar spent on each good is shown by points B_C and B_P in Figure 51.4. At that consumption bundle, Sammy's marginal utility per

figure 51.4

Marginal Utility per Dollar

Sammy's optimal consumption bundle is at point *C*, where his marginal utility per dollar spent on clams, MU_C/P_C, is equal to his marginal utility per dollar spent on potatoes, MU_P/P_P. This illustrates the optimal consumption rule: *at the optimal consumption bundle, the marginal utility per dollar spent on each good and service is the same.* At any other consumption bundle on Sammy's budget line, such as bundle *B* in Figure 51.3, represented here by points B_C and B_P, consumption is not optimal: Sammy can increase his utility at no additional cost by reallocating his spending.



dollar spent on clams would be approximately 3, but his marginal utility per dollar spent on potatoes would be only approximately 1. This shows that he has made a mistake: he is consuming too many potatoes and not enough clams.

How do we know this? If Sammy's marginal utility per dollar spent on clams is higher than his marginal utility per dollar spent on potatoes, he has a simple way to make himself better off while staying within his budget: spend \$1 less on potatoes and \$1 more on clams. By spending an additional dollar on clams, he adds about 3 utils to his total utility; meanwhile, by spending \$1 less on potatoes, he subtracts only about 1 util from his total utility. Because his marginal utility per dollar spent is higher for clams than for potatoes, reallocating his spending toward clams and away from potatoes would increase his total utility. On the other hand, if his marginal utility per dollar spent on potatoes is higher, he can increase his utility by spending less on clams and more on potatoes. So if Sammy has in fact chosen his optimal consumption bundle, his marginal utility per dollar spent on clams and potatoes must be equal.

This is a general principle, known as the **optimal consumption rule:** *when a consumer maximizes utility in the face of a budget constraint, the marginal utility per dollar spent on each good or service in the consumption bundle is the same.* That is, for any two goods C and *P*, the optimal consumption rule says that at the optimal consumption bundle

$$\textbf{(51-3)} \quad \frac{MU_C}{P_C} = \frac{MU_P}{P_P}$$

It's easiest to understand this rule using examples in which the consumption bundle contains only two goods, but it applies no matter how many goods or services a consumer buys: the marginal utilities per dollar spent for each and every good or service in the optimal consumption bundle are equal.

The **optimal consumption rule** says that in order to maximize utility, a consumer must equate the marginal utility per dollar spent on each good and service in the consumption bundle.

The main reason for studying consumer behavior is to look behind the market demand curve. In Module 46 we explained how the *substitution effect* leads consumers to buy less of a good when its price increases. We used the substitution effect to explain, in general, why the individual demand curve obeys the law of demand. Marginal analysis adds clarity to the utility-maximizing behavior of individuals and explains more precisely how an increase in price leads to less marginal utility per dollar and therefore a decrease in the quantity demanded.

Module 51 AP Review

Solutions appear at the back of the book.

Check Your Understanding

1. Explain why a rational consumer who has diminishing marginal utility for a good would not consume an additional unit when it generates negative marginal utility, even when that unit is free.
2. In the following two examples, find all the consumption bundles that lie on the consumer's budget line. Illustrate these consumption possibilities in a diagram, and draw the budget line through them.
   a. The consumption bundle consists of movie tickets and buckets of popcorn. The price of each ticket is $10.00, the price of each bucket of popcorn is $5.00, and the consumer's income is $20.00. In your diagram, put movie tickets on the vertical axis and buckets of popcorn on the horizontal axis.
   b. The consumption bundle consists of underwear and socks. The price of each pair of underwear is $4.00, the price of each pair of socks is $2.00, and the consumer's income is $12.00. In your diagram, put pairs of socks on the vertical axis and pairs of underwear on the horizontal axis.
3. In Table 51.3 you can see that the marginal utility per dollar spent on clams and the marginal utility per dollar spent on potatoes are equal when Sammy increases his consumption of clams from 3 pounds to 4 pounds and his consumption of potatoes from 9 pounds to 10 pounds. Explain why this is not Sammy's optimal consumption bundle. Illustrate your answer using a budget line like the one in Figure 51.3.

Tackle the Test: Multiple-Choice Questions

1. Generally, each successive unit of a good consumed will cause marginal utility to
   a. increase at an increasing rate.
   b. increase at a decreasing rate.
   c. increase at a constant rate.
   d. decrease.
   e. either increase or decrease.
2. Assume there are two goods, good *X* and good *Y*. Good *X* costs $5 and good *Y* costs $10. If your income is $200, which of the following combinations of good *X* and good *Y* is on your budget line?
   a. 0 units of good *X* and 18 units of good *Y*
   b. 0 units of good *X* and 20 units of good *Y*
   c. 20 units of good *X* and 0 units of good *Y*
   d. 10 units of good *X* and 12 units of good *Y*
   e. all of the above
3. The optimal consumption rule states that total utility is maximized when all income is spent and
   a. *MU*/*P* is equal for all goods.
   b. *MU* is equal for all goods.
   c. *P*/*MU* is equal for all goods.
   d. *MU* is as high as possible for all goods.
   e. The amount spent on each good is equal.
4. A consumer is spending all of her income and receiving 100 utils from the last unit of good A and 80 utils from the last unit of good B. If the price of good A is $2 and the price of good B is $1, to maximize total utility the consumer should buy
   a. more of good A.
   b. more of good B.
   c. less of good B.
   d. more of both goods.
   e. less of both goods.
5. The optimal consumption bundle is always represented by a point
   a. inside the consumer's budget line.
   b. outside the consumer's budget line.
   c. at the highest point on the consumer's budget line.
   d. on the consumer's budget line.
   e. at the horizontal intercept of the consumer's budget line.

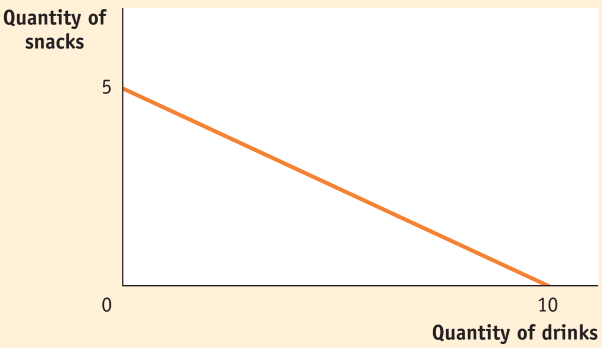
Tackle the Test: Free-Response Questions

1. Refer to the table provided. Assume you have $20 to spend.

Snacks (price = $4)		*Drinks (price = $2)*	
Quantity	*Total Utility (utils)*	*Quantity*	*Total Utility (utils)*
1	15	1	12
2	25	2	21
3	31	3	29
4	34	4	36
5	36	5	42
		6	47
		7	50
		8	52

a. Draw a correctly labeled budget line.
b. Determine the marginal utility and the marginal utility per dollar spent on the fourth drink.
c. What is the optimal consumption rule?
d. How many drinks and snacks should you purchase to maximize your total utility?

Answer (6 points)



1 point: Graph with "Quantity of snacks" and "Quantity of drinks" as axis labels.

1 point: Straight budget line with intercepts at 5 snacks and 0 drinks and at 0 snacks and 10 drinks.

1 point: MU = 7 utils

1 point: MU/P = 3.5 utils per dollar

1 point: Total utility is maximized when the marginal utility per dollar is equal for all goods.

1 point: 6 drinks, 2 snacks

2. Assume you have an income of $100. The price of good X is $5, and the price of good Y is $20.
   a. Draw a correctly labeled budget line with "Quantity of good X" on the horizontal axis and "Quantity of good Y" on the vertical axis. Be sure to correctly label the horizontal and vertical intercepts.
   b. With your current consumption bundle, you receive 100 utils from consuming your last unit of good X and 400 utils from consuming your last unit of good Y. Are you maximizing your total utility? Explain.
   c. What will happen to the total and marginal utility you receive from consuming good X if you decide to consume another unit of good X? Explain.

Section 9 Review

Summary

1. Changes in the price of a good affect the quantity consumed as a result of the **substitution effect,** and in some cases the **income effect.** Most goods absorb only a small share of a consumer's spending; for these goods, only the substitution effect—buying less of the good that has become relatively more expensive and more of the good that has become relatively cheaper—is significant. The income effect becomes substantial when there is a change in the price of a good that absorbs a large share of a consumer's spending, thereby changing the purchasing power of the consumer's income.

2. Many economic questions depend on the size of consumer or producer responses to changes in prices or other variables. *Elasticity* is a general measure of responsiveness that can be used to answer such questions.

3. The **price elasticity of demand**—the percent change in the quantity demanded divided by the percent change in the price (dropping the minus sign)—is a measure of the responsiveness of the quantity demanded to changes in the price. In practical calculations, it is usually best to use the **midpoint method,** which calculates percent changes in prices and quantities based on the average of the initial and final values.

4. Demand can fall anywhere in the range from **perfectly inelastic,** meaning the quantity demanded is unaffected by the price, to **perfectly elastic,** meaning there is a unique price at which consumers will buy as much or as little as they are offered. When demand is perfectly inelastic, the demand curve is a vertical line; when it is perfectly elastic, the demand curve is a horizontal line.

5. The price elasticity of demand is classified according to whether it is more or less than 1. If it is greater than 1, demand is **elastic;** if it is less than 1, demand is **inelastic;** if it is exactly 1, demand is **unit-elastic.** This classification determines how **total revenue,** the total value of sales, changes when the price changes. If demand is elastic, total revenue falls when the price increases and rises when the price decreases. If demand is inelastic, total revenue rises when the price increases and falls when the price decreases.

6. The price elasticity of demand depends on whether there are close substitutes for the good in question, whether the good is a necessity or a luxury, the share of income spent on the good, and the length of time that has elapsed since the price change.

7. The **cross-price elasticity of demand** measures the effect of a change in one good's price on the quantity of another good demanded. The cross-price elasticity of demand can be positive, in which case the goods are substitutes, or negative, in which case they are complements.

8. The **income elasticity of demand** is the percent change in the quantity of a good demanded when a consumer's income changes divided by the percent change in income. The income elasticity of demand indicates how intensely the demand for a good responds to changes in income. It can be negative; in that case the good is an inferior good. Goods with positive income elasticities of demand are normal goods. If the income elasticity is greater than 1, a good is **income-elastic;** if it is positive and less than 1, the good is **income-inelastic.**

9. The **price elasticity of supply** is the percent change in the quantity of a good supplied divided by the percent change in the price. If the quantity supplied does not change at all, we have an instance of **perfectly inelastic supply;** the supply curve is a vertical line. If the quantity supplied is zero below some price but infinite above that price, we have an instance of **perfectly elastic supply;** the supply curve is a horizontal line.

10. The price elasticity of supply depends on the availability of resources to expand production and on time. It is higher when inputs are available at relatively low cost and when more time has elapsed since the price change.

11. The **willingness to pay** of each individual consumer determines the shape of the demand curve. When price is less than or equal to the willingness to pay, the potential consumer purchases the good. The difference between willingness to pay and price is the net gain to the consumer, the **individual consumer surplus.**

12. **Total consumer surplus** in a market, which is the sum of all individual consumer surpluses in a market, is equal to the area below the market demand curve but above the price. A rise in the price of a good reduces consumer surplus; a fall in the price increases consumer surplus. The term **consumer surplus** is often used to refer to both individual and total consumer surplus.

13. The **cost** of each potential producer of a good, the lowest price at which he or she is willing to supply a unit of that good, determines the supply curve. If the price of a good is above a producer's cost, a sale generates a net gain to the producer, known as the **individual producer surplus.**

14. **Total producer surplus** in a market, the sum of the individual producer surpluses in a market, is equal to the area above the market supply curve but below the price. A rise in the price of a good increases producer surplus; a fall in the price reduces producer surplus. The term **producer surplus** is often used to refer to both individual and total producer surplus.

15. **Total surplus,** the total gain to society from the production and consumption of a good, is the sum of consumer and producer surplus.

16. Usually, markets are efficient and achieve the maximum total surplus. Any possible reallocation of consumption or sales, or change in the quantity bought and sold, reduces total surplus. However, society also cares about equity. So government intervention in a market that reduces efficiency but increases equity can be a valid choice by society.

17. A tax that rises more than in proportion to income is a **progressive tax.** A tax that rises less than in proportion to income is a **regressive tax.** A taxes that rises in proportion to income is, you guessed it, a **proportional tax.**

18. An **excise tax**—a tax on the purchase or sale of a good—raises the price paid by consumers and reduces the price received by producers, driving a wedge between the two. The **incidence** of the tax—how the burden of the tax is divided between consumers and producers—does not depend on who officially pays the tax.

19. The incidence of an excise tax depends on the price elasticities of supply and demand. If the price elasticity of demand is higher than the price elasticity of supply, the tax falls mainly on producers; if the price elasticity of supply is higher than the price elasticity of demand, the tax falls mainly on consumers.

20. The tax revenue generated by a tax depends on the **tax rate** and on the number of units sold with the tax. Excise taxes cause inefficiency in the form of deadweight loss because they discourage some mutually beneficial transactions. Taxes also impose **administrative costs:** resources used to collect the tax, to pay it (over and above the amount of the tax), and to evade it.

21. An excise tax generates revenue for the government but lowers total surplus. The loss in total surplus exceeds the tax revenue, resulting in a deadweight loss to society. This deadweight loss is represented by a triangle, the area of which equals the value of the transactions discouraged by the tax. The greater the elasticity of demand or supply, or both, the larger the deadweight loss from a tax. If either demand or supply is perfectly inelastic, there is no deadweight loss from a tax.

22. A **lump-sum tax** is a tax of a fixed amount paid by all taxpayers. Because a lump-sum tax does not depend on the behavior of taxpayers, it does not discourage mutually beneficial transactions and therefore causes no deadweight loss.
23. Consumers maximize a measure of satisfaction called **utility.** We measure utility in hypothetical units called **utils.**
24. A good's or service's **marginal utility** is the additional utility generated by consuming one more unit of the good or service. We usually assume that the **principle of diminishing marginal utility** holds: consumption of another unit of a good or service yields less additional utility than the previous unit. As a result, the **marginal utility curve** slopes downward.
25. A **budget constraint** limits a consumer's spending to no more than his or her income. It defines the consumer's **consumption possibilities,** the set of all affordable consumption bundles. A consumer who spends all of his or her income will choose a consumption bundle on the **budget line.** An individual chooses the consumption bundle that maximizes total utility, the **optimal consumption bundle.**
26. We use marginal analysis to find the optimal consumption bundle by analyzing how to allocate the marginal dollar. According to the **optimal consumption rule,** with the optimal consumption bundle, the **marginal utility per dollar** spent on each good and service—the marginal utility of a good divided by its price—is the same.

Key Terms

Substitution effect, p. 458
Income effect, p. 459
Price elasticity of demand, p. 460
Midpoint method, p. 462
Perfectly inelastic demand, p. 466
Perfectly elastic demand, p. 467
Elastic demand, p. 467
Inelastic demand, p. 467
Unit-elastic demand, p. 467
Total revenue, p. 468
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Marginal utility per dollar, p. 518
Optimal consumption rule, p. 520

Problems

1. Nile.com, the online bookseller, wants to increase its total revenue. One strategy is to offer a 10% discount on every book it sells. Nile.com knows that its customers can be divided into two distinct groups according to their likely responses to the discount. The accompanying table shows how the two groups respond to the discount.

	Group A (sales per week)	Group B (sales per week)
Volume of sales before the 10% discount	1.55 million	1.50 million
Volume of sales after the 10% discount	1.65 million	1.70 million

a. Using the midpoint method, calculate the price elasticities of demand for group A and group B.

b. Explain how the discount will affect total revenue from each group.

c. Suppose Nile.com knows which group each customer belongs to when he or she logs on and can choose whether or not to offer the 10% discount. If Nile.com wants to increase its total revenue, should discounts be offered to group A or to group B, to neither group, or to both groups?

2. Do you think the price elasticity of demand for Ford sport-utility vehicles (SUVs) will increase, decrease, or remain the same when each of the following events occurs? Explain your answer.

a. Other car manufacturers, such as General Motors, decide to make and sell SUVs.

b. SUVs produced in foreign countries are banned from the American market.

c. Due to ad campaigns, Americans believe that SUVs are much safer than ordinary passenger cars.

d. The time period over which you measure the elasticity lengthens. During that longer time, new models such as four-wheel-drive cargo vans appear.

3. The accompanying table gives part of the supply schedule for personal computers in the United States.

Price per computer	Quantity of computers supplied
$1,100	12,000
900	8,000

a. Using the midpoint method, calculate the price elasticity of supply when the price increases from $900 to $1,100.

b. Suppose firms produce 1,000 more computers at any given price due to improved technology. As price increases from $900 to $1,100, is the price elasticity of supply now greater than, less than, or the same as it was in part a?

c. Suppose a longer time period under consideration means that the quantity supplied at any given price is 20% higher than the figures given in the table. As price increases from $900 to $1,100, is the price elasticity of supply now greater than, less than, or the same as it was in part a?

4. The accompanying table lists the cross-price elasticities of demand for several goods, where the percent quantity change is measured for the first good of the pair, and the percent price change is measured for the second good.

Good	Cross-price elasticities of demand
Air-conditioning units and kilowatts of electricity	–0.34
Coke and Pepsi	+0.63
High-fuel-consuming sport-utility vehicles (SUVs) and gasoline	–0.28
McDonald's burgers and Burger King burgers	+0.82
Butter and margarine	+1.54

a. Explain the sign of each of the cross-price elasticities. What does it imply about the relationship between the two goods in question?

b. Compare the absolute values of the cross-price elasticities and explain their magnitudes. For example, why is the cross-price elasticity of McDonald's burgers and Burger King burgers less than the cross-price elasticity of butter and margarine?

c. Use the information in the table to calculate how a 5% increase in the price of Pepsi affects the quantity of Coke demanded.

d. Use the information in the table to calculate how a 10% decrease in the price of gasoline affects the quantity of SUVs demanded.

5. The accompanying table shows the price and yearly quantity sold of souvenir T-shirts in the town of Crystal Lake according to the average income of the tourists visiting.

Price of T-shirt	Quantity of T-shirts demanded when average tourist income is $20,000	Quantity of T-shirts demanded when average tourist income is $30,000
$4	3,000	5,000
5	2,400	4,200
6	1,600	3,000
7	800	1,800

a. Using the midpoint method, calculate the price elasticity of demand when the price of a T-shirt rises from $5 to $6 and the average tourist income is $20,000. Also calculate it when the average tourist income is $30,000.

b. Using the midpoint method, calculate the income elasticity of demand when the price of a T-shirt is $4 and the average tourist income increases from $20,000 to $30,000. Also calculate it when the price is $7.

6. In each of the following cases, do you think the price elasticity of supply is (i) perfectly elastic; (ii) perfectly inelastic; (iii) elastic, but not perfectly elastic; or (iv) inelastic, but not perfectly inelastic? Explain using a diagram.

a. An increase in demand this summer for luxury cruises leads to a huge jump in the sales price of a cabin on the Queen Mary 2.

b. The price of a kilowatt of electricity is the same during periods of high electricity demand as during periods of low electricity demand.

c. Fewer people want to fly during February than during any other month. The airlines cancel about 10% of their flights as ticket prices fall about 20% during this month.

d. Owners of vacation homes in Maine rent them out during the summer. Due to a soft economy, a 30% decline in the price of a vacation rental leads more than half of homeowners to occupy their vacation homes themselves during the summer.

7. Worldwide, the average coffee grower has increased the amount of acreage under cultivation over the past few years. The result has been that the average coffee plantation produces significantly more coffee than it did 10 to 20 years ago. Unfortunately for the growers, however, this has also been a period in which their total revenues have plunged. In terms of an elasticity, what must be true for these events to have occurred? Illustrate these events with a diagram, indicating the quantity effect and the price effect that gave rise to these events.

8. Determine the amount of consumer surplus generated in each of the following situations.

a. Leon goes to the clothing store to buy a new T-shirt, for which he is willing to pay up to $10. He picks out one he likes with a price tag of exactly \$10. When he is paying for it, he learns that the T-shirt has been discounted by 50%.

b. Alberto goes to the CD store hoping to find a used copy of *Nirvana's Greatest Hits* for up to \$10. The store has one copy selling for \$10, which he purchases.

c. After soccer practice, Stacey is willing to pay \$2 for a bottle of mineral water. The 7-Eleven sells mineral water for \$2.25 per bottle, so she declines to purchase it.

9. Determine the amount of producer surplus generated in each of the following situations.

a. Gordon lists his old Lionel electric trains on eBay. He sets a minimum acceptable price, known as his *reserve price,* of \$75. After five days of bidding, the final high bid is exactly \$75. He accepts the bid.

b. So-Hee advertises her car for sale in the used-car section of the student newspaper for \$2,000, but she is willing to sell the car for any price higher than \$1,500. The best offer she gets is \$1,200, which she declines.

c. Sanjay likes his job so much that he would be willing to do it for free. However, his annual salary is \$80,000.

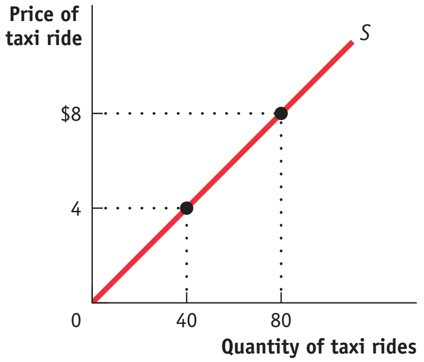
10. You are the manager of Fun World, a small amusement park. The accompanying diagram shows the demand curve of a typical customer at Fun World.

a. Suppose that the price of each ride is \$5. At that price, how much consumer surplus does an individual consumer get? (Recall that the area of a right triangle is ½ × the height of the triangle × the base of the triangle.)

b. Suppose that Fun World considers charging an admission fee, even though it maintains the price of each ride at \$5. What is the maximum admission fee it could charge? (Assume that all potential customers have enough money to pay the fee.)

c. Suppose that Fun World lowered the price of each ride to zero. How much consumer surplus does an individual consumer get? What is the maximum admission fee Fun World could charge?

11. The accompanying diagram illustrates a taxi driver's individual supply curve. (Assume that each taxi ride is the same distance.)



a. Suppose the city sets the price of taxi rides at \$4 per ride, and at \$4 the taxi driver is able to sell as many taxi rides as he desires. What is this taxi driver's producer surplus? (Recall that the area of a right triangle is ½ × the height of the triangle × the base of the triangle.)

b. Suppose that the city keeps the price of a taxi ride set at \$4, but it decides to charge taxi drivers a "licensing fee." What is the maximum licensing fee the city could extract from this taxi driver?

c. Suppose that the city allowed the price of taxi rides to increase to \$8 per ride. Again assume that, at this price, the taxi driver sells as many rides as he is willing to offer. How much producer surplus does an individual taxi driver now get? What is the maximum licensing fee the city could charge this taxi driver?

12. Consider the original market for pizza in Collegetown, illustrated in the accompanying table. Collegetown officials decide to impose an excise tax on pizza of \$4 per pizza.

Price of pizza	Quantity of pizza demanded	Quantity of pizza supplied
10	0	6
9	1	5
8	2	4
7	3	3
6	4	2
5	5	1
4	6	0
3	7	0
2	8	0
1	9	0

a. What is the quantity of pizza bought and sold after the imposition of the tax? What is the price paid by consumers? What is the price received by producers?

b. Calculate the consumer surplus and the producer surplus after the imposition of the tax. By how much has the imposition of the tax reduced consumer surplus? By how much has it reduced producer surplus?

c. How much tax revenue does Collegetown earn from this tax?

d. Calculate the deadweight loss from this tax.

13. The state needs to raise money, and the governor has a choice of imposing an excise tax of the same amount on one of two previously untaxed goods: either restaurant meals or gasoline. Both the demand for and the supply of restaurant meals are more elastic than the demand for and the supply of gasoline. If the governor wants to minimize the deadweight loss caused by the tax, which good should be taxed? For each good, draw a diagram that illustrates the deadweight loss from taxation.

14. For each of the following situations, decide whether Al has increasing, constant, or diminishing marginal utility.

a. The more economics classes Al takes, the more he enjoys the subject. And the more classes he takes, the easier each one gets, making him enjoy each additional class even more than the one before.

b. Al likes loud music. In fact, according to him, "the louder, the better." Each time he turns the volume up a notch, he adds 5 utils to his total utility.

c. Al enjoys watching reruns of the old sitcom *Friends*. He claims that these episodes are always funny, but he does admit that the more times he sees an episode, the less funny it gets.

d. Al loves toasted marshmallows. The more he eats, however, the fuller he gets and the less he enjoys each additional marshmallow. And there is a point at which he becomes satiated: beyond that point, more marshmallows actually make him feel worse rather than better.

15. Use the concept of marginal utility to explain the following: Newspaper vending machines are designed so that once you have paid for one paper, you could take more than one paper at a time. But soda vending machines, once you have paid for one soda, dispense only one soda at a time.

16. Brenda likes to have bagels and coffee for breakfast. The accompanying table shows Brenda's total utility from various consumption bundles of bagels and coffee.

Consumption bundle: Quantity of bagels	Consumption bundle: Quantity of coffee (cups)	Total utility (utils)
0	0	0
0	2	28
0	4	40
1	2	48
1	3	54
2	0	28
2	2	56
3	1	54
3	2	62
4	0	40
4	2	66

Suppose Brenda knows she will consume 2 cups of coffee for sure. However, she can choose to consume different quantities of bagels: she can choose either 0, 1, 2, 3, or 4 bagels.

a. Calculate Brenda's marginal utility from bagels as she goes from consuming 0 bagel to 1 bagel, from 1 bagel to 2 bagels, from 2 bagels to 3 bagels, and from 3 bagels to 4 bagels.

b. Draw Brenda's marginal utility curve of bagels. Does Brenda have increasing, diminishing, or constant marginal utility of bagels?

17. Bernie loves notebooks and Beyoncé CDs. The accompanying table shows the utility Bernie receives from each product.

Quantity of notebooks	Utility from notebooks (utils)	Quantity of CDs	Utility from CDs (utils)
0	0	0	0
2	70	1	80
4	130	2	150
6	180	3	210
8	220	4	260
10	250	5	300

The price of a notebook is $5, the price of a CD is $10, and Bernie has $50 of income to spend.

a. Which consumption bundles of notebooks and CDs can Bernie consume if he spends all his income? Illustrate Bernie's budget line with a diagram, putting notebooks on the horizontal axis and CDs on the vertical axis.

b. Calculate the marginal utility of each notebook and the marginal utility of each CD. Then calculate the marginal utility per dollar spent on notebooks and the marginal utility per dollar spent on CDs.

c. Draw a diagram like Figure 51.4 in which both the marginal utility per dollar spent on notebooks and the marginal utility per dollar spent on CDs are illustrated. Using this diagram and the optimal consumption rule, predict which bundle—from all the bundles on his budget line—Bernie will choose.

18. For each of the following situations, decide whether the bundle Lakshani is considering is optimal or not. If it is not optimal, how could Lakshani improve her overall level of utility? That is, determine which good she should spend more on and which good she should spend less on.

a. Lakshani has $200 to spend on sneakers and sweaters. Sneakers cost $50 per pair, and sweaters cost $20 each. She is thinking about buying 2 pairs of sneakers and 5 sweaters. She tells her friend that the additional utility she would get from the second pair of sneakers is the same as the additional utility she would get from the fifth sweater.

b. Lakshani has $5 to spend on pens and pencils. Each pen costs $0.50 and each pencil costs $0.10. She is thinking about buying 6 pens and 20 pencils. The last pen would add five times as much to her total utility as the last pencil.

c. Lakshani has $50 per season to spend on tickets to football games and tickets to soccer games. Each football ticket costs $10, and each soccer ticket costs $5. She is thinking about buying 3 football tickets and 2 soccer tickets. Her marginal utility from the third football ticket is twice as much as her marginal utility from the second soccer ticket.