

## >>Elasticity

### DRIVE WE MUST

**I**N EARLY 1998, LUIS TELLEZ HELD A secret meeting with his Saudi Arabian counterpart. Mr Tellez was Mexico's oil minister, the government official who decided how many barrels of oil Mexico would produce and sell to other countries. The purpose of the secret meeting? To increase their earnings, or revenues, from selling oil by raising the world price of oil, which had fallen 50 percent over the previous two years. This low world price was creating serious problems for both governments, which depended on revenue from oil sales. But a plan to raise oil prices would not succeed unless other oil-exporting countries were also willing to commit to reductions in oil production.

Why was it necessary to reduce production? Why not just raise prices? Because by the *law of demand*, a price increase leads to a fall in the quantity demanded. So if output didn't also fall, there would soon be a surplus of oil on the market, pushing the price right back down again. To make the plan work, Tellez had to persuade his fellow oil ministers to produce less. But how much less?

If consumers responded to the price increase by using a lot less oil, output would have to fall by a large amount. And

if output fell by a large enough amount in response to the price increase, revenue would decline, not increase. The crucial question for Tellez, then, was how responsive the quantity of oil demanded was to changes in the price of oil.

But how do we define *responsiveness*? The answer, and what Tellez needed to know in this case is a particular number: the *price elasticity of demand*. In this chapter, we will show how the price elasticity of demand is measured and why it is the best measure of how the quantity demanded



Gassing up: A hard habit to break.

responds to changes in the price. We will then see 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*. Finally, we will see how elasticities are used to determine who bears the greater share of the burden of a tax—producers or consumers.

# Chapter 5

### What you will learn in this chapter:

- ▶ The definition of **elasticity**, a measure of responsiveness to changes in prices or income
- ▶ The importance of the **price elasticity of demand**, which measures the responsiveness of the quantity demanded to price
- ▶ The meaning and importance of the **income elasticity of demand**, a measure of the responsiveness of demand to income
- ▶ The significance of the **price elasticity of supply**, which measures the responsiveness of the quantity supplied to price
- ▶ What factors influence the size of these various elasticities
- ▶ How elasticity affects the **incidence** of a tax, the measure of who bears its burden

## Defining And Measuring Elasticity

Luis Tellez, who is a trained economist, knew that to calculate the cut in oil output needed to achieve his price target, he would have to know the *price elasticity of demand* for oil.

### The Price Elasticity of Demand

Figure 5-1 shows a hypothetical world demand curve for oil. At a price of \$20 per barrel, world consumers would demand 10 million barrels of oil per day (point A); at a price of \$21 per barrel, the quantity demanded would fall to 9.9 million barrels (point B).

Figure 5-1, then, tells us the response of the quantity demanded to 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 in this chapter, 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, litres versus barrels of oil). But before we get to that, let's look at how elasticity is calculated.

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:

$$(5-1) \quad \% \text{ change in quantity demanded} = \frac{\text{Change in quantity demanded}}{\text{Initial quantity demanded}} \times 100$$

and

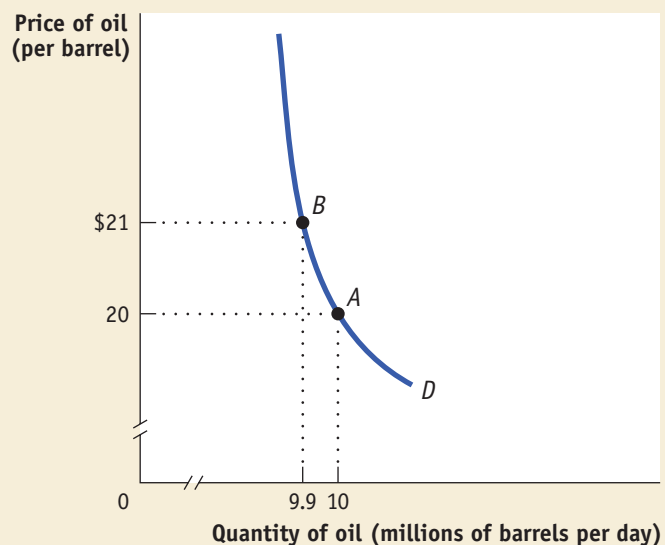
$$(5-2) \quad \% \text{ change in price} = \frac{\text{Change in price}}{\text{Initial price}} \times 100$$

In Figure 5-1, we see that when the price rises from \$20 to \$21, the quantity demanded falls from 10 million to 9.9 million barrels, yielding a change in the

**Figure 5-1**

#### The World Demand for Oil

At a price of \$20 per barrel, the world quantity of oil demanded is 10 million barrels per day (point A). When price rises to \$21 per barrel, world demand falls to 9.9 million barrels per day (point B).



quantity demanded of 0.1 million barrels. So the percent change in the quantity demanded is

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

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

$$(5-3) \text{ Price elasticity of demand} = \frac{\% \text{ change in quantity demanded}}{\% \text{ change in price}}$$

In Figure 5-1, the price elasticity of demand is therefore

$$\frac{1\%}{5\%} = 0.2$$

The *law of demand* says that demand curves slope downward. This means that the price elasticity of demand is, in strictly mathematical terms, a negative number (if the price rises, which is a positive percent change, the quantity demanded falls, which is strictly speaking a *negative* percent change). However, it is a nuisance to keep writing that 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 elasticity. 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. As we have just done, we follow this convention and drop the minus sign when referring to the price elasticity of demand.

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 Tellez needed for his strategy to increase revenue by raising oil prices.

## Using the Midpoint Method to Calculate Elasticities

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.

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 twice as much per litre in Europe as it does in Canada. So what is the percent difference between Canadian and European gas prices?

---

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.

---

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 starting and final values.

Well, it depends on which way you measure it. The price of gasoline in Europe is two times higher than in Canada, so it is 100 percent higher. The price of gasoline in Canada is half as high as in Europe, so it is 50 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*.

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

$$(5-4) \quad \% \text{ change in } X = \frac{\text{Change in } X}{\text{Average value of } X} \times 100$$

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 this method.

To see how this method works, suppose you have the following data for some good:

	Price	Quantity demanded
<b>Situation A</b>	\$0.90	1,100
<b>Situation B</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—200 units—with the *average* of the quantity demanded in the two situations. So we calculate

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

In the same way, we calculate

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

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

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

The important point is that we would get the same result, a price elasticity of demand of 1, whether we go 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 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

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

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

## economics in action

### 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 for 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 5-1. Although they used U.S. data, the thrust of their results easily carries over to Canada too. 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, where the quantity demanded is very sensitive to the price.

Notice that Table 5-1 is divided into two parts: inelastic and elastic demand. We'll explain in the next section the significance of that division. ■

#### >> CHECK YOUR UNDERSTANDING 5-1

1. 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.
2. 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 theatres must reduce price in order to sell 5,000 tickets.
3. 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 5-1 and 5-2 to calculate percent changes, and Equation 5-3 to relate price elasticity of demand to the percent changes.

Solutions appear at back of book.

TABLE 5-1

### Some Estimated Price Elasticities of Demand

Good	Price elasticity of demand
<b>Inelastic demand</b>	
Eggs <sup>1</sup>	0.1
Beef <sup>1</sup>	0.4
Stationery <sup>2</sup>	0.5
Gasoline <sup>2</sup>	0.5
<b>Elastic demand</b>	
Housing <sup>3</sup>	1.2
Restaurant meals <sup>3</sup>	2.3
Airline travel <sup>2</sup>	2.4
Foreign travel <sup>2</sup>	4.1

Please find source information on page xxii.

<sup>1</sup>Kuo S. Huang and Bing-Hwan Lin (2000).

"Estimation of Food Demand and Nutrient Elasticities from Household Survey Data," *United States Department of Agriculture Economic Research Service Technical Bulletin* 1887.

<sup>2</sup>H. S. Houthakker and Lester D. Taylor (1966).

*Consumer Demand in the United States, 1929-1970: Analyses and Projections* Cambridge, Mass.: Harvard University Press.

<sup>3</sup>H. S. Houthakker and Lester D. Taylor (1970) *Consumer Demand in the United States: Analyses and Projections*, 2nd ed. Cambridge, Mass.: Harvard University Press.

#### >> QUICK REVIEW

- ▶ The *price elasticity of demand* is equal to the percent change in the quantity demanded divided by the percent change in the price as you move along the demand curve.
- ▶ Percent changes are best measured using the *midpoint method*, in which the percent change in each variable is calculated using the average of starting and final values.

## Interpreting The Price Elasticity Of Demand

Mexico and other oil-producing countries believed they could succeed in driving up world oil prices with only a small decrease in the quantity sold because the price elasticity of oil 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.

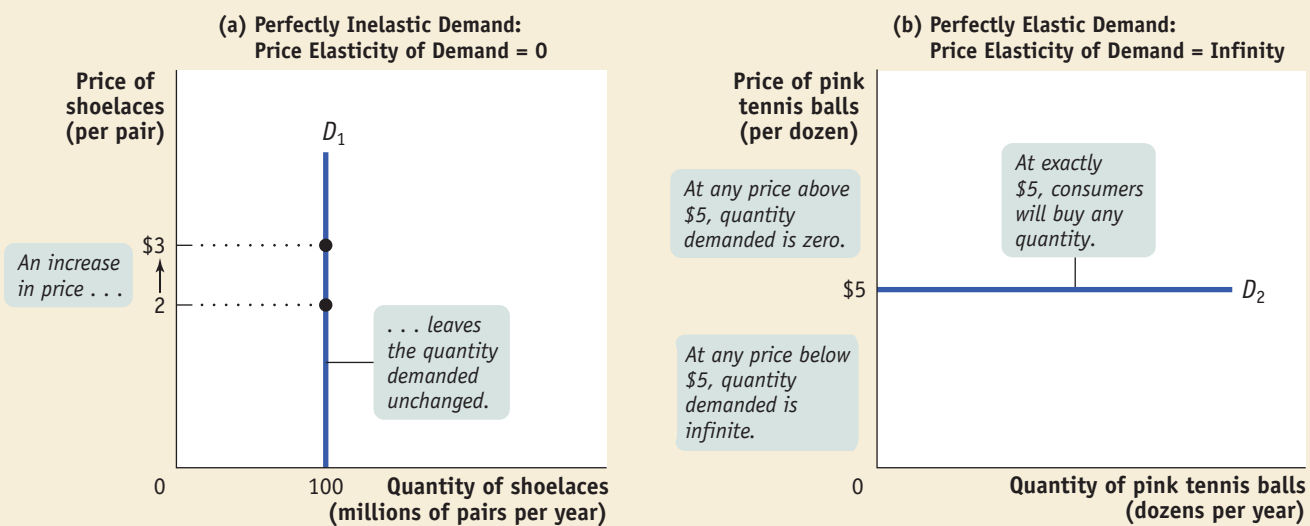
First, consider the demand for a good when people pay no attention to the price—say, shoelaces. Suppose that Canadian consumers will buy 100 million pairs of shoelaces per year regardless of the price. In this case, the demand curve for shoelaces would look like the curve shown in panel a. of Figure 5-2: it would be a vertical line at 100 million 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 5-2 shows the case of pink tennis balls; we suppose that tennis players really don't care what colour their tennis balls are and that other colours, 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. Roughly speaking, when you divide a number by zero, you get infinity, 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**.

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.

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.

**Figure 5-2** 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 100 million 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 price falls below \$5, they will buy an extremely large number of pink tennis balls and none of any other color.

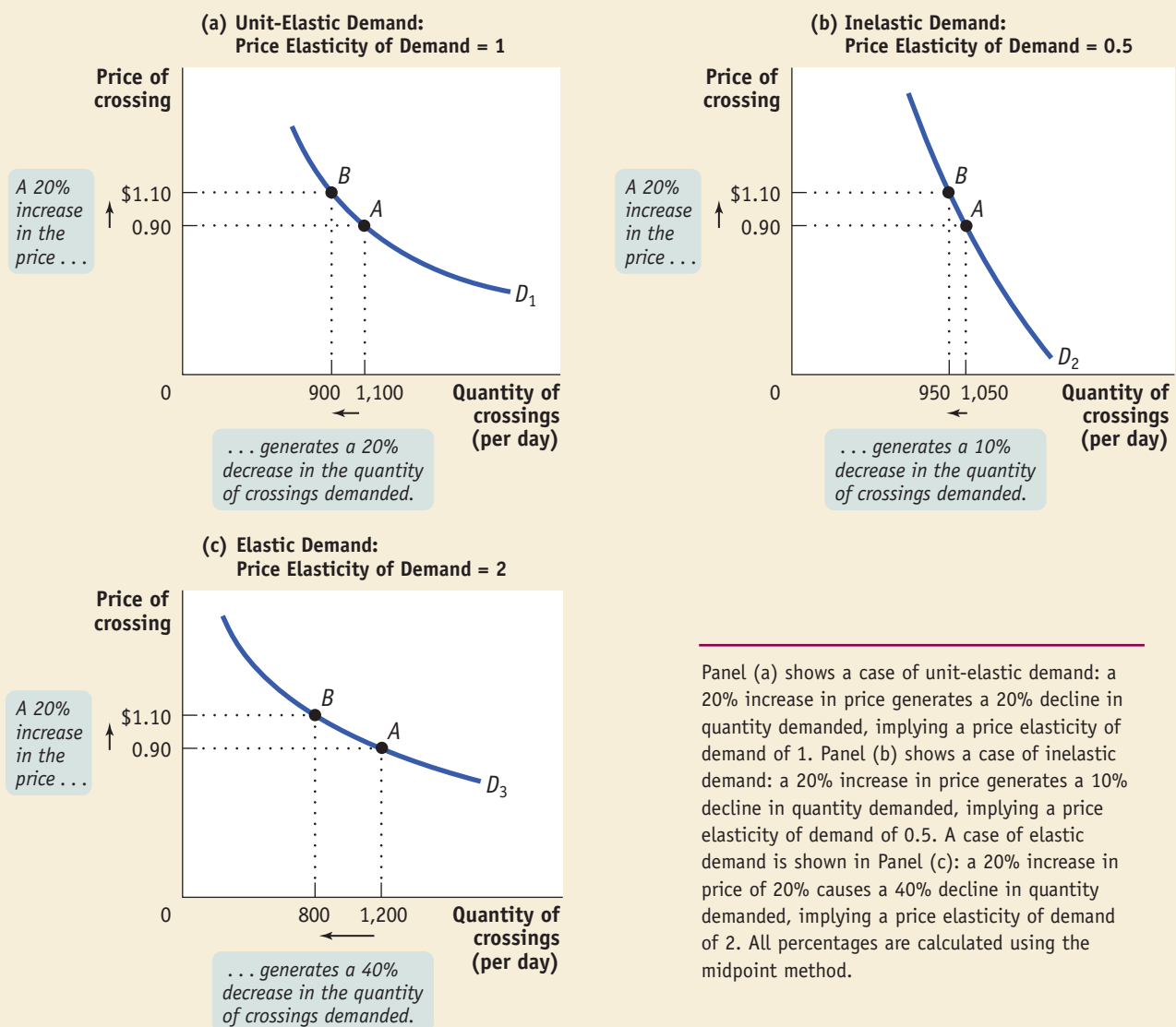
The price elasticity of demand for the vast majority of goods is somewhere between these two extreme cases. Economists use one main criterion for classifying these intermediate cases: they ask whether the price elasticity of demand is higher or lower than 1. When the price elasticity of demand is greater 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.

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 department of transportation. Other things equal, the number of drivers who use the bridge depends on the toll, the price charged for crossing the bridge: the higher the toll, the fewer the drivers who use the bridge.

Figure 5-3 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,

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.

**Figure 5-3** Unit-Elastic Demand, Inelastic Demand, and Elastic Demand



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 increase 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 increase 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  $10\%/20\% = 0.5$ .

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. And in many real-life situations, such as the one faced by Luis Tellez, 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.

---

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

---

$$(5-6) \text{ Total revenue} = \text{Price} \times \text{quantity sold}$$

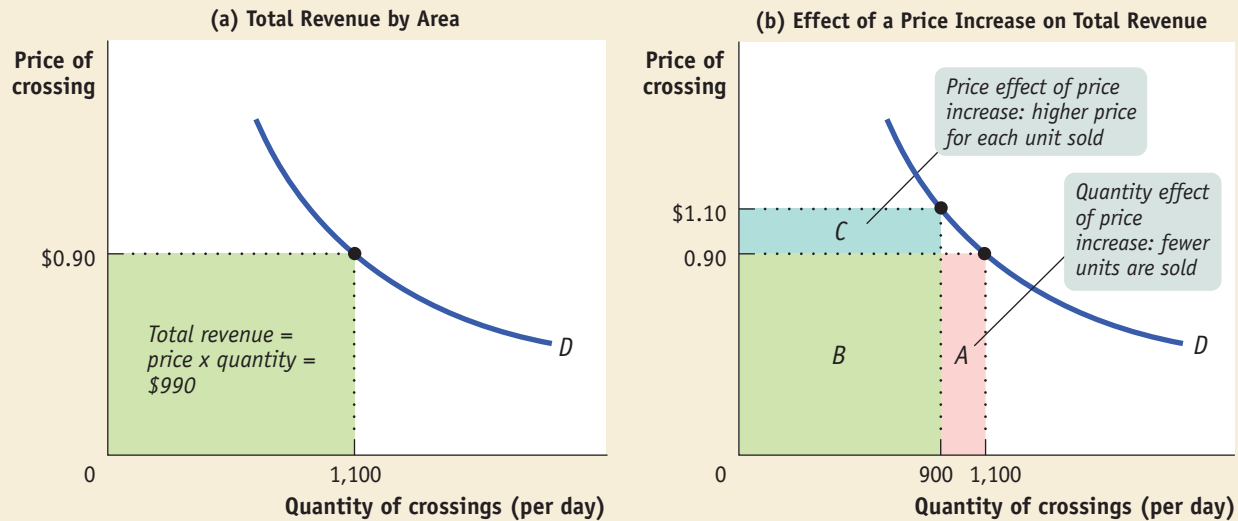
Total revenue has a useful graphical representation that can help us understand why knowing the price elasticity of demand is crucial when we ask whether a price rise will increase or reduce total revenue. Panel (a) of Figure 5-4 shows the same demand curve as panel (a) of Figure 5-3. We see that 1,100 drivers will use the bridge if the toll is \$0.90. The total revenue at a price of \$0.90 is therefore  $\$0.90 \times 1,100 = \$990$ . 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 department of transportation 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 department of transportation 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 5-4. 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  $\$0.20 \times 900 = \$180$  per day to total revenue, represented by area *C*. On the other hand, 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  $\$0.90 \times 200 = \$180$  per day, represented by area *A*. 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.



**Figure 5-4 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 the area C. The overall effect can go either way, depending on the price elasticity of demand.

- A *quantity effect*. After a price increase, fewer units are sold, which tends to lower revenue.

But then, you may ask, what is the 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 increase total revenue or may 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 *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.
- 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 *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.

Table 5-2 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 5-3. 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 5-2****Price Elasticity of Demand and Total Revenue**

	Price of crossing = \$0.90	Price of crossing = \$1.10
<b>Unit-elastic demand</b> (price elasticity of demand = 1)		
Quantity demanded	1,100	900
Total revenue	\$990	\$990
<b>Inelastic demand</b> (price elasticity of demand = 0.5)		
Quantity demanded	1,050	950
Total revenue	\$945	\$1,045
<b>Elastic demand</b> (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 in 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 *elastic*, the quantity effect dominates the price effect; so a fall in price increases total revenue.
- When demand is *inelastic*, the price effect dominates the quantity effect; so a fall in price reduces total revenue.
- When demand is *unit-elastic*, the two effects exactly balance; so a fall in price has no effect on total revenue.

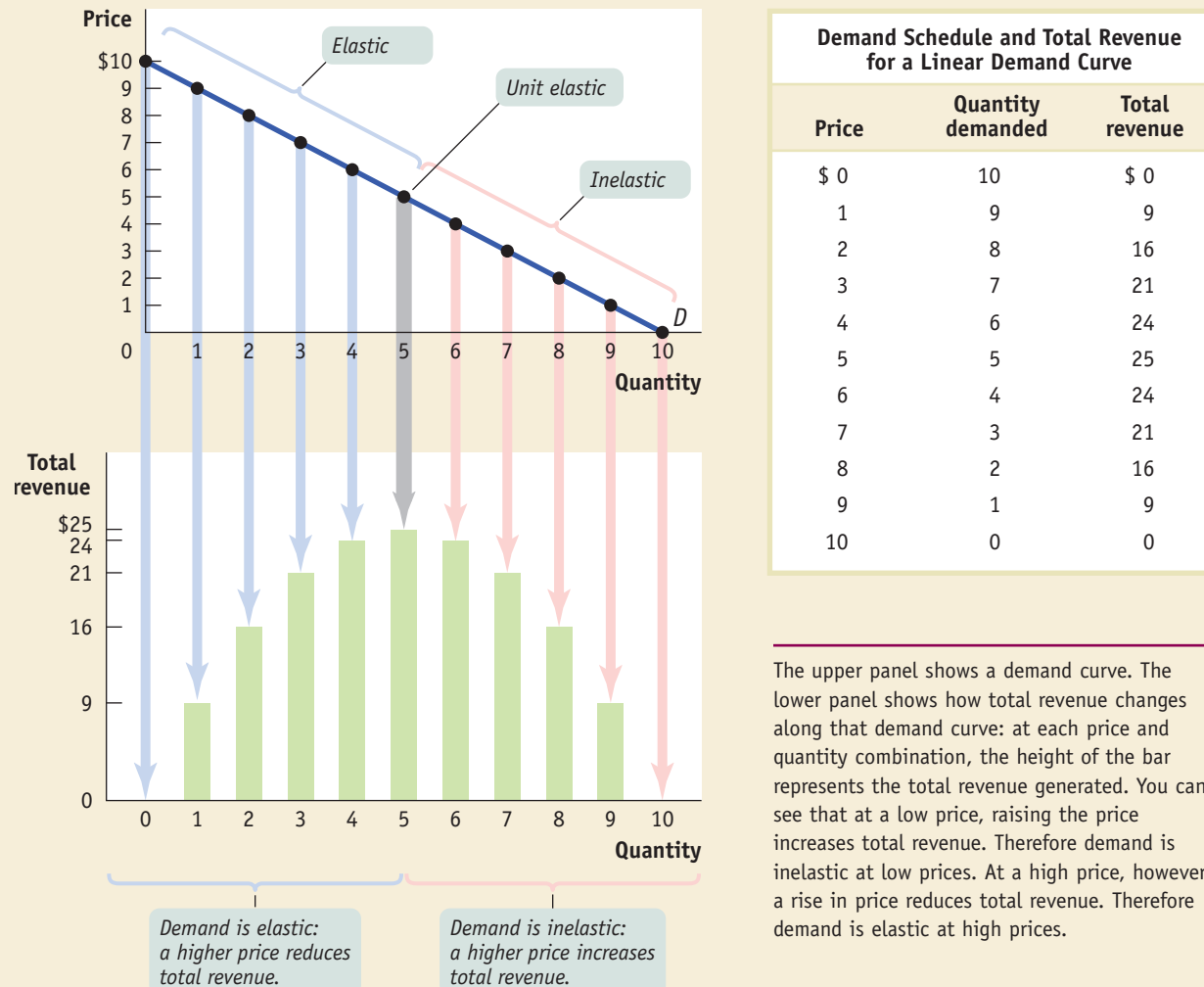
### Price Elasticity Along the Demand Curve

Suppose that 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 at other points along the same curve.

To see this, consider the table in Figure 5-5, 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 Figure 5-5 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 5-5, 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, raising the price to \$9 reduces total revenue, from \$16 to \$9. This

**Figure 5-5** The Price Elasticity of Demand Changes Along the Demand Curve

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 the elasticity, you are really measuring it at a particular point or section of the demand curve.

### What Factors Determine the Price Elasticity of Demand?

1998 was not the first time that oil-exporting countries tried to raise oil prices. Oil exporters succeeded in quadrupling world oil prices between 1973 and 1974, and in raising prices another 150 percent in 1979. Canadian oil prices increased in response to these rising world prices. So, how did the quantity demanded respond to these price hikes? Consumers in North America initially reacted by changing their consumption of gasoline very little. Over time, however, North American drivers gradually adapted to the higher gasoline prices. After a few years, drivers had cut their consumption of gasoline in various ways: increased carpooling, greater use of public transportation, and, most important, replacement of large, gas-guzzling cars with smaller, more fuel-efficient models.



Mike Thompson, Detroit Free Press. Reprinted by permission.

The experience of the 1970s illustrates the three main factors that determine elasticity: whether close substitutes are available, whether the good is a necessity or a luxury, and how much time has elapsed since the price change. We'll briefly examine each of these three 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.

**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.

So when gasoline prices first jumped at the beginning of the 1970s, 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, North Americans changed their habits in ways that enabled them to gradually reduce their gasoline consumption. The result was a steady decline in gasoline consumption throughout the 1980s 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.

## *economics in action*

### Reversing Falls and Reversing Flows

In Saint John, New Brunswick, the Reversing Falls is a popular tourist attraction. This occurs where the flow of the mighty Saint John River enters the Bay of Fundy—a place where some of the highest tides in the world periodically reverse the flow of the river.

Tourists might be interested in another reversal of flows, one that was produced not by natural phenomena but by changes in the value of the Canadian dollar—reversing flows of tourists. In 1992, 18.6 million Canadians visited the United States, but only 11.8 million U.S. residents visited Canada. By 2002, however, roles had been reversed: more U.S. residents visited Canada than vice versa.

Why did the tourist traffic reverse direction? Canada didn't get any warmer from 1992 to 2002—but it did get cheaper for Americans. The reason was a large change in the exchange rate between the two nations' currencies: in 1992 a Canadian dollar was worth US\$0.80, but by 2002 it had fallen in value by nearly 20 percent to about US\$0.65. This meant that our goods and services—particularly hotel rooms and meals—were about 20 percent cheaper for Americans in 2002 compared to 1992. Thus, Canada had become a cheap vacation destination for Americans by 2002. Things were not so rosy, however, for the tourist industry in the United States: American vacations had become 20 percent more expensive for Canadians. Canadians responded by choosing to spend holidays in their own country or in other parts of the world besides the United States.

Foreign travel is an example of a good that has a high price elasticity of demand: as we saw in Table 5-1, it has been estimated at about 4.1. One reason is that foreign travel is a luxury good for most people—you may regret not going to Paris this year, but you can live without it. A second reason is that a good substitute for foreign travel typically exists—domestic travel. A Canadian who finds it too expensive to vacation in San Francisco this year is likely to find that Vancouver is a very good alternative. ■



#### >> CHECK YOUR UNDERSTANDING 5-2

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

Solutions appear at back of book.

#### >> QUICK REVIEW

- Demand is *perfectly inelastic* if it is completely unresponsive to price. It is *perfectly elastic* if it is infinitely responsive to price.
- Demand is *elastic* if the price elasticity of demand is greater than 1; it is *inelastic* if the price elasticity of demand is less than 1; and it is *unit-elastic* if the price elasticity of demand is exactly 1.
- When demand is elastic, the quantity effect of a price increase dominates the price effect, and *total revenue* falls. When demand is inelastic, the price effect of a price increase dominates the quantity effect, and *total revenue* increases.
- Because the price elasticity of demand can change along the demand curve, economists mean a particular point on the demand curve when referring to “the” price elasticity of demand.
- The availability of close substitutes makes demand for a good more elastic, as does the length of time elapsed since the price change. Demand for a necessary good is less elastic; demand for a luxury good is more elastic.

## Other Demand Elasticities

The quantity of a good demanded depends not only on the price of that good but 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*.

### The Cross-Price Elasticity of Demand

In Chapter 3 you learned that the demand for a good is often affected by the prices of other, related goods—goods that are substitutes or complements. There you saw that 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 the other.

$$(5-7) \text{ Cross-price elasticity of demand between goods A and B} \\ = \frac{\% \text{ change in quantity of A demanded}}{\% \text{ change in price of B}}$$

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.

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; 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, it is a measure of how closely substitutable for each other 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 that someone told you that “If the price of hot dog buns rises by \$0.30, Canadians will buy 1 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* (buns are usually sold by the dozen)? 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, as a way of making sure that confusion over units doesn't arise.

## The Income Elasticity of Demand

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 **income elasticity of demand** is a measure of how much the demand for a good is affected by changes in consumers' incomes. It allows us to determine whether a good is a normal or inferior good as well as measure how intensely the demand for the good responds to changes in income.

$$(5-8) \quad \text{Income elasticity of demand} = \frac{\% \text{ change in quantity demanded}}{\% \text{ change in income}}$$

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 from Chapter 3 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*.

## FOR INQUIRING MINDS

## CANADA—NO LONGER A NATION OF FARMERS

At one time, most Canadians lived and worked on farms; and as recently as the 1940s, one-quarter of Canadian workers were still in agriculture. But the importance of agriculture has been steadily declining, and it is no longer true that we are a nation of farmers. Though farmers still swing a lot of political weight, nowadays less than 2 percent of the Canadian labour force works in agriculture. What accounts for this decline?

The immediate answer is that consumers in Canada spend a much smaller share of their income on food and other agricultural

products than they used to. And since farm products command a smaller share of spending, the producers must receive a smaller share of total income.

But why has the share of spending for food declined? It turns out that there are two answers, both having to do with elasticities. First, the income elasticity of demand for food is much less than one. So as an economy gets richer, other things being the same, it will spend only slightly more on food.

Second, throughout the twentieth century agriculture was a technologically progressive

sector; as a result, the prices of farm products have steadily fallen compared with the prices of nonagricultural goods. This could either raise or lower total spending on agricultural products, other things being the same; it depends on whether demand is elastic or inelastic. But all the evidence is that the price elasticity of demand for agricultural products is less than one—an inelastic demand—so falling prices reduced the total revenue, and hence the income, of farmers.

In short, the Canadian farm sector is a victim of its own success; indeed, it has been so successful that it has almost disappeared.

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 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.

## economics in action

### Spending It

Statistics Canada carries out extensive surveys of how families spend their incomes. This is not just a matter of intellectual curiosity. Quite a few government programs involve some adjustment for changes in the cost of living; to estimate those changes, the government must know how people spend their money. But an additional payoff to these surveys is evidence on the income elasticity of demand for various goods.

What stands out from these studies? The classic result is that the income elasticity of demand for “food eaten at home” is considerably less than 1: as a family’s income rises, the share of its income spent on food consumed at home falls. Correspondingly, the lower a family’s income, the higher the share of its income spent on food consumed at home. In poor countries, many families spend more than half their income on food consumed at home. Few people in Canada are that poor, but the income elasticity for “food eaten at home” is usually estimated at less than 0.5. “Food eaten away from home” has a much higher income elasticity, perhaps close to 1—families with higher incomes eat out more often and at fancier places. In fact, a sure sign of rising income levels in developing countries is the arrival of fast-food restaurants that cater to newly affluent customers. For example, McDonald’s can now be found in Jakarta, Shanghai, and Bombay.



Judging from the activity at this busy McDonald’s, incomes are rising in Jakarta, Indonesia.

AP/Wide World Photos

**>> QUICK REVIEW**

- Goods are substitutes when the *cross-price elasticity of demand* is positive. Goods are complements when the cross-price elasticity of demand is negative.
- Inferior goods have a negative *income elasticity of demand*. Most goods are normal goods, which have a positive income elasticity of demand.
- Normal goods may be either *income-elastic*, with an income elasticity of demand greater than 1, or *income-inelastic*, with an income elasticity of demand that is positive, but less than 1.

There is one clear example of an inferior good found in the surveys: rental housing. Families with higher income actually spend less on rent than families with lower income, because they are much more likely to own their own homes. And the category identified as “other housing”—which basically means second homes—is highly income-elastic: only higher-income families can afford a vacation home at all, so “other housing” has an income elasticity of demand greater than 1. ■

**>> CHECK YOUR UNDERSTANDING 5-3**

1. After Kathy’s income increased from \$12,000 to \$18,000 a year, her purchases of CDs increased from 10 to 40 CDs a year. Calculate Kathy’s income elasticity of demand for CDs using the midpoint method.
2. Expensive restaurant meals are income-elastic goods for most people, including Sanjay. Suppose his income falls by 10% this year. What can you predict about the change in Sanjay’s consumption of expensive restaurant meals?
3. 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?

Solutions appear at back of book.

## The Price Elasticity Of Supply

The Tellez plan to drive up the price of oil would have been much less effective if a higher price had induced large increases in output by countries that were not party to the agreement. For example, if Canadian oil producers had responded to the higher price by significantly increasing their production, they could have pushed the price of oil back down. But they didn’t—in fact, producers of oil who were not members of OPEC (Organization of Petroleum Exporting Countries) did not respond much to the higher price. This was another critical element in the success of the Tellez plan: a low responsiveness in output to a higher price of oil from other oil 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:

$$(5-9) \text{ Price elasticity of supply} = \frac{\% \text{ change in quantity supplied}}{\% \text{ change in price}}$$

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

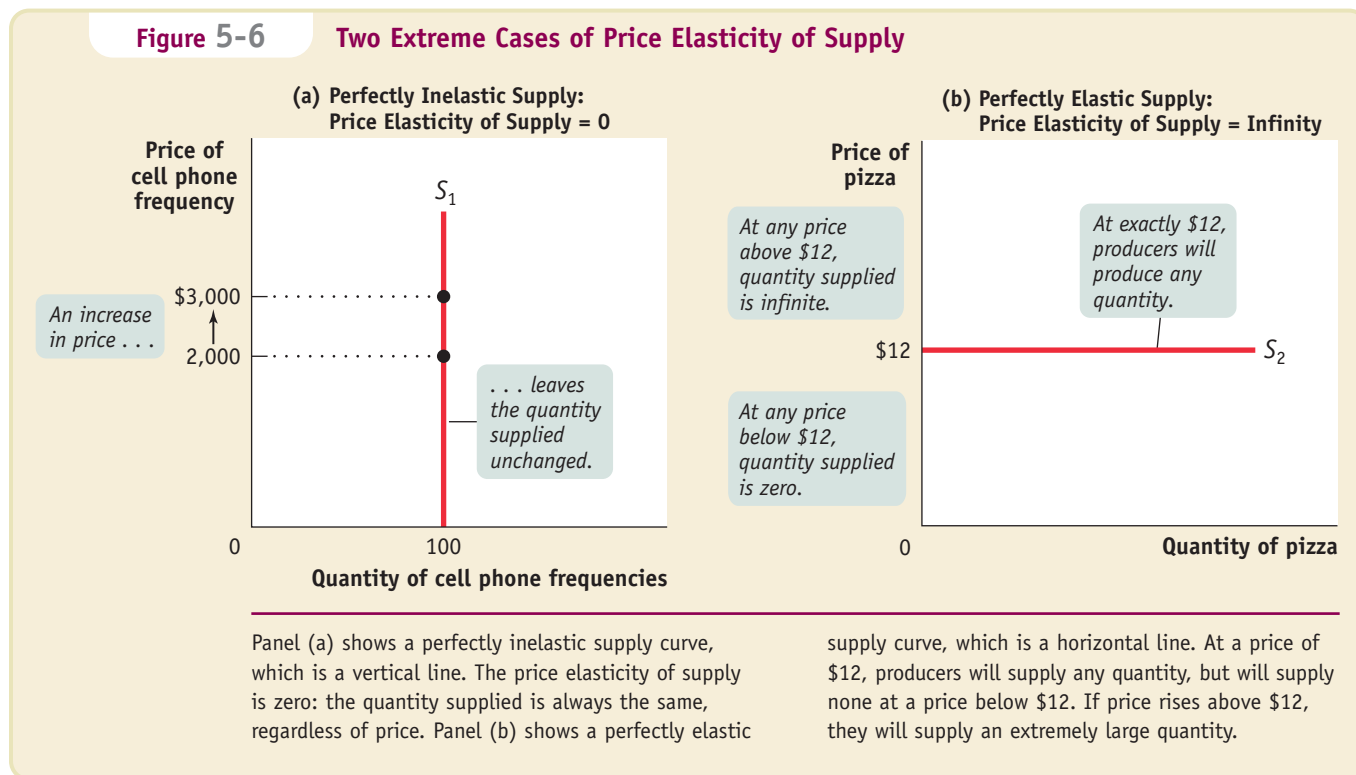
Suppose that the price of tomatoes rises by 10 percent. If the quantity of tomatoes supplied also increases by 10 percent in response, the price elasticity of supply of tomatoes is 1 (10% / 10%), and supply is unit-elastic. If the quantity supplied increases by 5%, the price elasticity of supply is 0.5 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 5-6 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. In Chapter 7, we will discuss how many governments recently sold off their cell phone frequencies to the highest bidder in an auction. But governments can’t increase or decrease the number of cell phone frequencies that they have to offer—for technical reasons, the quantity of frequencies suitable for cell phone operation is a fixed quantity. So the supply curve for cell phone frequencies

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.



**Figure 5-6 Two Extreme Cases of Price Elasticity of Supply**

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 quantity supplied by the government is zero, whatever the change in price. So panel a. illustrates a case in which the price elasticity of supply is zero. This is a case of **perfectly inelastic supply**.

Panel (b) shows the supply curve for pizza. We suppose that it costs \$12 to produce a pizza, including all opportunity costs such as the implicit cost of capital invested in pizza parlours. At any price below \$12, it would be unprofitable to produce pizza, and all the pizza parlours in Canada would go out of business. Alternatively, there are many producers who could operate pizza parlours if they were profitable. The ingredients—dough, tomatoes, cheese—are plentiful. And if necessary, more tomatoes could be grown, more milk could be produced to make mozzarella, and so on. So any price above \$12 would elicit an extremely large quantity of pizzas supplied. The implied supply curve is therefore a horizontal line at \$12. Since even a tiny increase in the price would lead to a huge increase in the quantity supplied, the price elasticity of supply would be more or less infinite. This is 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 relatively easy to find—much easier than their counterparts in demand.

### 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 easily available. It tends to be small when inputs are difficult to obtain.

**Time** The price elasticity of supply tends to become 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.

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.

There is **perfectly elastic supply** when even a tiny increase or reduction in the price will lead to very large changes in the quantity supplied, so that the price elasticity of supply is infinite. A perfectly elastic supply curve is a horizontal line.



3. True or false? Long-run price elasticities of supply are generally larger than short-run price elasticities of supply. Therefore the short-run supply curves are generally flatter than the long-run supply curves.
4. True or false? When supply is perfectly elastic, changes in demand have no effect on price.

Solutions appear at back of book.

## An Elasticity Menagerie

We've just run through quite a few different elasticities. Keeping them all straight can be a problem. So in Table 5-3 we provide a summary of all the elasticities we have discussed and their implications.

**TABLE 5-3**

An Elasticity Menagerie		
Name	Possible values	Significance
<b>Price elasticity of demand = <math>\frac{\% \text{ change in quantity demanded}}{\% \text{ change in price}}</math> (use absolute value)</b>		
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	Between 1 and $\infty$	A rise in price reduces total revenue.
Perfectly elastic demand	$\infty$	A rise in price causes quantity demanded to fall to 0. A fall in price leads to an infinite quantity demanded (horizontal demand curve).
<b>Cross-price elasticity of demand = <math>\frac{\% \text{ change in quantity of one good demanded}}{\% \text{ change in price of another good}}</math></b>		
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.
<b>Income elasticity of demand = <math>\frac{\% \text{ change in quantity demanded}}{\% \text{ change in income}}</math></b>		
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.
<b>Price elasticity of supply = <math>\frac{\% \text{ change in quantity supplied}}{\% \text{ change in price}}</math></b>		
Perfectly inelastic supply	0	Price has no effect on quantity supplied (vertical supply curve).
	Greater than 0, less than $\infty$	Ordinary upward-sloping supply curve.
Perfectly elastic supply	$\infty$	Any fall in price causes quantity supplied to fall to 0. Any rise in price elicits an infinite quantity supplied (horizontal supply curve).

## Using Elasticity: The Incidence Of An Excise Tax

In Chapter 4 we introduced the concept of the *incidence* of a tax—the measure of who really bears the burden of the tax. We saw in the case of an excise tax—a sales tax imposed on sales or purchases of a specific product—that the incidence does not depend on who literally pays the money to the government. It doesn't matter, in other words, whether the tax is a tax assessed on the sellers or the buyers. But we also noted that to determine who really pays the tax, we needed the concept of elasticity.

We are now ready to see how the price elasticity of demand and the price elasticity of supply determine the incidence of an excise tax.

### When an Excise Tax Is Paid Mainly by Consumers

Figure 5-7 shows an excise tax that falls mainly on consumers: an excise tax on gasoline, which we set at \$0.50 a litre. (There really is an excise tax on gasoline. Indeed, in Canada, taxes comprise over half the price of a litre of gasoline.) According to Figure 5-7, in the absence of the tax, gasoline would sell for \$0.45 a litre.

Two key assumptions are reflected in the supply and demand curves. First, the price elasticity of demand for gasoline is very low, so the demand curve is relatively steep. Second, the price elasticity of supply is very high, so the supply curve is relatively flat.

We know from Chapter 4 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, the price received by producers down. But as we can see from the figure, in this case those two effects are very unequal in size. The price received by producers falls only slightly, from \$0.45 to \$0.40, while the price paid by consumers rises by a lot, from \$0.45 to \$0.90.

This example illustrates a general principle: 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. This is probably a good description of the main excise taxes actually collected in Canada today, such as taxes on cigarettes and alcoholic beverages.

**Figure 5-7**

#### 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 pre-tax price of a litre of gas is \$0.45, and a tax of \$0.50 per litre is imposed. The cost to consumers doubles (it rises by \$0.45), 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.

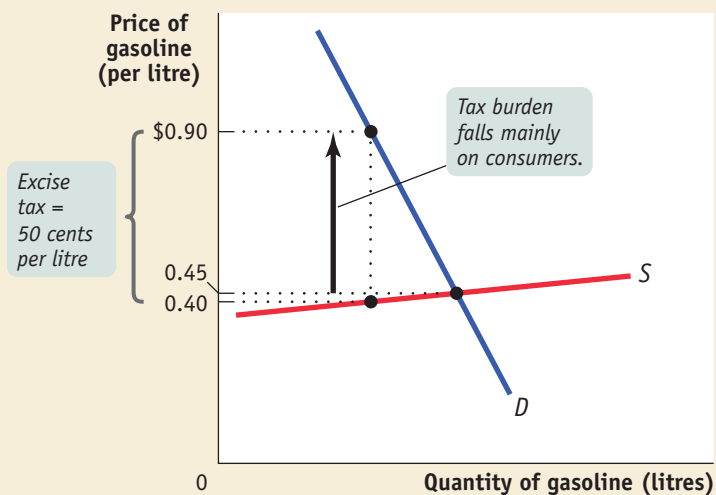


Figure 5-8

**An Excise Tax Paid Mainly by Producers**

The relatively flat demand curve here reflects a high price elasticity of demand for downtown parking, and a 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 burden of the tax. The price paid by consumers rises a small amount, \$0.50, to \$6.50, as they bear very little of the burden.

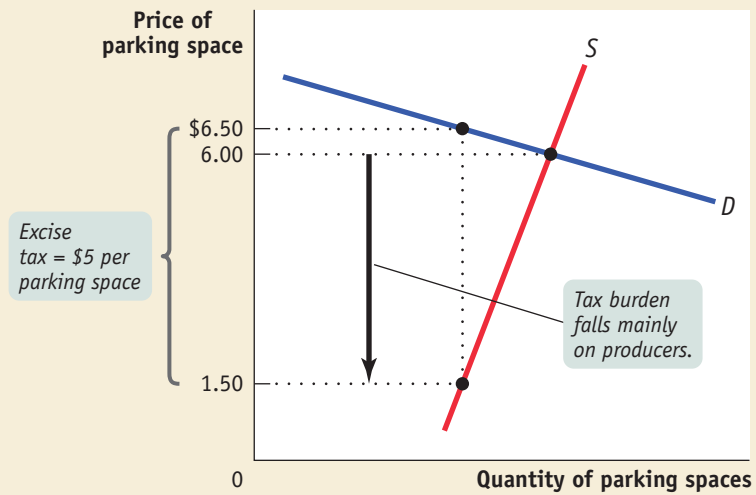
**When an Excise Tax Is Paid Mainly by Producers**

Figure 5-8 shows an excise tax paid mainly by producers. In this case we consider a \$5.00 per day tax on downtown parking in a small city. In the market equilibrium, parking would cost \$6.00 per day in the absence of the tax.

The price elasticity of supply is assumed to be very low because the lots used for parking have very few alternative uses. So the supply curve is relatively steep. The price elasticity of demand, however, is high: consumers can easily switch to other parking spaces a few minutes' walk from downtown. So the demand curve is relatively flat.

The tax drives a wedge between the price paid by consumers and the price received by producers. This time, however, the price to consumers rises only slightly, from \$6.00 to \$6.50, but the price received by producers falls a lot, from \$6.00 to \$1.50. So a consumer bears only \$0.50 of the \$5 tax, 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.

**Putting It All Together**

We've just seen that when the price elasticity of supply is high and the price elasticity of demand is low, an excise tax falls mainly on consumers; when the price elasticity of supply is low and the price elasticity of demand is high, an excise tax falls mainly on producers. This leads us to the general rule: when the price elasticity of demand is higher than the price elasticity of supply, an excise tax falls mainly on the producers. When the price elasticity of supply is higher than the price elasticity of demand, an excise tax falls mainly on consumers. So elasticity—not who literally pays the tax—determines the incidence of an excise tax.

One handy way to remember this is to think of an analogy—Tai Chi. Originally, Tai Chi was a martial art emphasizing flexibility and responsiveness. When two practitioners fight, the one to be hit will invariably be the one who is least flexible and least responsive. The same goes for the incidence of taxes. The hit of the tax will always fall on the group that is least responsive and least flexible—least elastic.

Let's check our understanding with one more real-world example. Over the past few years, many towns in desirable locations have seen house prices go up as well-off outsiders move in, a process called gentrification. Some of these towns have imposed taxes on house sales in an effort to extract money from the new arrivals. Do you think it works? Do the new arrivals bear the burden of the tax? Or does the burden of the tax fall on those selling their houses? We need to know which group is least flexible or elastic. In this case, that group is likely to be the sellers, since most sellers must sell their houses due to things like a job transfer to another location. On the other hand, buyers always have the option of moving to an alternative town nearby. So taxes on home purchases are actually paid mainly by the sellers and not, as town officials imagine, by wealthy buyers.

## *economics in action*

### Who Pays Payroll Taxes in Canada?

If you look closely at your last pay cheque, you'll see that a large chunk goes to the government in payroll taxes. There are various payroll taxes in Canada, depending on the province in which you live, but the three most important ones are: the Canada (and Quebec) pension plan contributions, employment insurance (EI) premiums, and workers' compensation premiums. Payroll taxes have grown considerably since the early 1980s when they were only about 5% of total wages and salaries, but this growth has levelled off since 1992. In 2001, payroll taxes amounted to about 12% of total wages and salaries.

Payroll taxes in Canada are shared between workers and employers, and this sharing seems to favour the worker—at least superficially. Employers and workers pay equally into the Canada (and Quebec) pension plan, but employer contributions towards EI (employment insurance) are 1.4 times the amount of worker contributions, while the employer pays the entire payroll tax that supports workers' compensation.

But we have learned that the incidence of a tax does not really depend on who actually makes out the cheque. So, who really bears the burden of payroll taxes in Canada? Almost all economists who have studied the issue agree that the incidence of payroll taxes falls almost entirely on workers, not on their employers. This is because wages are lower than they would be without payroll taxes. If payroll taxes paid by employers lead to offsetting reductions in wages, then workers will bear the entire burden—not only of the part they pay themselves, but also of the part paid by the employer.

The reason for this conclusion lies in a comparison of the price elasticities of supply and demand for labour. The evidence suggests that the price elasticity of demand for labour is quite high, at least 3. That is, an increase in average wages of 1% would lead to at least a 3% decline in the number of hours of work demanded. On the other hand, the price elasticity of supply of labour is generally believed to be very low. The reason is that although a rise in the wage rate increases the incentive to work, it also makes people richer and more able to afford leisure; so the number of hours people are willing to work increases very little, if at all, when the wage per hour goes up.

Our analysis already tells us that when the price elasticity of demand is much higher than the price elasticity of supply, the burden of an excise tax falls mainly on the suppliers. So payroll taxes fall mainly on the suppliers of labour, that is, workers—even though, on paper, employers pay more than half of these taxes.

#### >> QUICK REVIEW

- ▶ The price elasticity of demand and the price elasticity of supply determine the incidence of a tax.
- ▶ In general, the higher the price elasticity of supply and the lower the price elasticity of demand, the more heavily the burden of an excise tax falls on consumers. The lower the price elasticity of supply and the higher the price elasticity of demand, the more heavily the burden falls on producers.



#### >> CHECK YOUR UNDERSTANDING 5-5

1. The demand for economics textbooks is very inelastic, but the supply is somewhat elastic. What does this imply about the incidence of a tax? Illustrate with a diagram.
2. True or false? When a substitute for a good is readily available to consumers, but it is difficult for producers to adjust the quantity of the good produced, then the burden of a tax on the good falls more heavily on producers.

3. The supply of bottled spring water is very inelastic, but the demand for it is somewhat elastic. What does this imply about the incidence of a tax? Illustrate with a diagram.
4. True or false? Other things equal, consumers would prefer to face a less elastic supply curve when a tax is imposed.

Solutions appear at back of book.

#### • A LOOK AHEAD •

The concept of elasticity deepens our understanding of supply and demand, among other things helping us predict not only in which direction prices will move but also by how much. For example, we now know that supply and demand elasticities determine how the burden of a tax will be divided between producers and consumers. And, to come back to an example from very early on in this chapter, the concept of elasticity was just what Luis Tellez needed to be able to engineer a reduction in output by oil-exporting countries that led to an increase in oil prices and an increase in their total revenues.

But we don't yet have a way to translate the changes in prices that result from a tax, or from any other change in the situation, into a measure of gains or losses to individuals. In the next chapter, we show how to make that translation—how to use the supply and demand curves to calculate gains and losses to producers and consumers.

### SUMMARY

1. Many economic questions depend on the size of consumer or producer response to changes in prices or other variables. *Elasticity* is a general measure of responsiveness that can be used to answer such questions.
2. 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 starting and final values.
3. The responsiveness of the quantity demanded to price can range from **perfectly inelastic demand**, where the quantity demanded is unaffected by the price, to **perfectly elastic demand**, where 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.
4. 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.
5. 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, and the length of time that has elapsed since the price change.
6. 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.
7. 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 percentage 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**.
8. 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.
9. The price elasticity of supply depends on the availability of resources to expand production and on time. It is

higher when inputs are easily available, and the longer the time elapsed since the price change.

10. 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.

## KEY TERMS

Price elasticity of demand, p. xx  
Midpoint method, p. xx  
Perfectly inelastic demand, p. xx  
Perfectly elastic demand, p. xx  
Elastic demand, p. xx

Inelastic demand, p. xx  
Unit-elastic demand, p. xx  
Total revenue, p. xx  
Cross-price elasticity of demand, p. xx  
Income elasticity of demand, p. xx

Income-elastic demand, p. xx  
Income-inelastic demand, p. xx  
Price elasticity of supply, p. xx  
Perfectly inelastic supply, p. xx  
Perfectly elastic supply, p. xx

## PROBLEMS

1. TheNile.com, an online bookseller, wants to increase its total revenue. Currently, every book they sell is priced at \$10.50. One suggested strategy is to offer a discount that lowers the price of a book to \$9.50, a 10% reduction in price using the midpoint method. TheNile.com knows that its customers can be divided into two distinct groups according to their likely responses to the discount. The following table shows how the two groups respond to the discount.

	Group A (Sales per Week) (millions)	Group B (Sales per Week) (millions)
Volume of sales before the 10% discount	1.55	1.50
Volume of sales after the 10% discount	1.65	1.70

- 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 TheNile.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. 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 Canadian market.  
c. Due to ad campaigns, Canadians 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. Canadian wheat production increased dramatically in 1999 after a bumper harvest. The supply curve shifted rightward and, as a result, the price fell and the quantity demanded increased (a movement along the demand curve). The table below describes what happened to prices and the quantity of wheat demanded.

	Demand Data for Canadian Wheat 1998	1999
Bushels produced	1.74 billion	1.9 billion
Average price per bushel	\$3.70	\$2.72

- a. Using the midpoint method, calculate the price elasticity of demand for wheat.  
b. What is the total revenue for Canadian wheat farmers in 1998 and 1999?  
c. How did the bumper harvest affect the incomes of Canadian wheat farmers? How could you have predicted this from your answer to question a?
4. The table below gives part of the supply schedule for personal computers in Canada.

Price of computer	Quantity of computers supplied (thousands)
\$1,100	12,000
900	8,000

- a. Calculate the price elasticity of supply when the price rises from \$900 to \$1,100 using the midpoint method.  
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?
5. The following table lists the cross-price elasticities of demand for several goods, where the percent price change is measured for the first good of the pair, and the percent quantity change is measured for the second 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-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 for McDonald's and Burger King less than the cross-elasticity of butter and margarine?
- c. Use the information above to calculate how a 5% increase in the price of Pepsi affects the quantity of Coke demanded.
- d. Use the information above to calculate how a 10% fall in the price of gasoline affects the quantity of SUVs demanded.
6. What can you conclude about the price elasticity of demand in each of the following statements?
- a. "The pizza delivery business in this town is very competitive. I'd lose half my customers if I raised price by as little as 10%."
- b. "I owned both of the two Jerry Garcia autographed lithographs in existence. I sold one on eBay for a high price. But when I sold the second one, the price dropped a lot."
- c. "My economics professor has chosen to use the Krugman, Wells, Myatt textbook for this class. I have no choice but to buy this book."
- d. I always spend exactly \$10 per week on coffee.
7. Take a linear demand curve like that drawn in Figure 5-5, where the range of prices for which demand is elastic and inelastic is labelled. In each of the following scenarios, the supply curve shifts. Show along which portion of the demand curve (that is, the elastic or the inelastic portion) the supply curve must have shifted in order to generate the event described. In each case, show on the diagram the quantity effect and the price effect.

- a. Recent attempts to stop the flow of illegal drugs into Canada have actually benefited drug dealers.
- b. New construction increased the number of seats in the football stadium and resulted in greater total revenue from ticket sales.
- c. Increasing production of Porsches has led to a decline in total revenue for the Porsche Company.
8. The following table shows the price and yearly quantity sold of souvenir T-shirts in Charlottetown 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 when 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 average tourist income increases from \$20,000 to \$30,000 when the price of a T-shirt is \$4. Also calculate it when the price is \$7.
9. A recent study determined the following elasticities for Volkswagen Beetles:
- Price elasticity of demand = 2  
Income elasticity of demand = 1.5
- The supply of Beetles is elastic. Based on this information, are the following statements true or false? Explain your reasoning for each.
- a. A 10% increase in the price of a Beetle will reduce the quantity demanded by 20%.
- b. An increase in consumer income will increase the price and quantity of Beetles. Since price elasticity of demand is greater than 1, total revenue will go down.
10. 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 Nova Scotia rent them out during the summer. Due to the soft economy this year, a 30% decline in the rental rate leads more than half of homeowners to occupy their vacation homes themselves during the summer.
11. Use an elasticity concept to explain each of the following observations:
- During economic boom times, the number of new personal care businesses, such as gyms and tanning salons, is proportionately greater than the number of other new businesses, such as grocery stores.
  - Cement is the primary building material in Mexico. After new technology makes cement cheaper to produce, the supply curve for the Mexican cement industry becomes relatively flatter.
  - Some goods that were once considered luxuries, such as telephones, are now considered virtual necessities. As a result, the demand curve for telephone services has become steeper over time.
  - People in a less developed country like Guatemala spend proportionately more of their income on equipment for producing things at home, like sewing machines, than people in a more developed country like Canada.
12. Taiwan is a major world supplier of semiconductor chips. A recent earthquake in Taiwan severely damaged the production facilities of Taiwanese chip-producing companies, sharply reducing the amount of chips they could produce.
- Assume that the total revenue of a typical non-Taiwanese chip manufacturer rises due to these events. In terms of elasticity, what must be true for this to happen? Illustrate the change in total revenue with a diagram, indicating the “price effect” and the “sales effect” of the Taiwan earthquake on this company’s total revenue.
  - Now assume that the total revenue of a typical non-Taiwanese chip manufacturer falls due to these events. In terms of elasticity, what must be true for this to happen? Illustrate the change in total revenue with a diagram, indicating the price effect and the quantity effect of the Taiwan earthquake on this company’s total revenue.
13. There is a debate about whether sterile hypodermic needles should be passed out free of charge in cities with high drug use. Proponents argue that doing so will reduce the incidence of diseases, such as HIV/AIDS, that are often spread by needle sharing among drug users. Opponents believe that it will encourage more drug use by reducing the risks of this behaviour. As an economist asked to assess the policy, you must know the following: (i) how responsive the spread of diseases like AIDS/HIV is to the price of sterile needles; and (ii) how responsive is drug use to the price of sterile needles. Assuming that you know these two things, use the concepts of price elasticity of demand for sterile needles and cross-price elasticity between drug use and sterile needles to answer the following questions.
- In what circumstances do you believe that this is a beneficial policy?
  - In what circumstances do you believe that this is a bad policy?
14. Suppose that the government imposes an excise tax of 25 cents for every litre of gas sold. Before the tax, the price of a litre of gas is 50 cents. Consider the following four after-tax scenarios. In each of the cases, (i) use a concept from elasticity to explain what must be true for this scenario to arise; (ii) determine who bears relatively more of the burden of the tax, producers or consumers; and (iii) illustrate your answer with a diagram.
- The price of gasoline paid by consumers rises to 75 cents per litre. Assume that the demand curve is downward sloping.
  - The price paid by consumers remains at 50 cents a litre after the tax is imposed. Assume that the supply curve is upward sloping.
  - The price of gasoline paid by consumers rises to 70 cents.
  - The price of gasoline paid by consumers rises to 55 cents.
15. Describe how the following events will affect the incidence of taxation—that is, after the event, will the tax fall more heavily on consumers or producers in comparison to before the event? Use the concept of elasticity to explain your answer.
- Sales of gasoline are taxed. Ethanol, a substitute for gasoline, becomes widely available.
  - Sales of electricity to Quebec residents are taxed. Regulations are introduced that make it much more difficult for Quebec utility companies to divert supplies of electricity from the Quebec market to markets in neighbouring states in the U.S.
  - Sales of electricity to Quebec residents are taxed. Regulations are introduced that make it much easier for Quebec utility companies to divert supplies of electricity from the Quebec market to markets in neighbouring states in the U.S.
  - The sale of municipally provided water is taxed. Legislation is introduced that forbids the use of private sources of water such as wells and the diversion of rivers.
16. In devising taxes, there is often a debate about (i) who bears the burden of the tax and (ii) whether the tax achieves some desirable social goal, such as discouraging undesirable behaviour by making it more expensive. In the case of cigarettes, smokers tend to be highly addicted and have lower income than the average nonsmoker. Taxes on cigarettes have historically had the effect of raising the price to consumers almost one for one with the size of the tax.
- Why might such a tax be undesirable when considering issues of tax equity—that is, whether or not more of the tax burden falls more heavily on lower-income people? How do the elasticities of supply and demand for cigarettes affect the equity of cigarette taxation?
  - How do the elasticities of supply and demand for cigarettes affect the effectiveness of the tax in discouraging smoking?
  - In light of your answers to parts a and b and the historical response of price to the tax, what trade-offs must policy makers make when considering a cigarette tax?

16. 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 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.

• **>web...** To continue your study and review of concepts in this chapter, please visit the Krugman/Wells website for quizzes, animated graph tutorials, web links to helpful resources, and more.

• **[www.worthpublishers.com/krugmanwells](http://www.worthpublishers.com/krugmanwells)**