IN THIS CHAPTER YOU WILL LEARN:

1 About price elasticity of demand and how it can be measured.

2 How price elasticity of demand affects total revenue.

3 About price elasticity of supply and how it can be measured.

4 How price elasticity of demand and supply can be applied to real-world situations.

5 About income elasticity of demand and cross-elasticity of demand, and how they can be applied.

4

Elasticity of Demand and Supply

Why do buyers of some products respond to price increases by substantially reducing their purchases while buyers of other products respond by only slightly cutting back their purchases? Why do price hikes for some goods cause producers to greatly increase their output while price hikes on other products barely cause any output increase? Why does the demand for some products rise a great deal when household incomes increase while the demand for other products rises just a little? How can we tell whether a given pair of goods are complements, substitutes, or unrelated to each other?

The idea of elasticity (responsiveness) helps answer our questions. Let's explore this important topic.

Price Elasticity of Demand

ORIGIN OF THE IDEA

O 4.1

Price elasticity of demand

The law of demand tells us that, other things equal, consumers will buy more of a product when its price declines and less of it when its price increases. But how much more or less will they buy? The amount varies from product to product and over different price ranges for the same product. And such variations matter. For example, a firm contemplating a price hike will want to know how consumers will respond. If they remain highly loyal and continue to buy, the firm's revenue will rise. But if consumers defect en masse to other sellers or other products, its revenue will tumble.

price elasticity of demand
A measure of the responsiveness of the quantity of a product demanded by consumers when the product price changes.

The responsiveness of the quantity of a product demanded by consumers when the product price changes is measured by a product's **price elasticity of demand.** For some products (for example, restaurant meals) consumers are highly responsive to price changes. Modest price changes cause very large changes in the quantity purchased. Economists say that the demand for such products is *relatively elastic* or simply *elastic*.

For other products (for example, medical care) consumers pay much less attention to price changes. Substantial price changes cause only small changes in the amount purchased. The demand for such products is *relatively inelastic* or simply *inelastic*.

The Price-Elasticity Coefficient and Formula

Economists measure the degree of price elasticity or inelasticity of demand with the coefficient E_d, defined as

$$E_d = \frac{\text{percentage change in quantity demanded of X}}{\text{percentage change in price of X}}$$

The percentage changes in the equation are calculated by dividing the *change* in quantity demanded by the original quantity demanded and by dividing the *change* in price by the original price. So we can restate the formula as

$$E_d = \frac{\text{change in quantity demanded of X}}{\text{original quantity demanded of X}} \div \frac{\text{change in price of X}}{\text{original price of X}}$$

Using Averages

Unfortunately, an annoying problem arises in computing the price-elasticity coefficient. A price change from, say, \$4 to \$5 along a demand curve is a 25 percent (=\$1/\$4) increase, but the opposite price change from \$5 to \$4 along the same curve is a 20 percent (=\$1/\$5) decrease. Which percentage change in price should we use in the denominator to compute the price-elasticity coefficient? And when quantity changes, for example, from 10 to 20, it is a 100 percent (=10/10) increase. But when quantity falls from 20 to 10 along the identical demand curve, it is a 50 percent (=10/20) decrease. Should we use 100 percent or 50 percent in the numerator of the elasticity formula? Elasticity should be the same whether price rises or falls!

WORKED PROBLEMS

W 4.1

Elasticity of demand

The simplest solution to the problem is to use the averages of the two prices and the two quantities as the reference points for computing the percentages. That is

$$E_d = \frac{\text{change in quantity}}{\text{sum of quantities/2}} \div \frac{\text{change in price}}{\text{sum of prices/2}}$$

For the same \$5–\$4 price range, the price reference is \$4.50 [= (\$5 + \$4)/2], and for the same 10–20 quantity range, the quantity reference is 15 units [= (10 + 20)/2]. The percentage change in price is now \$1/\$4.50, or about 22 percent, and the percentage change in quantity is 10/15, or about 67 percent. So E_d is about 3. This solution eliminates the "up versus down" problem. All the elasticity coefficients that follow are calculated using averages, also known as the *midpoints approach*.

Elimination of Minus Sign

Because demand curves slope downward, the price-elasticity coefficient of demand E_d will always be a negative number. As an example, if price declines, quantity demanded will increase. This means that the numerator in our formula will be positive and the denominator negative, yielding a negative E_d. For an increase in price, the numerator will be negative but the denominator positive, again producing a negative E_d.

Economists usually ignore the minus sign and simply present the absolute value of the elasticity coefficient to avoid an ambiguity that might otherwise arise. It can be confusing to say that an E_d of -4 is greater than one of -2. This possible confusion is avoided when we say an E_d of 4 reveals greater elasticity than an E_d of 2. In what follows, we ignore the minus sign in the coefficient of price elasticity of demand and show only the absolute value.

Interpretations of E_d

We can interpret the coefficient of price elasticity of demand as follows.

Elastic Demand

Demand is **elastic** if a specific percentage change in price results in a larger percentage change in quantity demanded. Then E_d will be greater than 1. Example: Suppose that a 2 percent decline in the price of cut flowers results in a 4 percent increase in quantity demanded. Then demand for cut flowers is elastic and

$$E_d = \frac{.04}{.02} = 2$$

elastic demand
Product demand for which price changes cause relatively larger changes in quantity demanded.

Inelastic Demand

If a specific percentage change in price produces a smaller percentage change in quantity demanded, demand is **inelastic.** Then E_d will be less than 1. Example: Suppose that a 2 percent decline in the price of tea leads to only a 1 percent increase in quantity demanded. Then demand is inelastic and

$$E_d = \frac{.01}{.02} = .5$$

inelastic demand
Product demand for which price changes cause relatively smaller changes in quantity demanded.

Unit Elasticity

The case separating elastic and inelastic demands occurs where a percentage change in price and the resulting percentage change in quantity demanded are the same. Example: Suppose that a 2 percent drop in the price of chocolate causes a 2 percent increase in quantity demanded. This special case is termed **unit elasticity** because E_d is exactly 1, or unity. In this example,

$$E_d = \frac{.02}{.02} = 1$$

unit elasticity
Product demand for which relative price changes and changes in quantity demanded are equal.

Extreme Cases

When we say demand is "inelastic," we do not mean that consumers are completely unresponsive to a price change. In that extreme situation, where a price change results in no change whatsoever in the quantity demanded,

perfectly inelastic demand
Product demand for which quantity demanded does not respond to a change in price.

economists say that demand is **perfectly inelastic.** The price-elasticity coefficient is zero because there is no response to a change in price. Approximate examples include an acute diabetic's demand for insulin or an addict's demand for heroin. A line parallel to the vertical axis, such as D_1 in Figure 4.1a, shows perfectly inelastic demand graphically.

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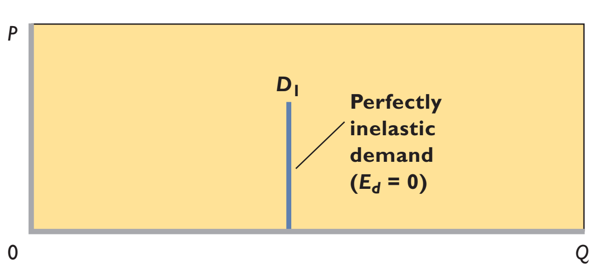
Photo Op Elastic versus Inelastic Demand

The demand for expensive leisure activities such as cruise vacations is elastic; the demand for surgery or other nonelective medical care is inelastic.

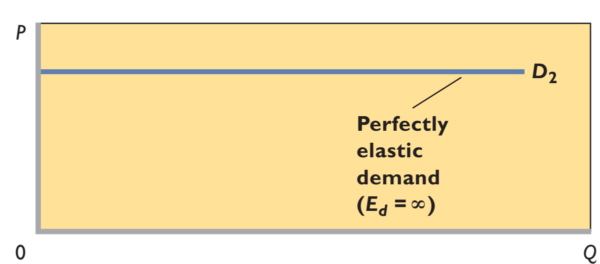
perfectly elastic demand
Product demand for which quantity demanded can be any amount at a particular price.

Conversely, when we say demand is "elastic," we do not mean that consumers are completely responsive to a price change. In that extreme situation, where a small price reduction causes buyers to increase their purchases from zero to all they can obtain, the elasticity coefficient is infinite (∞) and economists say demand is **perfectly elastic.** A line parallel to the horizontal axis, such as D_2 in Figure 4.1b, shows perfectly elastic demand. Such a demand curve, for example, faces wheat growers who can sell all or none of their wheat at the equilibrium market price.

FIGURE 4.1 Perfectly inelastic and elastic demands. Demand curve D_1 in (a) represents perfectly inelastic demand ($E_d = 0$). A price increase will result in no change in quantity demanded. Demand curve D_2 in (b) represents perfectly elastic demand. A price increase will cause quantity demanded to decline from an infinite amount to zero ($E_d = \infty$).



(a)
Perfectly inelastic demand



(b)
Perfectly elastic demand

ILLUSTRATING THE IDEA

A Bit of a Stretch

The following analogy might help you remember the distinction between "elastic" and "inelastic." Imagine two objects: (1) an Ace elastic bandage used to wrap injured joints and (2) a relatively firm rubber tie-down used for securing items for transport. The Ace bandage stretches a great deal when pulled with a particular force; the rubber tie-down stretches some, but not a lot.

Similar differences occur for the quantity demanded of various products when their prices change. For some products, a price change causes a substantial "stretch" of quantity demanded. When this stretch in percentage terms exceeds the percentage change in price, demand is elastic. For other products, quantity demanded stretches very little in response to the price change. When this stretch in percentage terms is less than the percentage change in price, demand is inelastic.

In summary:

- Elastic demand displays considerable "quantity stretch" (as with the Ace bandage).
- Inelastic demand displays relatively little "quantity stretch" (as with the rubber tie-down).

And through extension:

- Perfectly elastic demand has infinite quantity stretch.
- Perfectly inelastic demand has zero quantity stretch.

Question:
Which do you think has the most quantity stretch, given an equal percentage increase in price—toothpaste or townhouses?

The Total-Revenue Test

The importance of elasticity for firms relates to the effect of price changes on total revenue and thus on profits (total revenue minus total costs).

Total revenue (TR) is the total amount the seller receives from the sale of a product in a particular time period; it is calculated by multiplying the product price (P) by the quantity demanded and sold (Q). In equation form:

total revenue (TR) The total number of dollars received by a firm from the sale of a product in a particular period.

$$TR = P \times Q$$

Graphically, total revenue is represented by the $P \times Q$ rectangle lying below a point on a demand curve. At point *a* in Figure 4.2a, for example, price is \$2 and quantity demanded is 10 units. So total revenue is \$20 (= \$2 × 10), shown by the rectangle composed of the blue and gold areas under the demand curve. We know from basic geometry that the area of a rectangle is found by multiplying one side by the other. Here, one side is "price" (\$2) and the other is "quantity demanded" (10 units).

Total revenue and the price elasticity of demand are related. In fact, the easiest way to infer whether demand is elastic or inelastic is to employ the **total-revenue test.**

total-revenue test A test that determines elasticity by examining what happens to total revenue when price changes.

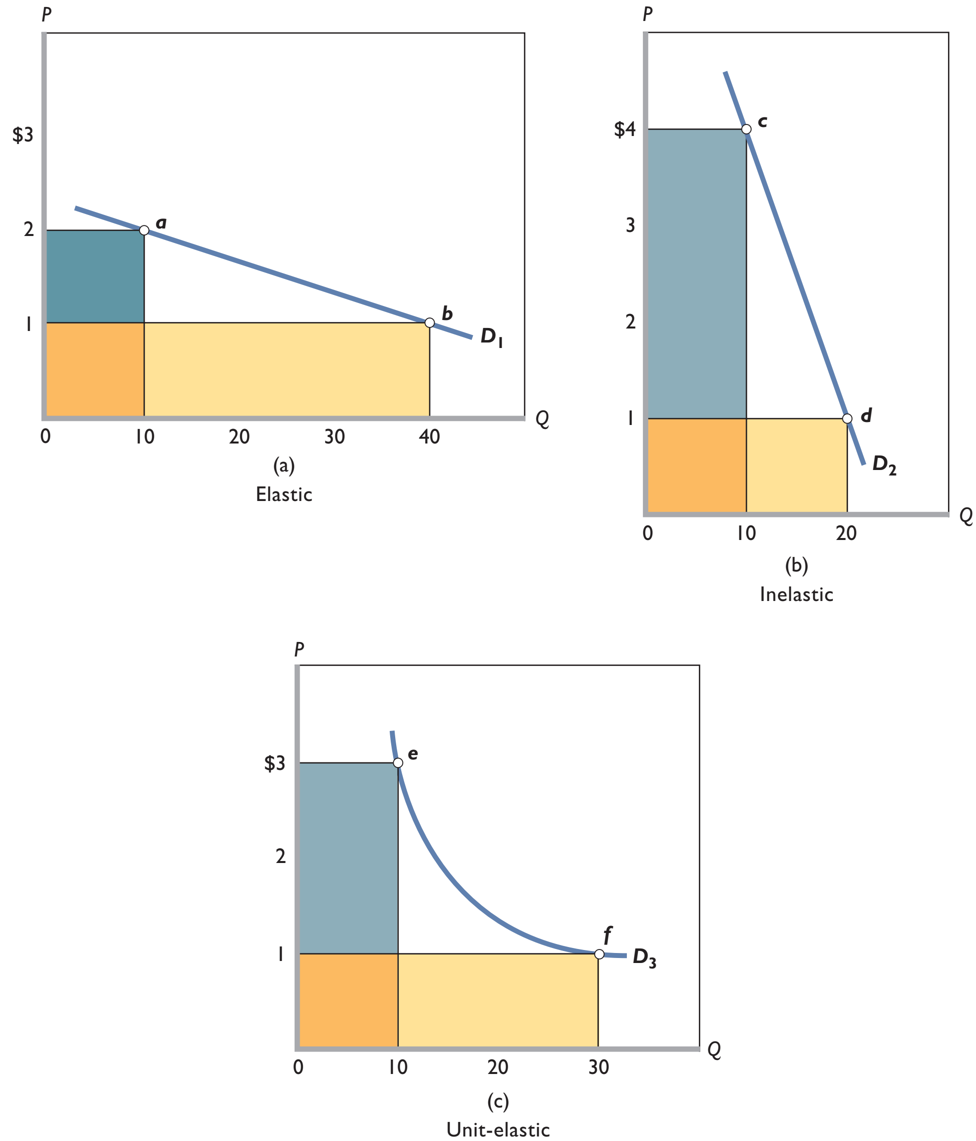


FIGURE 4.2 The total-revenue test for price elasticity. (a) Price declines from $2 to $1, and total revenue increases from $20 to $40. So demand is elastic. The gain in revenue (tan area) exceeds the loss of revenue (blue area). (b) Price declines from $4 to $1, and total revenue falls from $40 to $20. So demand is inelastic. The gain in revenue (tan area) is less than the loss of revenue (blue area). (c) Price declines from $3 to $1, and total revenue does not change. Demand is unit-elastic. The gain in revenue (tan area) equals the loss of revenue (blue area).

Here is the test: Note what happens to total revenue when price changes. If total revenue changes in the opposite direction from price, demand is elastic. If total revenue changes in the same direction as price, demand is inelastic. If total revenue does not change when price changes, demand is unit-elastic.

Elastic Demand

If demand is elastic, a decrease in price will increase total revenue. Even though a lesser price is received per unit, enough additional units are sold to more than make up for the lower price. For an example, look at demand curve D_1 in Figure 4.2a. We have already established that at point *a*, total revenue is $20 (= $2 × 10), shown as the blue plus gold area.

If the price declines from $2 to $1 (point *b*), the quantity demanded becomes 40 units and total revenue is $40 (= $1 × 40). As a result of the price decline, total

WORKED PROBLEMS

W 4.2

Total revenue test

revenue has increased from \$20 to \$40. Total revenue has increased in this case because the \$1 decline in price applies to 10 units, with a consequent revenue loss of \$10 (the blue area). But 30 more units are sold at \$1 each, resulting in a revenue gain of \$30 (the tan area). Visually, it is apparent that the gain of the tan area exceeds the loss of the blue area. As indicated, the overall result is a net increase in total revenue of \$20 (= \$30 − \$10).

The analysis is reversible: If demand is elastic, a price increase will reduce total revenue. The revenue gained on the higher-priced units will be more than offset by the revenue lost from the lower quantity sold. Bottom line: Other things equal, when price and total revenue move in opposite directions, demand is elastic. E_d is greater than 1, meaning the percentage change in quantity demanded is greater than the percentage change in price.

Inelastic Demand If demand is inelastic, a price decrease will reduce total revenue. The increase in sales will not fully offset the decline in revenue per unit, and total revenue will decline. To see this, look at demand curve D_2 in Figure 4.2b. At point *c* on the curve, price is \$4 and quantity demanded is 10. So total revenue is \$40, shown by the combined blue and gold rectangle. If the price drops to \$1 (point *d*), total revenue declines to \$20, which obviously is less than \$40. Total revenue has declined because the loss of revenue (the blue area) from the lower unit price is larger than the gain in revenue (the tan area) from the accompanying increase in sales. Price has fallen, and total revenue has also declined.

Our analysis is again reversible: If demand is inelastic, a price increase will increase total revenue. So, other things equal, when price and total revenue move in the same direction, demand is inelastic. E_d is less than 1, meaning the percentage change in quantity demanded is less than the percentage change in price.

Unit Elasticity In the special case of unit elasticity, an increase or a decrease in price leaves total revenue unchanged. The loss in revenue from a lower unit price is exactly offset by the gain in revenue from the accompanying increase in sales. Conversely, the gain in revenue from a higher unit price is exactly offset by the revenue loss associated with the accompanying decline in the amount demanded.

In Figure 4.2c (demand curve D_3) we find that at the \$3 price, 10 units will be sold, yielding total revenue of \$30. At the lower \$1 price, a total of 30 units will be sold, again resulting in \$30 of total revenue. The \$2 price reduction causes the loss of revenue shown by the blue area, but this is exactly offset by the revenue gain shown by the tan area. Total revenue does not change. In fact, that would be true for all price changes along this particular curve.

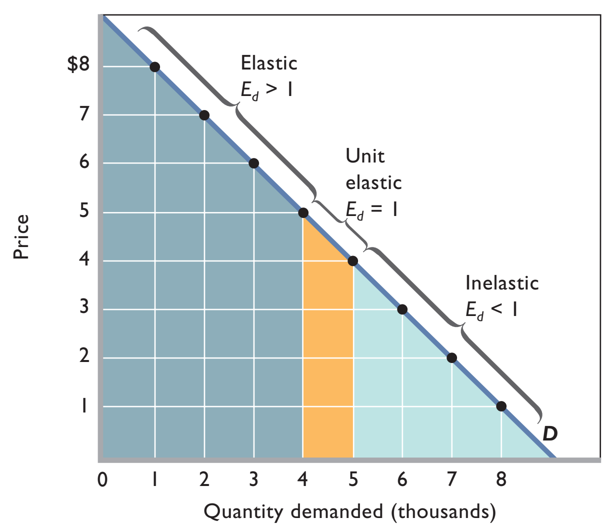
Other things equal, when price changes and total revenue remains constant, demand is unit-elastic (or unitary). E_d is 1, meaning the percentage change in quantity equals the percentage change in price.

Price Elasticity along a Linear Demand Curve

Now a major confession! Although the demand curves depicted in Figure 4.2 nicely illustrate the total-revenue test for elasticity, two of the graphs involve specific movements along linear (straight-line) demand curves. That presents no problem for explaining the total-revenue test. However, you need to know that elasticity typically varies over the different price ranges of the same demand curve. (The exception is the curve in Figure 4.2c. Elasticity is 1 along the entire curve.)

FIGURE 4.3 Price elasticity of demand along a linear demand curve as measured by the elasticity coefficient and the total-revenue test. Demand curve *D* is based on columns (1) and (2) of the table and is labeled to show that the hypothetical weekly demand for movie tickets is elastic at higher price ranges and inelastic at lower price ranges. That fact is confirmed by the elasticity coefficients (column 3) as well as the total-revenue test (columns 4 and 5) in the table.

(1) Total Quantity of Tickets Demanded per Week, Thousands	(2) Price per Ticket	(3) Elasticity Coefficient (E_d)	(4) Total Revenue, (1) × (2)	(5) Total-Revenue Test
1	$8		$ 8,000	
		5.00		Elastic
2	7		14,000	
		2.60		Elastic
3	6		18,000	
		1.57		Elastic
4	5		20,000	
		1.00		Unit elastic
5	4		20,000	
		0.64		Inelastic
6	3		18,000	
		0.38		Inelastic
7	2		14,000	
		0.20		Inelastic
8	1		8,000	



INTERACTIVE GRAPHS

G 4.1

Elasticity and revenue

Consider columns 1 and 2 of the table in Figure 4.3, which shows hypothetical data for movie tickets. We plot these data as demand curve *D* in the accompanying graph. The notation above the curve correctly suggests that demand is more price-elastic toward the upper left (here, the $5–$8 price range of *D*) than toward the lower right (here, the $4–$1 price range of *D*). This fact is confirmed by the elasticity coefficients in column (3) of the table: The coefficients decline as price falls. Also, note from column (4) that total revenue first rises as price falls and then eventually declines as price falls further. Column (5) employs the total-revenue test to show that elasticity declines as price falls along a linear demand curve.

The demand curve in Figure 4.3 illustrates that the slope of a demand curve (its flatness or steepness) is an unreliable basis for judging elasticity. The slope of the curve is computed from *absolute* changes in price and quantity, while elasticity involves *relative* or *percentage* changes in price and quantity. The demand curve in Figure 4.3 is linear, which means its slope is constant throughout. But this linear curve is elastic in its high-price ($8–$5) range and inelastic in its low-price ($4–$1) range.

Determinants of Price Elasticity of Demand

We cannot say what will determine the price elasticity of demand in each individual situation, but the following generalizations are often helpful.

Substitutability Generally, the larger the number of substitute goods that are available, the greater is the price elasticity of demand. Mercedes, BMWs, and Lincolns are effective substitutes for Cadillacs, making the demand for Cadillacs elastic. At the other extreme, we saw earlier that the diabetic's demand for insulin is highly inelastic because there simply are no close substitutes.

The elasticity of demand for a product depends on how narrowly the product is defined. Demand for Reebok sneakers is more elastic than is the overall demand for shoes. Many other brands are readily substitutable for Reebok sneakers, but there are few, if any, good substitutes for shoes.

Proportion of Income Other things equal, the higher the price of a product relative to one's income, the greater the price elasticity of demand for it. A 10 percent increase in the price of low-priced pencils or chewing gum amounts to a very small portion of most people's incomes, and quantity demanded will probably decline only slightly. Thus, price elasticity for such low-priced items tends to be low. But a 10 percent increase in the price of relatively high-priced automobiles or houses means additional expenditures of perhaps $3000 or $20,000. That price increase is a significant fraction of the incomes and budgets of most families, and the number of units demanded will likely diminish significantly. Price elasticity for such items tends to be high.

Luxuries versus Necessities In general, the more that a good is considered to be a "luxury" rather than a "necessity," the greater is the price elasticity of demand. Electricity is generally regarded as a necessity; it is difficult to get along without it. A price increase will not significantly reduce the amount of lighting and power used in a household. (Note the very low price-elasticity coefficient of these goods in Table 4.1.) An extreme case: A person does not decline emergency heart bypass surgery because the physician's fee has just gone up by 10 percent.

On the other hand, vacation travel and jewelry are luxuries that can easily be forgone. If the prices of vacation travel and jewelry rise, a consumer need not buy them and will suffer no great hardship without them.

What about the demand for a common product like salt? It is highly inelastic on three counts: There are few good substitutes available; salt is a negligible item in the family budget; and it is a "necessity" rather than a luxury.

Time Generally, product demand is more elastic the longer the time period under consideration. Consumers often need time to adjust to changes in prices. For example, consumers may not immediately reduce their purchases very much when the price of beef rises by 10 percent, but in time they may shift to chicken, pork, or fish.

Another consideration is product durability. Studies show that "short-run" demand for gasoline is more inelastic ($E_d = .2$) than is "long-run" demand ($E_d = .7$). In the

TABLE 4.1 Selected Price Elasticities of Demand

Product or Service	Coefficient of Price Elasticity of Demand (E_d)	Product or Service	Coefficient of Price Elasticity of Demand (E_d)
Newspapers	.10	Milk	.63
Electricity (household)	.13	Household appliances	.63
Bread	.15	Liquor	.70
Major-league baseball tickets	.23	Movies	.87
Cigarettes	.25	Beer	.90
Telephone service	.26	Shoes	.91
Sugar	.30	Motor vehicles	1.14
Medical care	.31	Beef	1.27
Eggs	.32	China, glassware, tableware	1.54
Legal services	.37	Residential land	1.60
Automobile repair	.40	Restaurant meals	2.27
Clothing	.49	Lamb and mutton	2.65
Gasoline	.60	Fresh peas	2.83

Source: Compiled from numerous studies and sources reporting price elasticity of demand.

short run, people are "stuck" with their present cars and trucks, but with rising gasoline prices they eventually replace them with smaller, more fuel-efficient vehicles.

Table 4.1 shows estimated price-elasticity coefficients for a number of products. Each reflects some combination of the elasticity determinants just discussed.

APPLYING THE ANALYSIS

Price Elasticity of Demand and College Tuition

For some goods and services, for-profit firms or not-for-profit institutions may find it advantageous to determine differences in price elasticity of demand for different groups of customers and then charge different prices to the different groups. Price increases for groups that have inelastic demand will increase total revenue, as will price decreases for groups that have elastic demand.

It is relatively easy to observe differences between group elasticities. Consider tuition pricing by colleges and universities. Prospective students from low-income families generally have more elastic demands for higher education than similar students from high-income families. This is true because tuition is a much larger proportion of household income for a low-income student or family than for his or her high-income counterpart. Desiring a diverse student body, colleges charge different *net* prices (= tuition *minus* financial aid) to the two groups on the basis of elasticity of demand. High-income students pay full tuition, unless they receive merit-based scholarships. Low-income students receive considerable financial aid in addition to merit-based scholarships and, in effect, pay a lower *net* price.

It is common for colleges to announce a large tuition increase and immediately cushion the news by emphasizing that they also are increasing financial aid. In effect, the college is increasing the tuition for students who have inelastic demand by the full amount and raising the *net* tuition of those with elastic demand by some lesser amount or not at all. Through this strategy, colleges boost revenue to cover rising costs while maintaining affordability for a wide range of students.

Question:
What are some other examples of charging different prices to different groups of customers on the basis of differences in elasticity of demand? (*Hint:* Think of price discounts based on age or time of purchase.)

APPLYING THE ANALYSIS

Decriminalization of Illegal Drugs

In recent years proposals to legalize drugs have been widely debated. Proponents contend that drugs should be treated like alcohol; they should be made legal for adults and regulated for purity and potency. The current war on drugs, it is argued, has been unsuccessful, and the associated costs—including enlarged police forces, the construction of more prisons, an overburdened court system, and untold human costs—have increased markedly. Legalization would allegedly reduce drug trafficking significantly by taking the profit out of it. Crack cocaine and heroin, for example, are cheap to produce and could be sold at low prices in legal markets. Because the demand of addicts is highly inelastic, the amounts consumed at the lower prices would increase only modestly. Addicts' total expenditures for cocaine and heroin would decline, and so would the street crime that finances those expenditures.

Opponents of legalization say that the overall demand for cocaine and heroin is far more elastic than proponents think. In addition to the inelastic demand of addicts, there is another market segment whose demand is relatively elastic. This segment consists of the occasional users or "dabblers," who use hard drugs when their prices are low but who abstain or substitute, say, alcohol when their prices are high. Thus, the lower prices associated with the legalization of hard drugs would increase consumption by dabblers. Also, removal of the legal prohibitions against using drugs might make drug use more socially acceptable, increasing the demand for cocaine and heroin.

Many economists predict that the legalization of cocaine and heroin would reduce street prices by up to 60 percent, depending on if and how much they were taxed. According to one study, price declines of that size would increase the number of occasional users of heroin by 54 percent and the number of occasional users of cocaine by 33 percent. The total quantity of heroin demanded would rise by an estimated 100 percent, and the quantity of cocaine demanded would rise by 50 percent.* Moreover, many existing and first-time dabblers might in time become addicts. The overall result, say the opponents of legalization, would be higher social costs, possibly including an increase in street crime.

Question:
In what ways do drug rehabilitation programs increase the elasticity of demand for illegal drugs?

*Henry Saffer and Frank Chaloupka, "The Demand for Illegal Drugs," *Economic Inquiry,* July 1999, pp. 401–411.

APPLYING THE ANALYSIS

Excise Taxes and Tax Revenue

The government pays attention to elasticity of demand when it selects goods and services on which to levy *excise taxes* (taxes levied on the production of a product or on the quantity of the product purchased). If a $1 tax is levied on a product and 10,000 units are sold, tax revenue will be $10,000 (= $1 × 10,000 units sold). If the government raises the tax to $1.50 but the higher price that results reduces sales (quantity demanded) to 4000 because demand is elastic, tax revenue will decline to $6000 (= $1.50 × 4000 units sold). So a higher tax on a product that has an elastic demand will bring in less tax revenue.

In contrast, if demand is inelastic, the tax increase from $1 to $1.50 will boost tax revenue. For example, if sales fall from 10,000 to 9000, tax revenue will rise from $10,000 to $13,500 (= $1.50 × 9000 units). Little wonder that legislatures tend to seek out products such as liquor, gasoline, cigarettes, and phone service when levying and raising taxes. Those taxes yield high tax revenues.

Question:
Under what circumstance might a reduction of an excise tax actually produce more tax revenue?

APPLYING THE ANALYSIS

Fluctuating Farm Income

Inelastic demand for farm products and year-to-year changes in farm output combine to produce highly volatile farm prices and incomes. Let's see why.

In industrially advanced economies, the price elasticity of demand for agricultural products is low. For farm products in the aggregate, the elasticity coefficient is between .20 and .25. These figures suggest that the prices of agricultural products would have to fall by 40 to 50 percent for consumers to increase their purchases by a mere 10 percent. Consumers apparently put a low value on additional farm output compared with the value they put on additional units of alternative goods.

Why is this so? Recall that a basic determinant of elasticity of demand is substitutability. When the price of one product falls, the consumer tends to substitute that product for other products whose prices have not fallen. But in relatively wealthy societies this substitution is very modest for food. Although people may eat more, they do not switch from three meals a day to, say, five or six meals a day in response to a decline in the relative prices of farm products. Real biological factors constrain an individual's capacity to substitute food for other products.

Farm output tends to fluctuate from year to year, mainly because farmers have limited control over their output. Floods, droughts, unexpected frost, insect damage, and similar disasters can mean poor crops, while an excellent growing season means bumper crops (extraordinarily large crops). Such natural phenomena are beyond the control of farmers, yet those phenomena exert an important influence on output.

In addition to natural phenomena, the highly competitive nature of agriculture makes it difficult for farmers to form huge combinations to control production. If the thousands of widely scattered and independent producers happened to plant an unusually large or an abnormally small portion of their land one year, an extra-large or a very small farm output would result even if the growing season were normal.

Combining inelastic demand with the instability of output, we can see why farm prices and incomes are unstable. Even if the market demand for some crop such as barley remains fixed, its price inelasticity will magnify small changes in output into relatively large changes in farm prices and income. For example, suppose that a "normal" barley crop of 100 million bushels results in a "normal" price per bushel of \$3 and a "normal" farm income of \$300 million (= \$3 × 100 million).

A bumper crop of barley will cause large deviations from these normal prices and incomes because of the inelasticity of demand. Suppose that a good growing season occurs and that the result is a large crop of 110 million bushels. As farmers watch their individual crops mature, little will they realize that their collectively large crop, when harvested, will drive the price per bushel down to, say, \$2.50. Their revenue will fall from \$300 million in the normal year to \$275 million (= \$2.50 × 110 million bushels) this year. When demand is inelastic, an increase in the quantity sold will be accompanied by a more-than-proportionate decline in price. The net result is that total revenue, that is, total farm income, will decline disproportionately.

Similarly, a small crop of 90 million bushels, perhaps caused by drought, might boost the price to \$3.50. Total farm income will rise to \$315 million (= \$3.50 × 90 million bushels) from the normal level of \$300 million. A decline in output will cause a more-than-proportionate increase in price and in income when demand is inelastic. Ironically, for farmers as a group, a poor crop may be a blessing and a bumper crop a hardship.

Question:
How might government programs to pay farmers to take land out of production in order to achieve conservation goals (such as erosion control and wildlife protection) increase crop prices and farm income?

Price Elasticity of Supply

ORIGIN OF THE IDEA

O 4.2

Price elasticity of supply

The concept of price elasticity also applies to supply. If the quantity supplied by producers is relatively responsive to price changes, supply is elastic. If it is relatively insensitive to price changes, supply is inelastic.

We measure the degree of price elasticity or inelasticity of supply with the coefficient E_s, defined almost like E_d except that we substitute "percentage change in quantity supplied" for "percentage change in quantity demanded":

$$E_s = \frac{\text{percentage change in quantity supplied of X}}{\text{percentage change in price of X}}$$

For reasons explained earlier, the averages, or midpoints, of the before and after quantities supplied and the before and after prices are used as reference points for the percentage changes. Suppose an increase in the price of a good from \$4 to \$6 increases the quantity supplied from 10 units to 14 units. The percentage change in price would be 2/5, or 40 percent, and the percentage change in quantity would be 4/12, or 33 percent:

$$E_s = \frac{.33}{.40} = .83$$

price elasticity of supply
A measure of the responsiveness of the quantity of a product supplied by sellers when the product price changes.

In this case, supply is inelastic, since the price-elasticity coefficient is less than 1. If E_s is greater than 1, supply is elastic. If it is equal to 1, supply is unit-elastic. Also, E_s is never negative, since price and quantity supplied are directly related. Thus, there are no minus signs to drop, as was necessary with elasticity of demand.

The degree of **price elasticity of supply** depends mainly on how easily and quickly producers can shift resources between alternative uses to alter production of a good. The easier and more rapid the transfers of resources, the greater is the price elasticity of supply. Take the case of a producer of surfboards. The producer's

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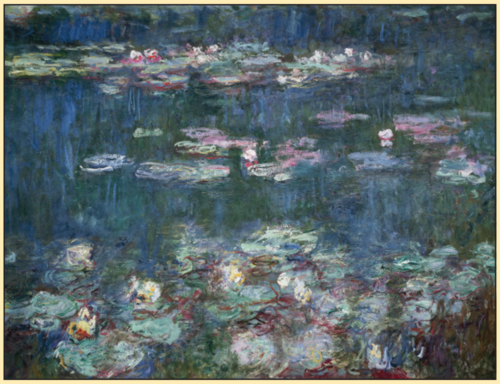

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Photo Op Elastic versus Inelastic Supply

The supply of automobiles is elastic, whereas the supply of Monet paintings is inelastic.

response to an increase in the price of surfboards depends on its ability to shift resources from the production of other products such as wakeboards, skateboards, and snowboards (whose prices we assume remain constant) to the production of surfboards. And shifting resources takes time: The longer the time, the greater the transferability of resources. So there will be a greater production response, and therefore greater elasticity of supply, the longer a firm has to adjust to a price change.

In analyzing the impact of time on elasticity, economists distinguish among the immediate market period, the short run, and the long run.

Price Elasticity of Supply: The Market Period

The **market period** is the period that occurs when the time immediately after a change in market price is too short for producers to respond with a change in the amount they supply. Suppose a farmer brings to market one truckload of tomatoes that is the entire season's output. The supply curve for the tomatoes is perfectly inelastic (vertical); the farmer will sell the truckload whether the price is high or low. Why? Because the farmer can offer only one truckload of tomatoes even if the price of tomatoes is much higher than anticipated. He or she might like to offer more tomatoes, but tomatoes cannot be produced overnight. Another full growing season is needed to respond to a higher-than-expected price by producing more than one truckload. Similarly, because the product is perishable, the farmer cannot withhold it from the market. If the price is lower than anticipated, he or she will still sell the entire truckload.

market period
A period in which producers of a product are unable to change the quantity produced in response to a change in price.

The farmer's costs of production, incidentally, will not enter into this decision to sell. Though the price of tomatoes may fall far short of production costs, the farmer will nevertheless sell out to avoid a total loss through spoilage. During the market period, our farmer's supply of tomatoes is fixed: Only one truckload is offered no matter how high or low the price.

Figure 4.4a shows the farmer's vertical supply curve during the market period. Supply is perfectly inelastic because the farmer does not have time to respond to a change in demand, say, from D_1 to D_2. The resulting price increase from P_0 to P_m simply determines which buyers get the fixed quantity supplied; it elicits no increase in output.

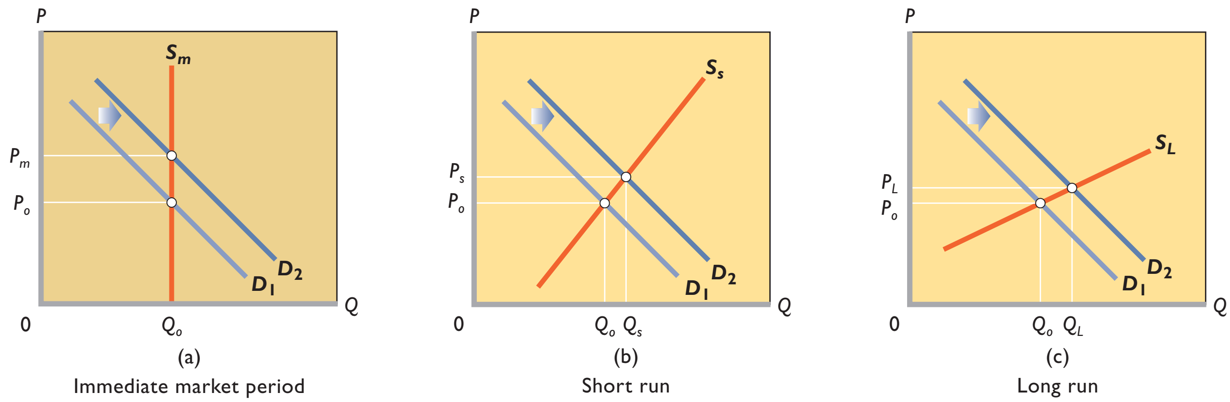
However, not all supply curves need be perfectly inelastic immediately after a price change. If the product is not perishable and the price rises, producers may choose to increase quantity supplied by drawing down their inventories of unsold, stored goods. This will cause the market supply curve to attain some positive slope. For our tomato farmer, the market period may be a full growing season; for producers of goods that can be inexpensively stored, there may be no market period at all.

Price Elasticity of Supply: The Short Run

The **short run** in microeconomics is a period of time too short to change plant capacity but long enough to use the fixed-size plant more or less intensively. In the short run, our farmer's plant (land and farm machinery) is fixed. But he does have time in the short run to cultivate tomatoes more intensively by applying more labor and more fertilizer and pesticides to the crop. The result is a somewhat greater output in response to a presumed increase in demand; this greater output is reflected in a more elastic supply of tomatoes, as shown by S_s in Figure 4.4b. Note now that the increase in demand from D_1 to D_2 is met by an increase in quantity (from Q_0 to Q_s), so there is a

short run
A period in which producers are able to change the quantities of some but not all the resources they employ.

FIGURE 4.4 Time and the elasticity of supply. The greater the amount of time producers have to adjust to a change in demand, here from D_1 to D_2, the greater will be their output response. In the immediate market period (a) there is insufficient time to change output, and so supply is perfectly inelastic. In the short run (b) plant capacity is fixed, but changing the intensity of its use can alter output; supply is therefore more elastic. In the long run (c) all desired adjustments, including changes in plant capacity, can be made, and supply becomes still more elastic.



smaller price adjustment (from P_0 to P_s) than would be the case in the market period. The equilibrium price is therefore lower in the short run than in the market period.

long run
A period long enough to enable producers of a product to change all the resources they employ.

Price Elasticity of Supply: The Long Run

The **long run** in microeconomics is a time period long enough for firms to adjust their plant sizes and for new firms to enter (or existing firms to leave) the industry. In the "tomato industry," for example, our farmer has time to acquire additional land and buy more machinery and equipment. Furthermore, other farmers may, over time, be attracted to tomato farming by the increased demand and higher price. Such adjustments create a larger supply response, as represented by the more elastic supply curve S_L in Figure 4.4c. The outcome is a smaller price rise (P_0 to P_L) and a larger output increase (Q_0 to Q_L) in response to the increase in demand from D_1 to D_2.

There is no total-revenue test for elasticity of supply. Supply shows a positive or direct relationship between price and amount supplied; the supply curve is upsloping. Regardless of the degree of elasticity or inelasticity, price and total revenue always move together.

APPLYING THE ANALYSIS

Antiques and Reproductions

The *Antiques Road Show* is a popular PBS television program in which people bring antiques to a central location for appraisal by experts. Some people are pleased to learn that their old piece of furniture or funky folk art is worth a large amount, say, $30,000 or more.

The high price of a particular antique is due to strong demand and limited, highly inelastic supply. Because a genuine antique can no longer be reproduced, its quantity supplied either does not rise or rises only slightly as its price goes up. The higher price might prompt the discovery of a few more of the remaining originals and thus add to the quantity available for sale, but this quantity response is usually quite small. So the supply of antiques and other collectibles tends to be inelastic. For one-of-a-kind antiques, the supply is perfectly inelastic.

Factors such as increased population, higher income, and greater enthusiasm for collecting antiques have increased the demand for antiques over time. Because the supply of antiques is limited and inelastic, those increases in demand have greatly boosted the prices of antiques.

Contrast the inelastic supply of original antiques with the elastic supply of modern "made-to-look-old" reproductions. Such faux antiques are quite popular and widely available at furniture stores and knickknack shops. When the demand for reproductions increases, the firms making them simply boost production. Because the supply of reproductions is highly elastic, increased demand raises their prices only slightly.

Question:
How does the reluctance to sell antiques add to their inelastic supply?

APPLYING THE ANALYSIS

Volatile Gold Prices

The price of gold is quite volatile, sometimes rocketing upward one period and plummeting downward the next. The main sources of these fluctuations are shifts in demand and highly inelastic supply. Gold production is a costly and time-consuming process of exploration, mining, and refining. Moreover, the physical availability of gold is highly limited. For both reasons, increases in gold prices do not elicit substantial increases in quantity supplied. Conversely, gold mining is costly to shut down, and existing gold bars are expensive to store. Price decreases therefore do not produce large drops in the quantity of gold supplied. In short, the supply of gold is inelastic.

The demand for gold is partly derived from the demand for its uses, such as for jewelry, dental fillings, and coins. But people also demand gold as a speculative financial investment. They increase their demand for gold when they fear general inflation or domestic or international turmoil that might undermine the value of currency and more traditional investments. They reduce their demand when events settle down. Because of the inelastic supply of gold, even relatively small changes in demand produce relatively large changes in price.

Question:
What is the current price of gold? (See www.goldprices.com.) What were the highest and the lowest prices over the last 12 months?

Income Elasticity of Demand

income elasticity of demand
A measure of the responsiveness of the quantity of a product demanded to changes in consumer income.

Income elasticity of demand measures the degree to which the quantity of a product demanded responds, positively or negatively, to a change in consumers' incomes. The coefficient of income elasticity of demand E_i is determined with the formula

$$E_i = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in income}}$$

Normal Goods

For most goods, the income-elasticity coefficient E_i is positive, meaning that more of them are demanded as income rises. Such goods are called *normal* or *superior goods*, which we first described in Chapter 3. But the value of E_i varies greatly among normal goods. For example, income elasticity of demand for automobiles is about +3, while income elasticity for most farm products is only about +.20.

Inferior Goods

A negative income-elasticity coefficient designates an inferior good. Used mattresses, long-distance bus tickets, used clothing, and some frozen meals are likely candidates. Consumers decrease their purchases of inferior goods as their incomes rise.

APPLYING THE ANALYSIS

Which Consumer Products Suffer the Greatest Demand Decreases during Recessions?

Coefficients of income elasticity of demand provide insights into how recessions impact the sales of different consumer products. A recession is defined as two or more consecutive quarters (six months) of falling real output, and is typically characterized by rising unemployment rates, lower profits for business firms, falling consumer incomes, and weaker demand for products. In December 2007, the U.S. economy entered its tenth recession since 1950. Because of a worsening mortgage debt crisis, the recession continued through 2008 and into 2009. When recessions occur and incomes fall, coefficients of income elasticity of demand help predict which products will experience more rapid declines in demand than other products.

Products with relatively high income elasticity coefficients such as automobiles ($E_i = +3$), housing ($E_i = +1.5$), and restaurant meals ($E_i = +1.4$) are generally hit hardest by recessions. Those with low or negative income elasticity coefficients are much less affected. For example, food products ($E_i = +.20$) respond relatively little to income fluctuations. When incomes drop, purchases of food (and toothpaste and toilet paper) drop little compared to purchases of movie tickets, luxury vacations, and wide-screen TVs. Products we view as essential tend to have lower income elasticity coefficients than products we view as luxuries. When our incomes fall, we cannot easily eliminate or postpone the purchase of essential products.

Question:
Why have discount clothing stores (such as Kohl's) suffered less than high-end clothing stores (such as Nordstrom) during the most recent U.S. recession?

Cross-Elasticity of Demand

Cross-elasticity of demand measures how the quantity of a product demanded (say, X) responds to a change in the price of some other product (say, Y). We calculate the coefficient of cross-elasticity of demand E_{xy} just as we do the coefficient of simple price elasticity, except that we relate the percentage change in the consumption of X to the percentage change in the price of Y:

cross-elasticity of demand
A measure of the responsiveness of the quantity demanded of one product to a change in the price of another product.

$$E_{xy} = \frac{\text{percentage change in quantity demanded of product X}}{\text{percentage change in price of product Y}}$$

This cross-elasticity (or cross-price-elasticity) concept allows us to quantify and more fully understand substitute and complementary goods, introduced in Chapter 3.

Substitute Goods

If cross-elasticity of demand is positive, meaning that sales of X move in the same direction as a change in the price of Y, then X and Y are substitute goods. An example is Evian water (X) and Dasani (Y). An increase in the price of Dasani causes consumers to buy more Evian, resulting in a positive cross-elasticity. The larger the positive cross-elasticity coefficient, the greater is the substitutability between the two products.

Complementary Goods

When cross-elasticity is negative, we know that X and Y "go together"; an increase in the price of one decreases the demand for the other. This indicates that the two are complementary goods. For example, a decrease in the price of digital cameras will increase the number of memory sticks purchased. The larger the negative cross-elasticity coefficient, the greater is the complementarity between the two goods.

Independent Goods

A zero or near-zero cross-elasticity suggests that the two products being considered are unrelated or independent goods. An example is textbooks and plums: We would not expect a change in the price of textbooks to have any effect on purchases of plums, and vice versa.

APPLYING THE ANALYSIS

Using Cross-Elasticity to Make Business and Regulatory Decisions

The degree of substitutability of products, measured by the cross-elasticity coefficient, is important to businesses and government. For example, suppose that Coca-Cola is considering whether or not to lower the price of its Sprite brand. Not only will it want to know something about the price elasticity of demand for Sprite (will the price cut increase or decrease total revenue?), but it also will be interested in knowing if the increased sales of Sprite will come at the expense of its Coke brand. How sensitive are the sales of one of its products (Coke) to a change in the price of another of its products (Sprite)? By how much will the increased sales of Sprite "cannibalize" the sales of Coke? A low cross-elasticity would indicate that Coke and Sprite are weak substitutes for each other and that a lower price for Sprite would have little effect on Coke sales.

Government also implicitly uses the idea of cross-elasticity of demand in assessing whether a proposed merger between two large firms will substantially reduce competition and therefore violate the antitrust laws. For example, the cross-elasticity between Coke and Pepsi is high, making them strong substitutes for each other. Consequently, the government would likely block a merger between them because the merger would lessen competition. In contrast, the cross-elasticity between cola and gasoline is low or zero. A merger between Coke and Shell would have a minimal effect on competition. So government would let that merger happen.

Question:
Prior to the recent recession, why did sales of sport utility vehicles (SUVs) decline dramatically, while sales of hybrid vehicles rose significantly? Relate your answer to cross-elasticity of demand.

Summary

1. Price elasticity of demand measures the responsiveness of the quantity of a product demanded when the price changes. If consumers are relatively sensitive to price changes, demand is elastic. If they are relatively unresponsive to price changes, demand is inelastic.
2. The price-elasticity coefficient E_d measures the degree of elasticity or inelasticity of demand. The coefficient is found by the formula

$$E_d = \frac{\text{percentage change in quantity demanded of X}}{\text{percentage change in price of X}}$$

   Economists use the averages of prices and quantities under consideration as reference points in determining percentage changes in price and quantity. If E_d is greater than 1, demand is elastic. If E_d is less than 1, demand is inelastic. Unit elasticity is the special case in which E_d equals 1.
3. Perfectly inelastic demand is graphed as a line parallel to the vertical axis; perfectly elastic demand is shown by a line above and parallel to the horizontal axis.
4. Total revenue (TR) is the total number of dollars received by a firm from the sale of a product in a particular period. It is found by multiplying price times quantity. Graphically, TR is shown as the $P \times Q$ rectangle under a point on a demand curve.
5. If total revenue changes in the opposite direction from prices, demand is elastic. If price and total revenue change in the same direction, demand is inelastic. Where demand is of unit elasticity, a change in price leaves total revenue unchanged.
6. Elasticity varies at different price ranges on a demand curve, tending to be elastic in the upper-left segment and inelastic in the lower-right segment. Elasticity cannot be judged by the steepness or flatness of a demand curve.
7. The number of available substitutes, the size of an item's price relative to one's budget, whether the product is a luxury or a necessity, and the length of time to adjust are all determinants of elasticity of demand.
8. The elasticity concept also applies to supply. The coefficient of price elasticity of supply is found by the formula

$$E_s = \frac{\text{percentage change in quantity supplied of X}}{\text{percentage change in price of X}}$$

   The averages of the prices and quantities under consideration are used as reference points for computing percentage changes.
9. Elasticity of supply depends on the ease of shifting resources between alternative uses, which varies directly with the time producers have to adjust to a price change.

10. Income elasticity of demand indicates the responsiveness of consumer purchases to a change in income. The coefficient of income elasticity of demand is found by the formula

$$E_i = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in income}}$$

The coefficient is positive for normal goods and negative for inferior goods.

11. Cross-elasticity of demand indicates the responsiveness of consumer purchases of one product (X) to a change in the price of some other product (Y). The coefficient of cross-elasticity is found by the formula

$$E_{xy} = \frac{\begin{array}{c}\text{percentage change in quantity}\\ \text{demanded of product X}\end{array}}{\begin{array}{c}\text{percentage change in price}\\ \text{of product Y}\end{array}}$$

The coefficient is positive if X and Y are substitute goods and negative if X and Y are complements.

Terms and Concepts

price elasticity of demand
elastic demand
inelastic demand
unit elasticity
perfectly inelastic demand
perfectly elastic demand
total revenue (TR)
total-revenue test
price elasticity of supply
market period
short run
long run
income elasticity of demand
cross-elasticity of demand

Study Questions

connect economics

1. What is the formula for measuring price elasticity of demand? What does it mean (in terms of relative price and quantity changes) if the price-elasticity coefficient is less than 1? Equal to 1? Greater than 1? **LO1**
2. Graph the accompanying demand data, and then use the price-elasticity formula (midpoints approach) for E_d to determine price elasticity of demand for each of the four possible $1 price changes. What can you conclude about the relationship between the slope of a curve and its elasticity? **LO1**

Product Price	Quantity Demanded
$5	1
4	2
3	3
2	4
1	5

3. Calculate total-revenue data from the demand schedule in question 2. Referring to changes in price and total revenue, describe the total-revenue test for elasticity. **LO2**
4. You are chairperson of a state tax commission responsible for establishing a program to raise new revenue through excise taxes. Why would elasticity of demand be important to you in determining the products on which the taxes should be levied? **LO4**
5. How would the following changes in price affect total revenue? That is, would total revenue increase, decline, or remain unchanged? **LO2**
   a. Price falls and demand is inelastic.
   b. Price rises and demand is elastic.
   c. Price rises and supply is elastic.
   d. Price rises and supply is inelastic.
   e. Price rises and demand is inelastic.
   f. Price falls and demand is elastic.
   g. Price falls and demand is of unit elasticity.
6. What are the major determinants of price elasticity of demand? Use those determinants and your own reasoning in judging whether demand for each of the following products is probably elastic or inelastic: (a) bottled water; (b) toothpaste; (c) Crest toothpaste; (d) ketchup; (e) diamond bracelets; (f) Microsoft Windows operating system. **LO1**
7. What effect would a rule stating that university students must live in university dormitories have on the price elasticity of demand for dormitory space? What impact might this in turn have on room rates? **LO1**
8. What is the formula for measuring the price elasticity of supply? Suppose the price of apples goes up from $20 to $22 a box. In direct response, Goldsboro Farms supplies 1200

boxes of apples instead of 1000 boxes. Compute the coefficient of price elasticity (midpoints approach) for Goldsboro's supply. Is its supply elastic, or is it inelastic? **LO3**

9. In May 2004 Pablo Picasso's 1905 painting *Boy with a Pipe* sold at auction for $104 million. Portray this sale in a demand and supply diagram, and comment on the elasticity of supply. Comedian George Carlin once mused, "If a painting can be forged well enough to fool some experts, why is the original so valuable?" Provide an answer. **LO4**

10. Because of a legal settlement over state health care claims, in 1999 the U.S. tobacco companies had to raise the average price of a pack of cigarettes from $1.95 to $2.45. The decline in cigarette sales was estimated at 8 percent. What does this imply for the elasticity of demand for cigarettes? Explain. **LO4**

11. The income elasticities of demand for movies, dental services, and clothing have been estimated to be +3.4, +1 and +.5, respectively. Interpret these coefficients. What does it mean if an income-elasticity coefficient is negative? **LO5**

12. Suppose the cross-elasticity of demand for products A and B is +3.6, and for products C and D is −5.4. What can you conclude about how products A and B are related? Products C and D? **LO5**

FURTHER TEST YOUR KNOWLEDGE AT
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Web-Based Questions

At the text's Online Learning Center, **www.mcconnellbriefmicro1e.com,** you will find a multiple-choice quiz on this chapter's content. We encourage you to take the quiz to see how you do. Also, you will find one or more Web-based questions that require information from the Internet to answer.