PRICE ELASTICITY

The theory of demand helps explain consumer behavior. But it's not terribly helpful to the theater owner who's actually worried about popcorn sales. The general observation that popcorn sales decline when prices increase would be of little use. What the theater owner wants to know is *by how much* the quantity demanded would fall if the price were raised. Steve Jobs wanted to know the same thing about the demand for iPhones.

The central question in all these decisions is the response of quantity demanded to a change in price. ***The response of consumers to a change in price is measured by the price elasticity of demand.*** Specifically, the **price elasticity of demand** refers to the percentage change in quantity demanded divided by the percentage change in price—that is,

price elasticity of demand: The percentage change in quantity demanded divided by the percentage change in price.

$$\text{Price elasticity } (E) = \frac{\%\text{ change in quantity demanded}}{\%\text{ change in price}}$$

What would the value of price elasticity be if air travel didn't change at all when airfares were cut by 5 percent? In that case the price elasticity of demand would be

$$E = \frac{\%\text{ change in quantity demanded}}{\%\text{ change in price}}$$

$$= \frac{0}{5} = 0$$

But is this realistic? According to the law of demand, the quantity demanded goes up when price goes down. So we'd expect *somebody* to buy more airline tickets if fares fell by 5 percent. In a large market like air travel, we don't expect *everybody* to jump on a plane when airfares are reduced. But if *some* consumers fly more, the percentage change in quantity demanded will be larger than zero. Indeed, ***the law of demand implies that the price elasticity of demand will always be greater than zero.*** Technically, the price elasticity of demand (E) would be a negative number since quantity demanded and price always move in opposite directions. For simplicity, however, E is typically expressed in absolute terms (without the minus sign). ***The key question, then, is how much greater than zero* E *actually is.***

Computing Price Elasticity

To get a feel for the dimensions of elasticity, let's return to the popcorn counter at the movies. We've already observed that at a price of 45 cents an ounce (point *B* in Figure 5.3), the average moviegoer demands 2 ounces of popcorn per show. At the lower price of 40 cents per ounce (point *C*), the quantity demanded jumps to 4 ounces per show.

We can summarize this response with the price elasticity of demand. To do so, we have to calculate the *percentage* changes in quantity and price. Consider the percentage change in quantity first. In this case, the change in quantity demanded is 4 ounces − 2 ounces = 2 ounces. The *percentage* change in quantity is therefore

$$\%\text{ change in quantity} = \frac{2}{q}$$

Topic Podcast: The Law of Demand

The problem is to transform the denominator q into a number. Should we use the quantity of popcorn purchased *before* the price reduction, that is, $q_1 = 2$? Or should we use the quantity purchased *after* the price reduction, that is, $q_2 = 4$? The choice of denominator will have a big impact on the computed percentage change. To ensure consistency, economists prefer to use the *average* quantity in the denominator.[1] The average quantity is simply

$$\text{Average quantity} = \frac{q_1 + q_2}{2} = \frac{2 + 4}{2} = 3\text{ ounces}$$

[1]This procedure is referred to as the *arc* (midpoint) elasticity of demand. If a single quantity (price) is used in the denominator, we refer to the *point* elasticity of demand.

We can now complete the calculation of the percentage change in quantity demanded. It is

$$\text{\% change in quantity demanded} = \frac{\text{change in quantity}}{\text{average quantity}} = \frac{q_2 - q_1}{\frac{q_1 + q_2}{2}} = \frac{2}{3} = 0.667$$

Popcorn sales increased by an average of 67 percent when the price of popcorn was reduced from 45 cents to 40 cents per ounce.

The computation of the percentage change in price is similar. We first note that the price of popcorn fell by 5 cents (45¢ − 40¢) when we move from point *B* to point *C* on the demand curve (Figure 5.3). We then compute the *average* price of popcorn in this range of the demand curve as

$$\text{Average price of popcorn} = \frac{p_1 + p_2}{2} = \frac{45 + 40}{2} = 42.5 \text{ cents}$$

This average is our denominator in calculating the percentage price change. Using these numbers, we see that the absolute value of the percentage change is

$$\text{\% change in price} = \frac{\text{change in price}}{\text{average price}} = \frac{p_2 - p_1}{\frac{p_1 + p_2}{2}} = \frac{5}{42.5} = 0.118$$

The price of popcorn fell by 11.8 percent.

Now we have all the information required to compute the price elasticity of demand. In this case,

$$E = \frac{\text{\% change in quantity demanded}}{\text{\% change in price}} = \frac{0.667}{0.118} = 5.65$$

What we get from all these calculations is a very useful number. It says that the consumer response to a price reduction will be extremely large. Specifically, the quantity of popcorn consumed will increase 5.65 times as fast as price falls. A 1 percent reduction in price brings about a 5.65 percent increase in purchases. The theater manager can therefore boost popcorn sales greatly by lowering price a little.

Elastic vs. Inelastic Demand. We characterize the demand for various goods in one of three ways: *elastic, inelastic,* or *unitary elastic.* If **E** ***is larger than 1, demand is elastic.*** Consumer response is large relative to the change in price.

If *E* is less than 1, we say demand is inelastic. ***If demand is inelastic (E < 1), consumers aren't very responsive to price changes.***

If *E* is equal to 1, demand is *unitary* elastic. In this case, the percentage change in quantity demanded is exactly equal to the percentage change in price.

Consider the case of smoking. Many smokers claim they'd "pay anything" for a cigarette after they've run out. But would they? Would they continue to smoke just as many cigarettes if prices doubled or tripled? If so, the demand curve would be vertical (as in Figure 5.4*b* on the next page) rather than downward-sloping. Research suggests this is not the case: Higher cigarette prices *do* curb smoking. There is at least *some* elasticity in the demand for cigarettes. But the elasticity of demand is low; Table 5.1 indicates that the price elasticity of cigarette demand is only 0.4.

Although the average adult smoker is not very responsive to changes in cigarette prices, teen smokers apparently are. As the News on page 399 indicates, teen smoking drops by almost 7 percent when cigarette prices increase by 10 percent. Thus, the price elasticity of

webnote

The American Cancer Society stages a Great American Smokeout every November. The society's goal is to help people, particularly teenagers, stop smoking. For statistics on smoking trends, visit www.cancer.org/docroot/PED/PED_10_4_Great_American_Smokeout.asp

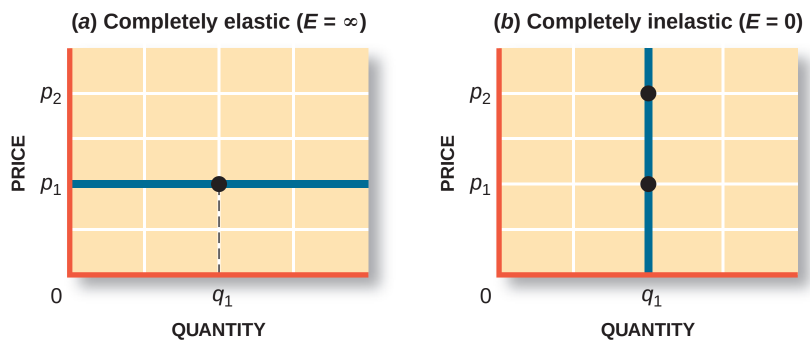

FIGURE 5.4
Extremes of Elasticity

If demand were perfectly elastic ($E = \infty$), the demand curve would be *horizontal.* In that case, any increase in price (e.g., p_1 to p_2) would cause quantity demanded to fall to zero.

A *vertical* demand curve implies that an increase in price won't affect the quantity demanded. In this situation of completely *in*elastic ($E = 0$) demand, consumers are willing to pay *any* price to get the quantity q_1.

In reality, elasticities of demand for goods and services lie between these two extremes (obeying the law of demand).

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teen demand for smoking is

$$E = \frac{\text{percent drop in quantity demanded}}{\text{percent increase in price}} = \frac{7\%}{10\%} = 0.7$$

Hence, higher cigarette prices can be an effective policy tool for curbing teen smoking. The drop in teen smoking after prices jumped in 1998 (see News) confirms this expectation.

TABLE 5.1
Elasticity Estimates

Price elasticities vary greatly. When the price of gasoline increases, consumers reduce their consumption only slightly. When the price of fish increases, however, consumers cut back their consumption substantially. These differences reflect the availability of immediate substitutes, the prices of the goods, and the amount of time available for changing behavior.

Product	Price Elasticity
Relatively elastic ($E > 1$)	
Airline travel, long run	2.4
Restaurant meals	2.3
Fresh fish	2.2
New cars, short run	1.2–1.5
Unitary elastic ($E = 1$)	
Private education	1.1
Radios and televisions	1.2
Shoes	0.9
Movies	0.9
Relatively inelastic ($E < 1$)	
Cigarettes	0.4
Coffee	0.3
Gasoline, short run	0.2
Electricity (in homes)	0.1
Long-distance phone calls	0.1

Source: Compiled from Hendrick S. Houthakker and Lester D. Taylor, *Consumer Demand in the United States,* 1929–1970 (Cambridge: Harvard University Press, 1966); F. W. Bell, "The Pope and Price of Fish," *American Economic Review,* December 1968; Herbert Scarf and John Shoven, *Applied General Equilibrium Analysis* (New York: Cambridge University Press, 1984); and Michael Ward, "Product Substitutability and Competition in Long-Distance Telecommunications," *Economic Inquiry,* October 1999.

IN THE NEWS

Dramatic Rise in Teenage Smoking

Smoking among youths in the United States rose precipitously starting in 1992 after declining for the previous 15 years. By 1997, the proportion of teenage smokers had risen by one-third from its 1991 trough.

A prominent explanation for the rise in youth smoking over the 1990s was a sharp decline in cigarette prices in the early 1990s, caused by a price war between the tobacco companies. Gruber and Zinman find that young people are very sensitive to the price of cigarettes in their smoking decisions. The authors estimate that for every 10 percent decline in the price, youth smoking rises by almost 7 percent, a much stronger price sensitivity than is typically found for adult smokers. As a result, the price decline of the early 1990s can explain about a quarter of the smoking rise from 1992 through 1997. Similarly, the significant decline in youth smoking observed in 1998 is at least partially explainable by the first steep rise in cigarette prices since the early 1990s. The authors also find that black youths and those with less-educated parents are much more responsive to changes in cigarette prices than are white teens and those with more-educated parents.

However, price does not appear to be an important determinant of smoking by younger teens. This may be because they are more experimental smokers.

Source: National Bureau of Economic Research, *NBER Digest*, October 2000. www.nber.org/digest

Analysis: The effectiveness of higher cigarette prices in curbing teen smoking depends on the price elasticity of demand.

According to Table 5.1, the demand for airline travel is even more price-elastic. Whenever a fare cut is announced, the airlines get swamped with telephone inquiries. If fares are discounted by 25 percent, the number of passengers may increase by as much as 60 percent. As Table 5.1 shows, the elasticity of airline demand is 2.4, meaning that the percentage change in quantity demanded (60 percent) will be 2.4 times larger than the price cut (25 percent).

Determinants of Elasticity

Why are consumers price-sensitive ($E > 1$) with some goods and not ($E < 1$) with others? To answer that, we must go back to the demand curve itself. The elasticity of demand is computed between points on a given demand curve. Hence, ***the price elasticity of demand is influenced by all the determinants of demand.*** Four factors are particularly worth noting.

Necessities vs. Luxuries. Some goods are so critical to our everyday life that we regard them as "necessities". A hair brush, toothpaste, and perhaps textbooks might fall into this category. Our "taste" for such goods is so strong that we can't imagine getting along without them. As a result, we don't change our consumption of "necessities" very much when the price increases; ***demand for necessities is relatively inelastic.***

A "luxury" good, by contrast, is something we'd *like* to have but aren't likely to buy unless our income jumps or the price declines sharply, such as vacation travel, new cars, and iPhones. We want them but can get by without them. That is, ***demand for luxury goods is relatively elastic.***

Availability of Substitutes. Our notion of which goods are necessities is also influenced by the availability of substitute goods. The high elasticity of demand for fish (Table 5.1) reflects the fact that consumers can always eat chicken, beef, or pork if fish prices rise. On the other hand, most bleary-eyed coffee drinkers can't imagine any other product that could substitute for a cup of coffee. As a consequence, when coffee prices rise, consumers don't reduce their purchases very much at all. Likewise, the low elasticity of demand for gasoline reflects the fact that most cars can't run on alternative fuels. In general, ***the greater the availability of substitutes, the higher the price elasticity of demand.*** This is a principle that New York City learned when it raised the price of cigarettes in 2002. As the News explains, smugglers quickly supplied a substitute good and legal sales of cigarettes declined drastically in New York City.

Relative Price (to income). Another important determinant of elasticity is the price of the good in relation to a consumer's income. Airline travel and new cars are quite expensive, so even a small percentage change in their prices can have a big impact on a consumer's

IN THE NEWS

New York City's Costly Smokes

New York City has the nation's costliest smokes. NYC Mayor Michael Bloomberg raised the city's excise tax from 8 cents a pack to $1.50 effective July 2002. Together with state and federal taxes, that raised the retail price of smokes in NYC to nearly $8 a pack.

Mayor Bloomberg expected the city to reap a tax bonanza from the 350 million packs of cigarettes sold annually in NYC. What he got instead was a lesson in elasticity. NYC smokers can buy cigarettes for a lot less money outside the city limits. Or they can stay home and buy cigarettes on the Internet from (untaxed) Indian reservations, delivered by UPS. They can also buy cigarettes smuggled in from low-tax states like Kentucky, Virginia, and North Carolina. What matters isn't the price elasticity of demand for cigarettes in general (around 0.4), but the elasticity of demand for *NYC-taxed* cigarettes. That turned out to be quite high. Unit sales of NYC cigarettes plummeted by 44 percent after the "Bloomberg tax" was imposed.

Source: "*NewsFlash*," *Economy Today*, October 2002.

Analysis: If demand is price-elastic, a price increase will lead to a disproportionate drop in unit sales. In this case, the ready availability of substitutes (cigarettes from other jurisdictions) made demand highly price-elastic.

budget (and consumption decisions). The demand for such big-ticket items tends to be elastic. By contrast, coffee is so cheap that even a large *percentage* change in price doesn't affect consumer behavior very much.

Because the relative price of a good affects price elasticity, the value of E_1 *changes* along a given demand curve. At current prices the elasticity of demand for coffee is low. How would consumers behave, however, if coffee cost $5 a cup? Some people would still consume coffee. At such higher prices, however, the quantity demanded would be much more sensitive to price changes. Accordingly, when we observe, as in Table 5.1, that the demand for coffee is price-inelastic, that observation applies only to the current range of prices. Were coffee prices dramatically higher, the price elasticity of demand would be higher as well. As a rule, ***the price elasticity of demand declines as price moves down the demand curve.***

Time. Finally, time affects the price elasticity of demand. Car owners can't switch to electric autos every time the price of gasoline goes up. In the short run, the elasticity of demand

IN THE NEWS

Professor Becker Corrects President's Math

President Clinton has seized upon the cigarette excise tax as an expedient and politically correct means of increasing federal revenue. In 1994, the federal government took in $12 billion from the present 24-cents-per-pack tax. If the tax were quadrupled to $1 a pack, Clinton figures tax revenues would increase by more than $50 billion over three years. Those added revenues would help finance the health-care reforms the President so dearly wants.

Professor Gary Becker, a Nobel Prize–winning economist at the University of Chicago, says Clinton's math is wrong. The White House assumed that cigarette sales would drop by 4 percent for every 10 percent increase in price. Professor Becker says that reflects only the first-year response to higher prices, not the full adjustment of smokers' behavior. Over a three-year period, cigarette consumption is likely to decline by 8 percent for every 10 percent increase in price—twice as much as Clinton assumed. As a result, the $1-a-pack tax will bring in much less revenue than President Clinton projected.

Source: *BusinessWeek*, August 15, 1994. © 1994 The McGraw-Hill Companies, Inc. Reprinted with permission. www.businessweek.com

Analysis: It takes time for people to adjust their behavior to changed prices. Hence, the short-run price elasticity of demand is lower than the long-run elasticity.

for gasoline is quite low. With more time to adjust, however, consumers can buy more fuel-efficient cars, relocate their homes or jobs, and even switch fuels. As a consequence, ***the long-run price elasticity of demand is higher than the short-run elasticity.*** Nobel Prize–winning economist Gary Becker used the distinction between long-run and short-run elasticities to explain why a proposed increase in cigarette excise taxes wouldn't generate nearly as much revenue as President Clinton expected (see previous News).

PRICE ELASTICITY AND TOTAL REVENUE

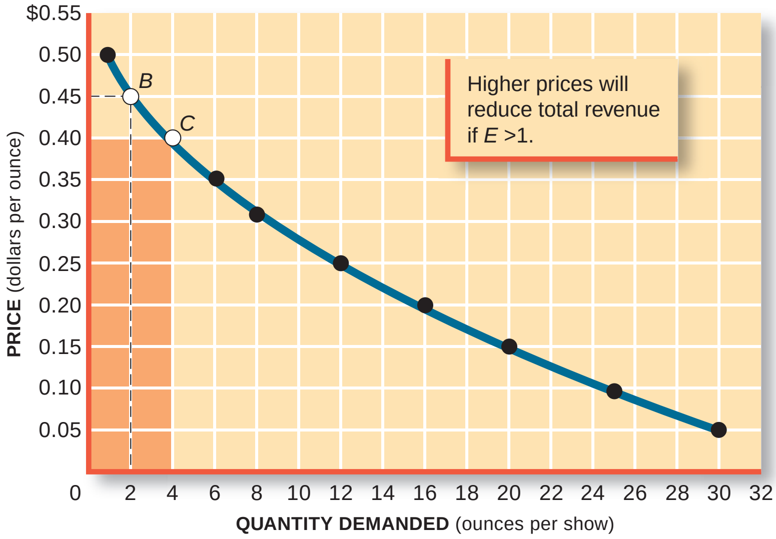
The concept of price elasticity refutes the popular misconception that producers charge the "highest price possible." Were that true, Steve Jobs would have priced the initial iPhone at $8,996. Except in the very rare case of completely inelastic demand, this notion makes no sense. Indeed, higher prices not only reduce unit sales, but may actually reduce total sales revenue as well.

The **total revenue** of a seller is the amount of money received from product sales. It is determined by the quantity of the product sold and the price at which it is sold:

total revenue: The price of a product multiplied by the quantity sold in a given time period.

$$\text{Total revenue} = \text{price} \times \text{quantity sold}$$

In the movie theater example, if the price of popcorn is 40 cents per ounce and only 4 ounces are sold, total revenue equals $1.60 per show. This revenue is illustrated by the shaded rectangle in Figure 5.5. (The area of a rectangle is equal to its height [*p*] times its width [*q*].)



	Price	×	Quantity Demanded	=	Total Revenue
A	50¢		1		$0.50
B	45		2		0.90
C	40		4		1.60
D	35		6		2.10
E	30		8		2.40
F	25		12		3.00
G	20		16		3.20
H	15		20		3.00
I	10		25		2.50
J	5		30		1.50

FIGURE 5.5
Elasticity and Total Revenue

Total revenue is equal to the price of the product times the quantity sold. It is illustrated by the area of the rectangle formed by $p \times q$.

The shaded rectangle illustrates total revenue ($1.60) at a price of 40 cents and a quantity demanded of 4 ounces. When price is increased to 45 cents (point *B*), the rectangle and total revenue shrink (see dashed lines) because demand is relatively elastic in that price range. Price hikes increase total revenue only if demand is inelastic.

TABLE 5.2
Price Elasticity of Demand and Total Revenue

The impact of higher prices on total revenue depends on the price elasticity of demand. Higher prices result in higher total revenue only if demand is inelastic. If demand is elastic, *lower* prices result in *higher* revenues.

If Demand is	Effect on Total Revenue of: Price Increase	Price Reduction
Elastic ($E > 1$)	Decrease	Increase
Inelastic ($E < 1$)	Increase	Decrease
Unitary elastic ($E = 1$)	No change	No change

Now consider what happens to total revenue when the price of popcorn is increased. From the law of demand, we know that an increase in price will lead to a decrease in quantity demanded. But what about total revenue? The change in total revenue depends on *how much* quantity demanded falls when price goes up.

Suppose we raise popcorn prices again, from 40 cents back to 45 cents. What happens to total revenue? At 40 cents per box, 4 ounces are sold (see Figure 5.5) and total revenue equals $1.60. If we increase the price to 45 cents, only 2 ounces are sold and total revenue drops to 90 cents. In this case, an *increase* in price leads to a *decrease* in total revenue. This new and smaller total revenue is illustrated by the dashed rectangle in Figure 5.5.

Price increases don't always lower total revenue. If consumer demand was relatively *inelastic* ($E < 1$), a price increase would lead to *higher* total revenue. Thus, we conclude that

- ***A price hike increases total revenue only if demand is inelastic* (E < 1).**
- ***A price hike reduces total revenue if demand is elastic* (E > 1).**
- ***A price hike does not change total revenue if demand is unitary-elastic* E = 1.**

Table 5.2 summarizes these and other responses to price changes.

Changing Value of *E*. Once we know the price elasticity of demand, we can predict how consumers will respond to changing prices. We can also predict what will happen to the total revenue of the seller when price is raised or reduced. Figure 5.6 shows how elasticity and total revenue change along a given demand curve. Demand for cigarettes is *elastic* ($E > 1$) at prices above $6 per pack but *inelastic* ($E < 1$) at lower prices.

The bottom half of Figure 5.6 shows how total revenue changes along the demand curve. At very high prices (e.g., $14 a pack), few cigarettes are sold and total revenue is low. As the price is reduced, however, the quantity demanded increases so much that total revenue *increases*, despite the lower price. With each price reduction from $14 down to $6 total revenue increases.

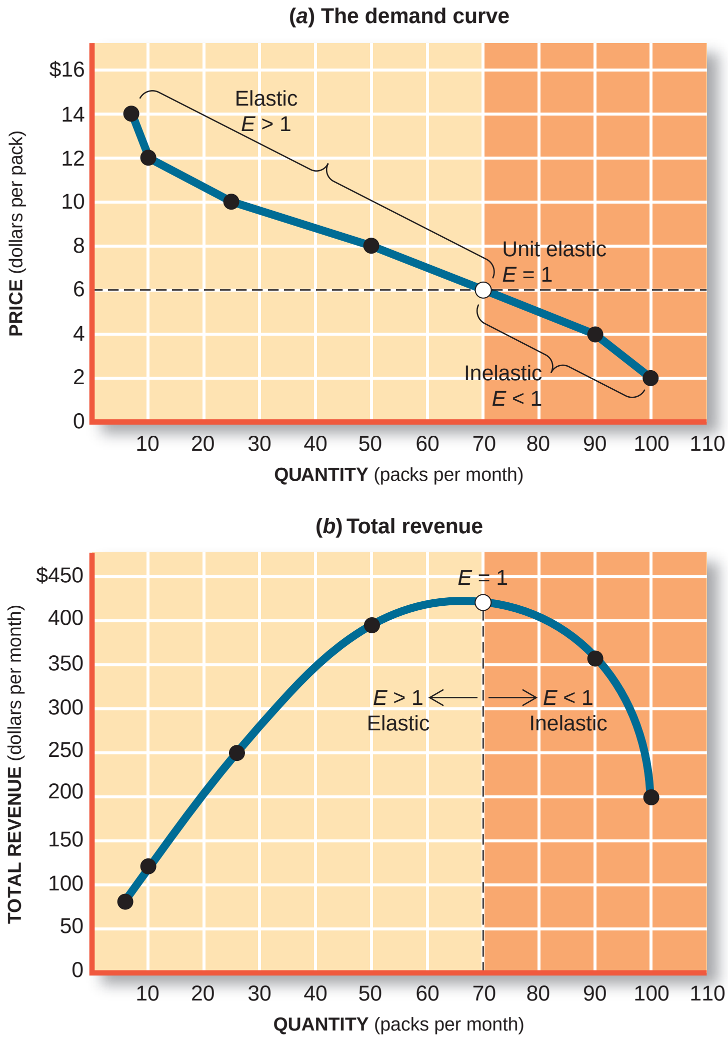
Price cuts below $6 a pack continue to increase the quantity demanded (the law of demand). The increase in unit sales is no longer large enough, however, to offset the price reductions. Total revenue starts falling after price drops below $6 per pack. The lesson to remember here is that ***the impact of a price change on total revenue depends on the (changing) price elasticity of demand.***

OTHER ELASTICITIES

The price elasticity of demand tells us how consumers will respond to a change in the price of a good under the assumption of *ceteris paribus*. But other factors do change, and consumption behavior may respond to those changes as well.

Shifts vs. Movements

We recognized this problem in Chapter 3 when we first distinguished *movements* along a demand curve from *shifts* of the demand curve. A movement along an unchanged demand curve represents consumer response to a change in the *price* of that specific good. The magnitude of that movement is expressed in the price elasticity of demand.



Price of Cigarettes	×	Quantity Demanded	=	Total Revenue	
$2		100		$200	Low elasticity; $E < 1$ (total revenue rises when price increases)
4		90		360	
6		70		420	
8		50		400	High elasticity; $E > 1$ (total revenue falls when price increases)
10		25		250	
12		10		120	
14		6		84	

FIGURE 5.6

Price Elasticity Changes along a Demand Curve

The concept of price elasticity can be used to determine whether people will spend more money on cigarettes when price rises. The answer to this question is yes and no, depending on how high the price goes.

Notice in the table and the graphs that total revenue rises when the price of cigarettes increases from $2 to $4 a pack and again to $6. At low prices, the demand for cigarettes appears relatively inelastic: Price and total revenue move in the same direction.

As the price of cigarettes continues to increase, however, total revenue starts to fall. As the price is increased from $6 to $8 a pack, total revenue drops. At higher prices, the demand for cigarettes is relatively elastic: Price and total revenue move in *opposite* directions. Hence, the price elasticity of demand depends on where one is on the demand curve.

When the underlying determinants of demand change, the entire demand curve shifts. These shifts also alter consumer behavior. The *price* elasticity of demand is of no use in gauging these behavioral responses, since it refers to price changes (movements along a constant demand curve) for that good only.

Income Elasticity

A change in any determinant of demand will shift the demand curve. Suppose consumer incomes were to increase. How would popcorn consumption be affected? Figure 5.7 pro-