# 4

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# Elasticity: The Measure of Responsiveness

## Learning Objectives

By the end of this chapter, you will be able to:

- Review the most important concepts in supply and demand analysis.
- Define elasticity as a measure of responsiveness.
- Define and calculate the coefficient of price elasticity of demand.
- Define and calculate the income elasticity of demand and the cross elasticity of demand.
- Define and calculate the price elasticity of supply.
- Determine the incidence of an excise tax.

## Introduction

**Consider this. . .** One day while shopping you notice an old oil lamp in the window of a consignment store. Intrigued, you go into the store and pick up the lamp. When you rub it, a genie appears and offers you three wishes. For one of your wishes, you ask to be the sole inventor, owner, and producer of a revolutionary new smartphone device. Your wish is granted.

You now are in a position to be very rich. What price should you charge for the smartphones? How many should you sell? For the sake of argument let's assume you want to be as rich as possible and that you can produce the devices at no cost—they just appear like the genie. Now, what price should you charge and how many should you sell? You know that demand curves slope downward to the right, so in order to sell more you will have to lower your price. What a dilemma! This chapter will show you how to be as rich as possible!

To do so we extend the concepts of supply and demand by developing another tool of the microeconomist—the elasticity measurement. **Elasticity** is the measure of the sensitivity, or responsiveness, of quantity demanded or quantity supplied to changes in price (or other conditions). We will develop several elasticity measures and then demonstrate their usefulness in the analysis of public policy—and selling smartphones.

## *4.1* Supply and Demand Revisited

Supply and demand are basic to economic analysis. It is worth reviewing them before beginning to expand your kit of economic tools.

When developing the concept of demand, we stressed the distinction between shifts in demand curves and movement along demand curves. Any movement along a demand curve occurs in response to a change in price and is referred to as a *change in quantity demanded*. Any shift of the demand curve itself is called a *change in demand*. Changes in demand occur in response to changes in one or more of the ceteris paribus conditions that underlie the demand curve: the tastes of the group demanding the good or service, the size of that group, the income and wealth of that group, the prices of other goods and services, or expectations about any of these conditions.

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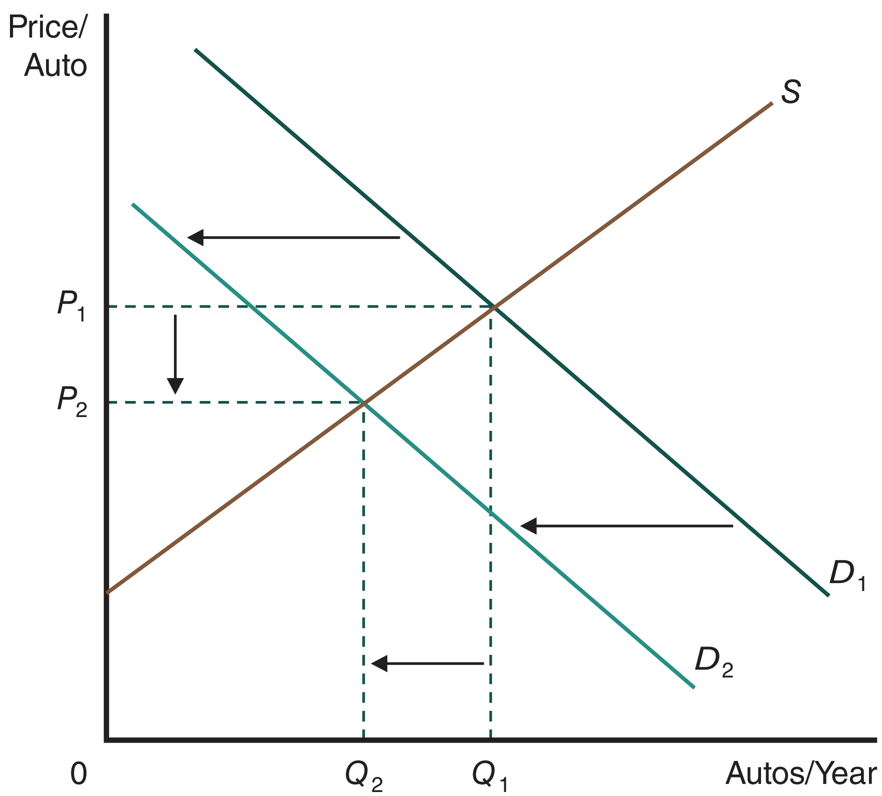
**Gasoline prices can shift the demand for automobiles, which can also affect automobile production.**

Similarly, there is an important difference between changes in supply and changes in quantity supplied. The phrase *change in quantity supplied* indicates to the economist that the change that occurred was in response to a change in price. The phrase *change in supply* means that the change occurred in response to a change in one or more of the ceteris paribus conditions affecting supply: the prices of the productive factors, the number of sellers, the technology used to produce the good, or expectations about any of these conditions.

These principles and terms are useful in explaining economic events. Figure 4.1 is a diagram of supply and demand in the market for automobiles. Stable ceteris paribus conditions have been assumed, and differences in autos' quality, size, and gas mileage have been ignored, so that a demand curve for like units can be drawn. The market determines an equilibrium price of $P_1$ and quantity of $Q_1$. Now suppose the price of gasoline increases. Since gasoline and automobiles are complements, you know that the increase in the price of gasoline is going to cause the demand for automobiles to shift from $D_1$ to $D_2$ in Figure 4.1. That is, with gasoline being more expensive, people drive less, reducing the demand for automobiles. This decrease in demand for autos causes the price to fall to $P_2$ and the quantity supplied to decrease to $Q_2$. Remember that quality and other factors are held constant. Thus, the decrease in the demand for automobiles could represent a switch to smaller cars or less frequent trade-ins for newer models.

## Figure 4.1: The market for automobiles




**Gasoline is a complementary good to automobiles. If the price of gasoline rises, there will be a decrease in the demand for automobiles. The price of autos will fall from $P_1$ to $P_2$, and the equilibrium quantity will decrease from $Q_1$ to $Q_2$. There has been a decrease in the quantity supplied.**

## 4.2 Elasticity as a General Concept

Elasticity measures the way one variable responds to changes in other variables. One variable is described as the dependent variable because it depends upon, or changes in response to, some other variable, called the independent variable.

Elasticity is a measure of how the dependent variable responds to changes in any one of the independent variables. The general formula to determine this responsiveness is

$$\text{Elasticity} = \frac{\text{Percent change in the dependent variable}}{\text{Percent change in the independent variable}}$$

Using the symbol Δ (the Greek letter delta) to represent change, this is written:

$$E = \frac{\%\Delta y}{\%\Delta x}$$

In examining demand, economists are interested in how the quantity demanded responds to changes in price and to changes in certain other ceteris paribus conditions that can affect demand. The quantity demanded of good *A* ($Q_A^d$) is thus the dependent variable. The independent variables include factors such as the price of good *A* ($P_A$), income ($I$), tastes ($T$), the price of complements ($P_c$), and the price of substitutes ($P_s$).

## 4.3 Price Elasticity of Demand

In order to determine how quantity demanded $Q_d$ responds to change in any of the independent variables, we hold all but one of them constant and calculate the elasticity coefficient using the equation above. For example, to see how quantity demanded responds to price, we use

$$\text{Elasticity coefficient} = \frac{\text{Percent change in the quantity of good A demanded}}{\text{Percent change in the price of good A}}$$

$$E_d = \frac{\%\Delta Q_A^d}{\%\Delta P_A}$$

where $E_d$ is the coefficient of price elasticity of demand. This formula gives us the price elasticity of demand. Price elasticity of demand is the measure of the relative responsiveness of the quantity demanded to changes in price. Note an important advantage of measuring in terms of percentage change. There are no units associated with the elasticity coefficient; it is simply a ratio.

In the late nineteenth century, the famous English economist Alfred Marshall developed the concept of elasticity to compare the demands for various products. When comparisons are made, the coefficient indicates the relative responsiveness of the quantity demanded to price changes. The slope of the demand curve, calculated as $\Delta P/\Delta Q$, is used to calculate absolute responsiveness. Relative comparisons make it possible to measure and then describe the sensitivity of the demand relationship.

The **coefficient of price elasticity of demand ($E_d$)** is the numerical measure of price elasticity of demand. It is the percent change in quantity demanded of a good divided by the percent change in price. That is, as you have seen, for good *A*,

$$E_d = \frac{\%\Delta {Q_A}^d}{\%\Delta P_A}$$

Since the percent change is calculated by dividing the change in the variable by the base amount of the variable, this can be rewritten as

$$E_d = \frac{\Delta {Q_A}^d / {Q_A}^d}{\Delta P_A / P_A}$$

## Types of Elasticity

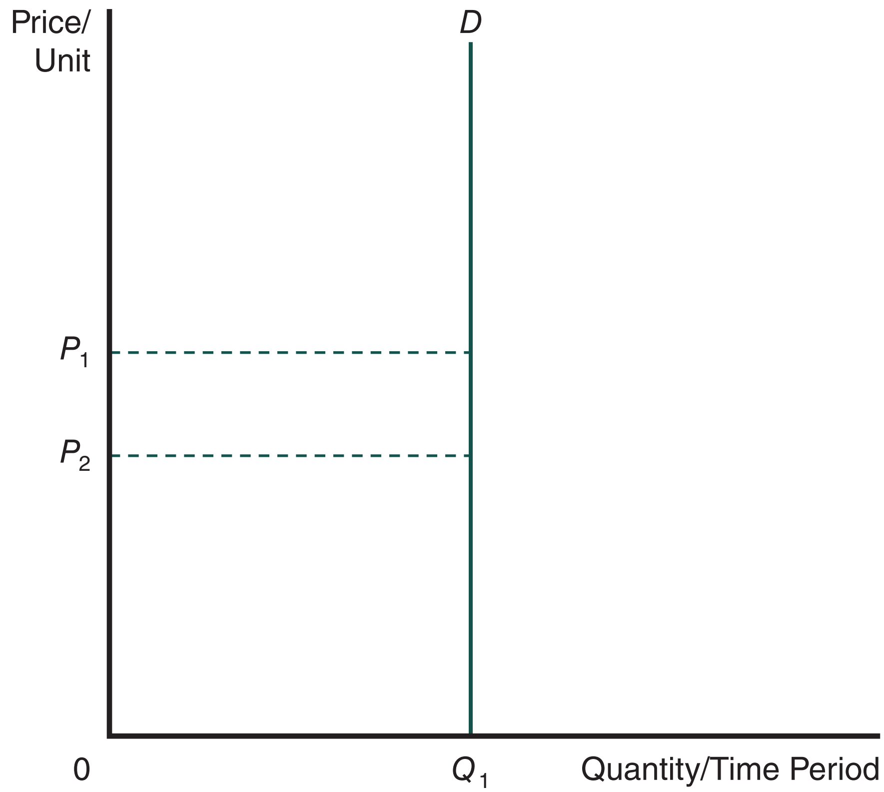
Most straight-line demand curves look like those illustrated in Figure 4.1. Demand curve $D_1$ has a range of elasticity coefficients from infinity (at the intersection with the vertical axis) to zero (at the intersection with the horizontal axis). No two points on a straight line demand curve have the same elasticity coefficient. When the coefficient is less than 1, demand is said to be *inelastic*; the percent change in quantity demanded is less than the percent change in price. When the coefficient is greater than 1, the quantity demanded changes relatively more than the price and the demand is thus described as *elastic*. Of course, there are degrees of responsiveness. The larger the coefficient, the greater the responsiveness.

With most demand curves, the elasticity coefficient varies along the curve. However, some demand curves have a constant price elasticity of demand. We will examine three special cases.

Figure 4.2 shows a vertical demand curve. With this curve, quantity demanded is totally unresponsive to changes in price. As price changes from $P_1$ to $P_2$, there is no change in the quantity demanded. The elasticity coefficient is

$$E_d = \frac{\Delta Q^d / Q_1}{\Delta P / P_1} = 0$$

## Figure 4.2: Perfectly inelastic demand curve

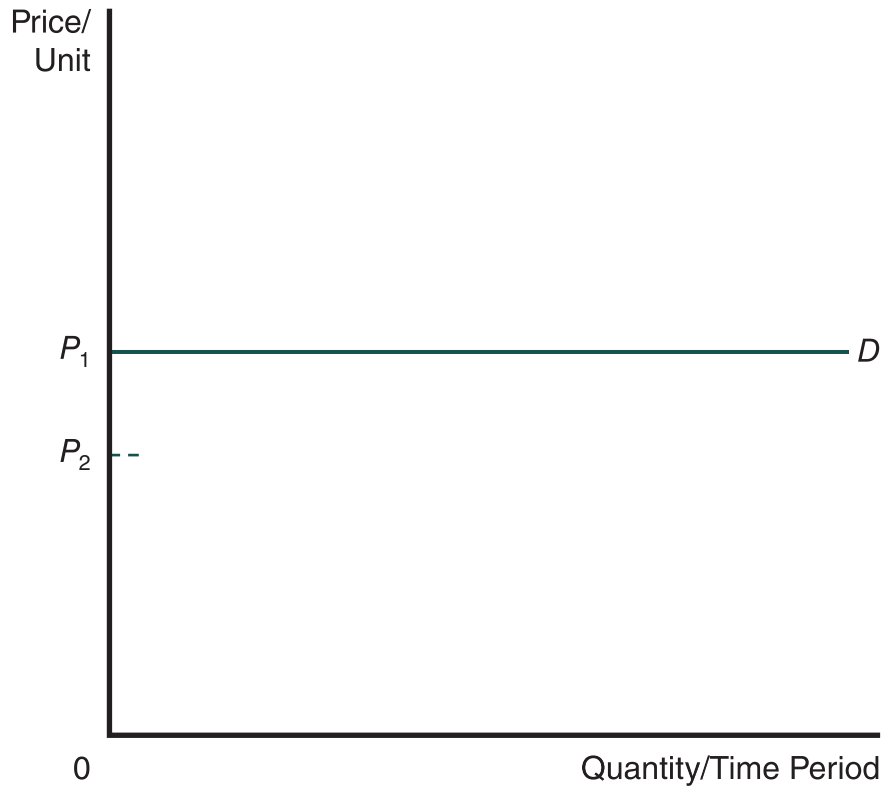



**On a perfectly inelastic demand curve, such as *D*, the quantity demanded has no responsiveness to changes in price.**

This vertical demand curve is a limiting case that violates the law of demand and is not known to exist in the real world. This curve is called a perfectly inelastic demand curve. **Perfectly inelastic demand** occurs when the coefficient of price elasticity of demand is zero. There is no response of quantity demanded to changes in price. To illustrate this, consider the plight of a person who is wandering lost in the desert, slowly succumbing to thirst. If that person should arrive at an oasis and find water for sale, they will be willing to pay any price for a drink. An increase in price will not have any effect whatsoever on the quantity demanded. Similarly, the parents of a sick child whose survival depends on a life saving drug will not be deterred by a price increase.

Another limiting case is a horizontal demand curve, as shown in Figure 4.3. When price drops below $P_1$ an infinite increase in quantity of the good is demanded.

## Figure 4.3: Perfectly elastic demand curve




**On a perfectly elastic demand curve, such as *D*, the quantity demanded has an infinite response to changes in price. If price rises above $P_1$, no amount of the good will be purchased. If price falls to $P_2$, all that is available will be purchased.**

If the price rises above $P_1$, quantity demanded drops to zero. Calculating the elasticity coefficient for a price change from $P_1$ to $P_2$ yields

$$E_d = \frac{\Delta Q^d / Q_1}{\Delta P / P_1} = \infty$$

A farmer who is selling produce into an established commodity market may encounter a horizontal demand curve. If the farmer should set an asking price for the crop that is even slightly above the market price, they will find no purchasers for their goods. Conversely, if they should set the price below the market they will immediately be overwhelmed by infinite demand.

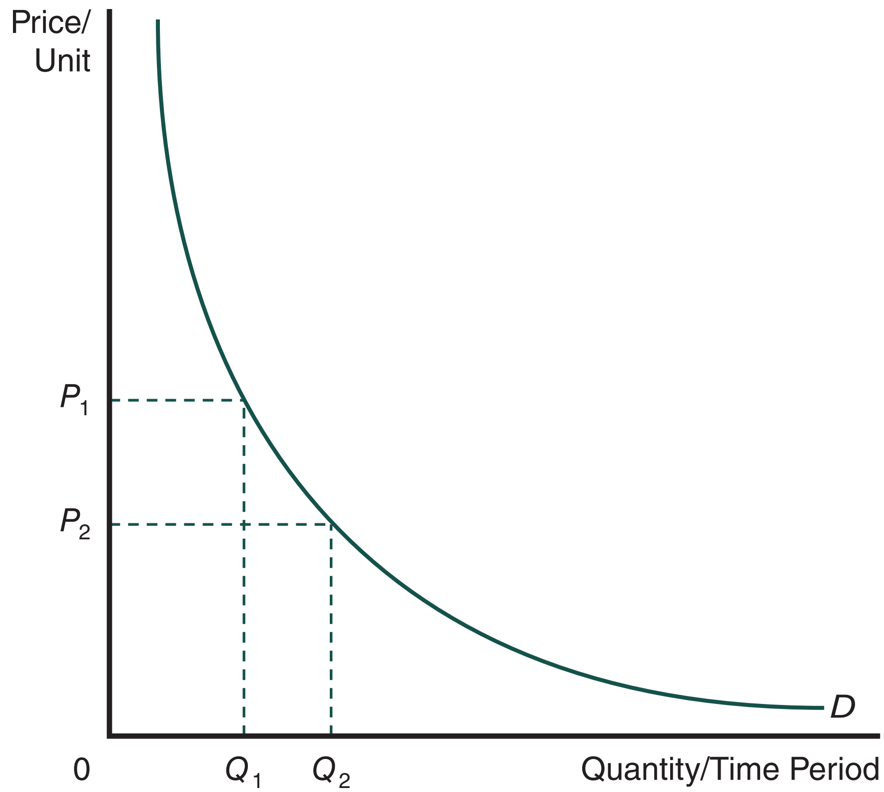
A horizontal demand curve is called a perfectly elastic demand curve because the response to changes in price is infinite. **Perfectly elastic demand** occurs when the coefficient of price elasticity of demand is infinite.

A third kind of demand curve is shown in Figure 4.4. Any percent decrease or increase in price results in the exact same percent increase or decrease in the quantity demanded.

A 15 percent price increase will produce a 15 percent decrease in quantity demanded, and so on. This means that the elasticity coefficient at any point along this demand curve is equal to 1. For example, if you calculated the elasticity coefficient for a price change from $P_1$ to $P_2$, you would find that

$$E_d = \frac{\Delta Q^d / Q_1}{\Delta P / P_1} = 1$$

## Figure 4.4: Unitary elastic demand curve

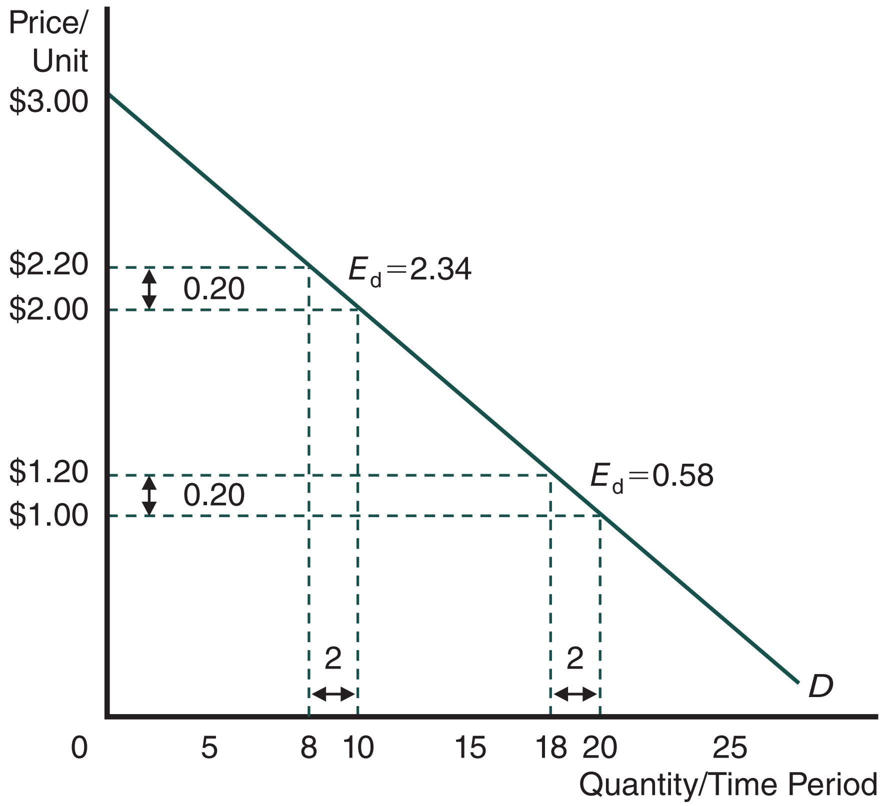



**With a unitary elastic demand curve, a change in price brings about the same percentage change in quantity demanded.**

Such a demand curve is referred to as a unit elastic demand curve. **Unit elastic demand** occurs when the coefficient of price elasticity of demand is unitary (equal to 1).

Most demand curves are not shaped like those in Figures 4.2, 4.3, and 4.4. Most straight-line demand curves look like the one in Figure 4.5. Demand curve *D* has a range of elasticity coefficients from infinity (at the intersection with the vertical axis) to zero (at the intersection with the horizontal axis). When the coefficient is less than 1, demand is inelastic because the percent change in quantity demanded is less than the percent change in price. When the coefficient is greater than 1, demand is elastic because the quantity demanded changes relatively more than the price. Of course, there are degrees of responsiveness. The larger the coefficient, the greater the responsiveness.

## Figure 4.5: Straight-line demand curve with varying elasticity coefficients




**A straight-line demand curve has elasticity coefficients that vary from zero at the horizontal-axis intercept to infinity at the vertical-axis intercept.**

### Check Point: A Guide to Elasticity Coefficient

| Type of elasticity | Responsiveness of quantity demanded to a change in price | Elasticity coefficient |
|---|---|---|
| Perfectly inelastic | No response | $E_d = 0$ |
| Inelastic | Quantity demanded changes by a smaller percentage than the price changes | $0 < E_d < 1$ |
| Unit elastic | Quantity demanded changes by the same percentage as the price changes. | $E_d = 1$ |
| Elastic | Quantity demanded changes by a larger percentage than the price changes. | $1 < E_d < \infty$ |
| Perfectly elastic | Quantity demanded becomes infinite, or all that is available is demanded. | $E_d = \infty$ |

## 4.4 Calculating Elasticity

The best way to understand elasticity is to calculate and interpret some elasticity coefficients. Before we do this, we need to clarify two points. Remember that elasticity varies along a demand curve and that no two points have the same coefficient. There are two methods to calculate an elasticity coefficient; elasticity can be calculated at a single point or between two points. The elasticity between two points is the value of the coefficient at the midpoint between the points. In other words, the average of the two. This value is called **arc elasticity**. For the purpose of this discussion we will compute values of arc elasticities which require only arithmetic to calculate particular coefficients.

Many economists use a different, but related, measure called **point elasticity**, which uses calculus to evaluate the responsiveness of quantity demanded to price at a particular point on a demand curve. Basically, the elasticity is measured at a point by assuming tiny changes in price and quantity demanded.

The second important point is that the formula for an elasticity coefficient will always produce a negative number because demand curves are negatively sloped. That is, they slope downward to the right. In practice, economists ignore the minus signs on coefficients of price elasticity of demand. An $E_d$ value of $-5$ is considered to be larger than an $E_d$ value of $-4$, for example. That is, these coefficients are treated as absolute values. It will be important later when considering other measures of elasticity to keep track of their signs, but the sign is not important for price elasticity of demand. Some economists put a negative sign in front of the formula to change the sign of the calculated coefficient.

### The Midpoint Method

The demand schedule of Table 4.1 can be used to calculate some coefficients of price elasticity of demand. Again, the formula is

$$E_d = \frac{\text{Percent change in quantity demanded}}{\text{Percent change in price}}$$

**Table 4.1: Demand curve schedule for straight-line demand curve in Figure 4.5**

| Price | Quantity demanded |
|---|---|
| $0.50 | 25 |
| 1.00 | 20 |
| 1.20 | 18 |
| 1.40 | 16 |
| 1.60 | 14 |
| 1.80 | 12 |
| 2.00 | 10 |
| 2.20 | 8 |

*(continued)*

| Table 4.1: Demand curve schedule for straight-line demand curve in Figure 4.5 *(continued)* | |
|---|---|
| **Price** | **Quantity demanded** |
| 2.40 | 6 |
| 2.60 | 4 |
| 2.80 | 2 |
| 3.00 | 0 |

Since we are calculating arc elasticity, we use averages. The reason averages are used to calculate elasticity can be illustrated using two points from the demand schedule in Table 4.1. First, consider the elasticity of a price increase as we move along the demand curve from Point *A* ($.50) to Point *B* ($1.00):

| | *A* | *B* | % change |
|---|---|---|---|
| Price | $.50 | $1.00 | 100% |
| Quantity demanded | 25 | 20 | 80% |

Using the formula

$$E_d = \frac{\text{Percent change in quantity demanded}}{\text{Percent change in price}}$$

$$E_d = 80/100 = .80$$

Now consider the same two points, but use Point *B* as the starting point, and observe a price decrease (from $1.00 to $.50):

| | *B* | *A* | % change |
|---|---|---|---|
| Price | $1.00 | $.50 | 50% |
| Quantity demanded | 20 | 25 | 125% |

Now when we use the same formula and the same two points we get the following result:

$$E_d = 125/50 = 2.5$$

As you can see, if, instead of average values, we used the beginning or ending price and quantity as the bases, the formula would produce different elasticity measures between the same two points. By using averages we don't have to distinguish between price increases and decreases.

To build these averages into our formula, we divide both the sum of the beginning price and the ending price and the sum of the beginning quantity and the ending quantity by two.

For our purposes, this expression can be written as

$$E_d = \frac{\dfrac{\Delta Q}{\dfrac{Q_1 + Q_2}{2}}}{\dfrac{\Delta P}{\dfrac{P_1 + P_2}{2}}}$$

Since we are calculating arc elasticity, we use averages. That is, we divide both the sum of the beginning price and the ending price and the sum of the beginning quantity and the ending quantity by two. This is called the **midpoint method**.

We can now compute the elasticity coefficients for two different price changes on the demand curve in Figure 4.5. First, the elasticity coefficient for the increase in price from \$1.00 to \$1.20:

$$E_d = \frac{\dfrac{20 - 18}{\dfrac{20 + 18}{2}}}{\dfrac{\$1.00 - \$1.20}{\dfrac{\$1.00 + \$1.20}{2}}} = \frac{\dfrac{2}{19}}{\dfrac{-.20}{\$1.10}} = \frac{0.105}{-0.182} = 0.58$$

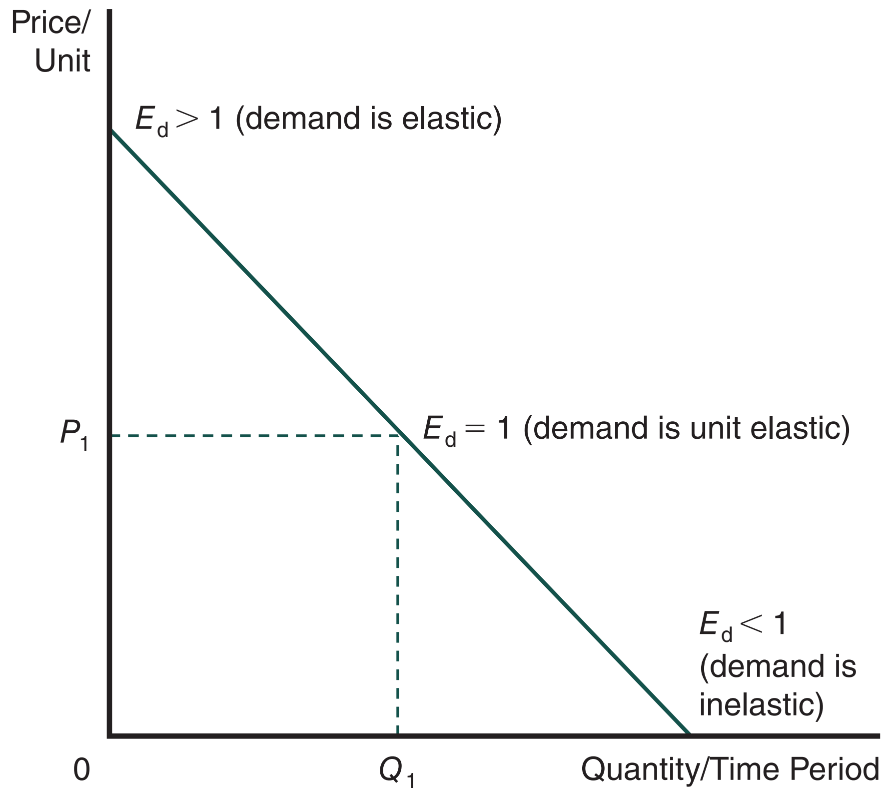
Recall that economists ignore the sign (whether positive or negative) and just look at the absolute value of price elasticities of demand.

Now for the elasticity coefficient for the increase in price from \$2.00 to \$2.20:

$$E_d = \frac{\dfrac{10 - 8}{\dfrac{10 + 8}{2}}}{\dfrac{\$2.00 - \$2.20}{\dfrac{\$2.00 + \$2.20}{2}}} = \frac{\dfrac{2}{9}}{\dfrac{-.20}{\$2.10}} = \frac{0.222}{-0.095} = 2.34$$

Note that the elasticity varies along this demand curve, which has a constant slope. In fact, all linear demand curves, except those that are vertical or horizontal, have elasticity coefficients that range from zero through infinity. On a demand curve such as the one shown in Figure 4.6, all points above price $P_1$ (which corresponds to the midpoint on a straight-line demand curve) have an elasticity coefficient greater than 1. At those points, demand is elastic. At price $P_1$ the elasticity coefficient is equal to 1. At that point, demand is unit elastic. All points below $P_1$ have an elasticity coefficient less than 1. In this region, demand is inelastic.

## Figure 4.6: The unit elastic price and the demand curve




**The point on the demand curve where $E_d = 1$ represents the unit elastic price ($P_1$) and divides the curve into two regions. At all prices above the unit elastic price, demand is elastic. At all prices below the unit elastic price, demand is inelastic.**

The price elasticity of demand depends not only on the slope of the linear curve, but in addition, the size of quantity and price. Because the demand is a straight line, the demand curve in Figure 4.6 has a constant slope. However, the elasticity coefficients vary along this straight-line demand curve. The elasticity changes as we move along the curve. At the top of the curve price is high and quantity demanded is low. As a result, the elasticity coefficient will be high. As we move along the curve, price falls and quantity demanded increases; the coefficient therefore decreases as we move down the curve. Yet many students confuse the two. This confusion comes from the fact that economists sometimes use imprecise language. They often compare curves as to their elasticity, referring to one curve as being more inelastic than another. Be careful! All linear curves have portions that are elastic and portions that are inelastic, but some are more elastic at each price (or quantity) than others.

## 4.5 Factors Affecting Price Elasticity of Demand

It is impossible to predict what will determine the price elasticity of demand in every situation; no two buyers in a market are identical in terms of wants, resources, tastes, and such. Each purchase decision is based on a unique set of considerations. Nevertheless, economists recognize a number of factors that shape price elasticity of demand. One is the availability of acceptable substitute goods that consumers may decide to purchase instead in response to a price increase. Time is also a factor; effects will vary according to how long consumers have to adjust their buying behavior. The size of a purchase as a function of the consumer's income, and the extent to which a good is perceived to be a luxury or a necessity, may also impact price elasticity of demand.

**Economics in Action:** The Value of Things

Dr. Mary J. McGlasson gauges consumers' reactions over price changes for cigarettes and airline tickets. The customers' reactions are critical in determining the elasticity of demand. Learn more by watching the video at http://www.youtube.com/watch?v=4oj_lnj6pXA.

### Elasticity and Substitutability

An important factor in determining price elasticity of demand is the number of substitutes a good or service has. If a product, such as table salt, has relatively few substitutes, it will tend to have a relatively inelastic demand. This is just another way of saying that the quantity demanded of a good like table salt isn't very responsive to changes in price, over a wide range of prices. Conversely, the greater the number of substitutes available, the greater the price elasticity of demand will be. The elasticity of demand for a broad category of goods will be lower than that for a specific good. For example, the elasticity of demand for soft drinks in general will be lower than the elasticity of demand for Coca-Cola. Consumers also tend to be less price sensitive when it comes to goods that they consume habitually. Established buying patterns tend to mitigate elasticity.

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**Table salt is a product that has relatively few substitutes. The quantity demanded of a good isn't very responsive to changes in price over a wide range of prices.**

The brand loyalty that a product engenders will also influence price elasticity of demand. When a strong brand loyalty has been established, consumers may be willing to tolerate price increases to retain the benefits they enjoy; thus, demand will be relatively inelastic. On the other hand, demand for a product that has little or no brand loyalty is likely to be comparatively elastic; an increase in price would lead to a reduction in quantity demanded as buyers switch to available substitutes. If a clothing retailer raised prices of all their merchandise by an equal percentage, they might experience a minimal effect on the sales of Levi's jeans, while the same price increase might have a significant negative impact on the quantity demanded of no-name jeans.

Sometimes there is a cost associated with switching between products. A cell phone service contract may include a penalty for early termination, or sometimes switching a cell phone requires buying all new accessories. The additional cost tends to make demand relatively inelastic.

## Time

Another determinant of the elasticity of demand is time. The longer the period of time consumers have to adjust, the more elastic the demand becomes. The reason for this is that a longer time period allows more opportunities to modify behavior and substitute different products. A good example is the elasticity of demand for natural gas. In the short run, the demand is likely to be very inelastic. Over time, however, if industry and homes were to convert to other sources of energy, the elasticity would increase. Similarly, an increase in the price of meat might have little effect on the grocery buying habits of households in the short run. If, however, the price remained at the higher level, consumers might, over time, change their dietary intake to include more fish and poultry.

In some markets there are periods when demand is higher than at others. Hotels typically have different room rates for peak months and off season. Many resorts are able to command special—high—rates for a reservation on holidays such as New Year's Eve. In general, demand tends to be more price inelastic at peak times, and more elastic at off-peak times. Table 4.2 lists estimated elasticities for some commonly purchased items in the range of their typical prices.

**Table 4.2: Some estimated elasticities**

| Item | $E_d$ |
|---|---|
| Salt | 0.1 |
| Coffee | 0.25 |
| Medical services | 0.6 |
| Private education | 1.1 |
| Airline travel | 2.4 |
| Fresh tomatoes | 4.6 |

*Anderson, P. L., McLellan R. D., Overton, J.P., & Wolfram, G.L. (1997).* Price elasticity of demand. *Retrieved from Makinac Center for Public Policy website:* http://www.mackinac.org/article.aspx?ID=1247

## Price Elasticity of Demand and Total Revenue

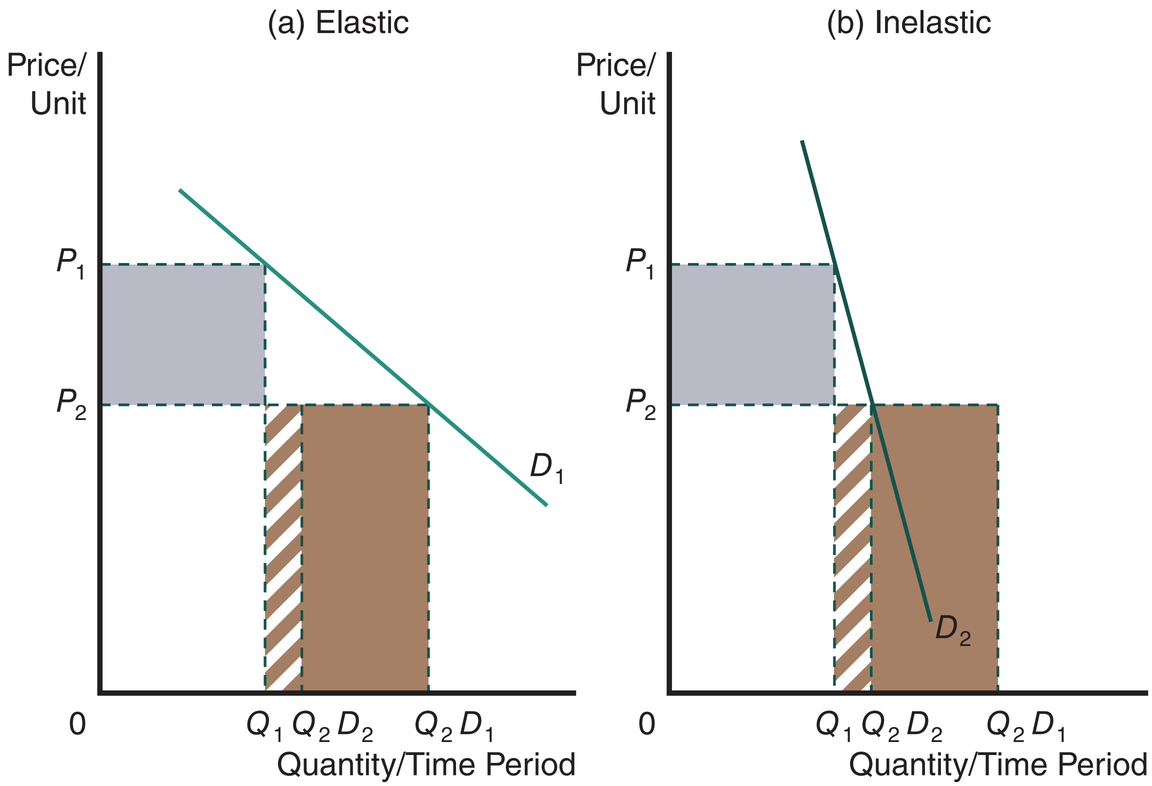
Demand curves illustrate price and quantity relationships. Quantity, or the number of items sold, multiplied by price equals the **total revenue** generated. The relationship between total revenue and price elasticity of demand explains how firms set and change prices. This relationship was first considered by French mathematician and economist Antoine Augustin Cournot (1801–1877). He wondered what the owner of a hypothetical mineral spring should charge for the spring's water, which was desired for its healing powers. Cournot made three assumptions: that the spring cost nothing to operate, that it produced an unlimited quantity of output, and that the owner wanted as much income as possible.

To determine the correct price, Cournot first recognized that a price change has two (opposite) effects on total revenue. The first effect is that a price decrease, by itself, will decrease total revenue. The other effect is that a price decrease causes quantity demanded to increase, thus increasing total revenue. The net effect of these two changes on total revenue depends on whether the relative price decrease exceeds the relative increase in quantity demanded, or vice versa. This is exactly the information that the price elasticity of demand provides.

For a concrete application of this principle, look again at Figure 4.5 and Table 4.1. At a price of $2.00, quantity demanded is 10 units, thus the total revenue (*TR*) is $20.00. An increase in price from $2.00 to $2.20 causes quantity demanded to decline to 8 units and *TR* to fall from $20.00 to $17.60. *TR* drops because the 10% increase in price caused an even greater percent decrease—20%—in quantity demanded. The elasticity coefficient at that point was greater than 1. Conversely, if the price rises from $1.00 to $1.20, *TR* increases from $20.00 to $21.60 because the 20% increase in price is greater than the 10% decrease in quantity demanded. The elasticity coefficient at that point is less than 1.

Figure 4.7 illustrates the same principle. On both demand curves, the price falls from $P_1$ to $P_2$ and quantity demanded increases from $Q_1$ to $Q_2$. This price change causes the total revenue to change. Some revenue is lost as a result of the price decrease while some revenue is gained because of increased sales. Total revenue at the initial price is equal to the area of the rectangle with sides at $P_1$ and $Q_1$ and at the ending price equal to the rectangle with sides at $P_2$ and $Q_2$. The blue area represents revenue that has been lost as the price fell. The bronze area represents revenue that has been gained by additional sales. While in the more inelastic region of a demand curve, a decrease in price brings about a decrease in total revenue. While in the more elastic region of a demand curve, a decrease in price brings about an increase in total revenue.

## Figure 4.7: Changes in total revenue




**Equal price changes bring about different changes in total revenue, depending on the elasticity of the demand curve. If the demand curve is relatively inelastic, a decrease in price will bring about a decrease in total revenue. If the demand curve is relatively elastic, the same decrease in price will bring about an increase in total revenue.**

In other words, you can determine what will happen to total revenue when price changes if you know the elasticity of demand. While a reduction in price will always cause an increase in quantity demanded, total revenue will decrease with inelastic demand and increase with relatively elastic demand. Similarly, a rise in price will cause total revenue to fall when demand is relatively elastic and to rise when demand is relatively inelastic.

The answer to Cournot's question is that the owner of the mineral spring should not try to charge the highest possible price or to sell the largest possible amount. The owner should set the price where the elasticity coefficient is 1. To see why, imagine that the price is where the elasticity coefficient is 0.5. Demand is inelastic. If the owner raises the price, quantity demanded will decrease, but by only half the rate of the price increase. Therefore, total revenue will rise. On the other hand, if the elasticity coefficient is 2 (or demand is elastic), the owner should decrease the price. If the price is lowered, the quantity demanded increases at twice the rate of the price. The owner will maximize total revenue when the demand coefficient is 1, or demand is unit elastic. So the mineral spring owner should set the price at $P_1$ in Figure 4.6. At price $P_1$, the area $P_1 \times Q_1$ represents maximum possible total revenue.

A good example of the importance of elasticity of demand in setting prices occurred in the U.S. airline industry. The airline industry had historically opposed deregulation in the belief that the demand for air travel was inelastic. They reasoned that increased competition would result in lower fares. When deregulation did occur, the revenues of the airline companies increased dramatically despite the lower fares. The experience indicated that the demand for air travel was in fact relatively elastic, or at least much more elastic than the airlines had thought. The airlines had set their prices based on incorrect estimates of the elasticity of demand. Now every summer the airlines run deep discounts to attract family travel, which has an elastic demand.

Perhaps the best example of the effect of price elasticity on total revenue is that of Henry Ford's Model T. When Ford began his business, automobiles were a curiosity for the rich. Ford's strategy was to make autos for the average person through mass production—but he had to sell them. He found that by reducing prices, he sold more autos and increased profits. In the process, Ford Motor Company revolutionized production. In the early years of the Model T, Henry Ford said, "Every time I reduce the charge for our car by one dollar, I get a thousand new buyers" (Folsom, n.d.).

**Check Point:** Elasticity and Total Revenue

| Change in price | Change in quantity demanded | Coefficient of elasticity | Change in total revenue |
|---|---|---|---|
| Increase | Decrease | $E_d > 1$ elastic | Decrease |
| Increase | Decrease | $E_d = 1$ unit elastic | Unchanged |
| Increase | Decrease | $E_d < 1$ inelastic | Increase |
| Decrease | Increase | $E_d > 1$ elastic | Increase |
| Decrease | Increase | $E_d = 1$ unit elastic | Unchanged |
| Decrease | Increase | $E_d < 1$ inelastic | Decrease |

## *4.6* Other Demand Elasticities

Price elasticity of demand is not the only microeconomic measure of responsiveness. It is possible to calculate the elasticity of almost anything because what an elasticity coefficient measures is the responsiveness of one measurable quantity to another. Two other demand elasticities are quite common in economics.

### Income Elasticity of Demand

The first of these other concepts is the **income elasticity of demand**. This measures the way in which demand responds to changes in income, assuming all other things, including price, are held constant. The formula is expressed as

$$E_I = \frac{\text{Percent change in quantity demanded}}{\text{Percent change in income}}$$

or

$$E_I = \frac{\%\Delta Q_d}{\%\Delta I}$$

Unlike the price elasticity of demand, the sign of the coefficient of the income elasticity of demand is important. If the sign is positive, the good is a normal good. If the sign is negative, indicating a negative relationship between income and demand, the good is said to be an inferior good.

For normal goods, if $E_I > 1$, demand for the good is income elastic. If $E_I < 1$, demand for the good is income inelastic. Goods that have high and positive income elasticities are classified as luxury goods. In fact, the concept of income elasticity of demand is used as a definition of what a luxury good is. Necessities, such as food, have a low (but positive) income elasticity. Luxuries, such as sports cars and foreign travel, have a high income elasticity.

Income elasticity is useful to producers in forecasting sales. If producers can forecast changes in consumer income and know the income elasticity of demand for their product, they can estimate how much more to produce. This planning is one of the reasons why firms are interested in economic forecasts.

## Cross Elasticity of Demand

The other common demand elasticity concept is the **cross elasticity of demand**. Cross elasticity measures the responsiveness of changes in demand of one good to changes in the price of another. The formula for the coefficient of the cross elasticity of demand is

$$E_{AB} = \frac{\text{Percent change in quantity demanded of good A}}{\text{Percent change in price of good B}}$$

$$E_{AB} = \frac{\%\Delta Q_A^d}{\%\Delta P_B}$$

Two goods that are completely unrelated (independent of one another) have a zero cross elasticity of demand. If the cross elasticity is equal to anything but zero, the two goods are related. They are either complements or substitutes. If the sign of the coefficient is negative, the relationship is an inverse one. An increase in the price of good *B* will bring about a decrease in the demand of good *A*. A negative cross elasticity coefficient thus indicates that good *A* and good *B* are complements. Complements are goods that are used together, such as coffee and cream or pens and paper. A positive cross elasticity coefficient indicates a substitute relationship between good *A* and good *B*. An increase in the price of good *B* will lead to an increase in the demand for good *A*. Substitute goods can be used in place of each other. Examples are coffee and tea, and beef and chicken. The size of the coefficient tells how strong the complementary or substitute relationship is between the two goods.

As we will see in later chapters, cross elasticity is useful in defining markets and industries because it is a measure of how closely goods are related.

### Global Outlook: Income Elasticity of Demand for Consumer Goods

Although China experienced rapid economic growth prior to the global financial crisis of 2007-2009, it has recovered slowly in subsequent years. This has led China to focus its efforts on expanding domestic demand, primarily in rural areas. Because income is the main factor influencing consumption, the level of income will determine the likelihood and size of future economic growth. Income elasticity highlights the relationship between income and consumer demand and is therefore an important component in any attempt to stimulate consumption.

Research by Luo and Song (2012) has shown that from 2003 to 2008 the total income elasticity of consumer demand of China's rural residents is higher than 1, meaning that the overall growth rate of consumer demand of rural residents is faster than the growth rate of income. Looking more closely, the income elasticity of consumer demand for goods like clothes, household equipment, and transportation is obviously greater than 1, indicating that the growth rate of consumer demand for those kinds of goods is faster than the growth rate of income. However, the income elasticity of consumer demand for food is slightly less than l, meaning that the growth in demand for food is slightly less than the income growth rate.

What does this all mean for future economic growth in China? An income elasticity greater than 1 indicates that for a given percentage change in income, we would expect to see an even greater percentage change in consumer demand. If China chose to adjust its income distribution to increase the incomes of its rural residents, which account for more than half of its population, this could increase consumption and effectively stimulate domestic demand.

## 4.7 Price Elasticity of Supply

The concept of elasticity of demand is also applicable to supply schedules and supply curves. **Price elasticity of supply** is the measure of the responsiveness of the quantity supplied to changes in the price. The **coefficient of price elasticity of supply ($E_s$)** is the numerical measure of price elasticity of supply. The equation for the coefficient of price elasticity of supply is

$$E_s = \frac{\text{Percent change in quantity supplied}}{\text{Percent change in price}}$$

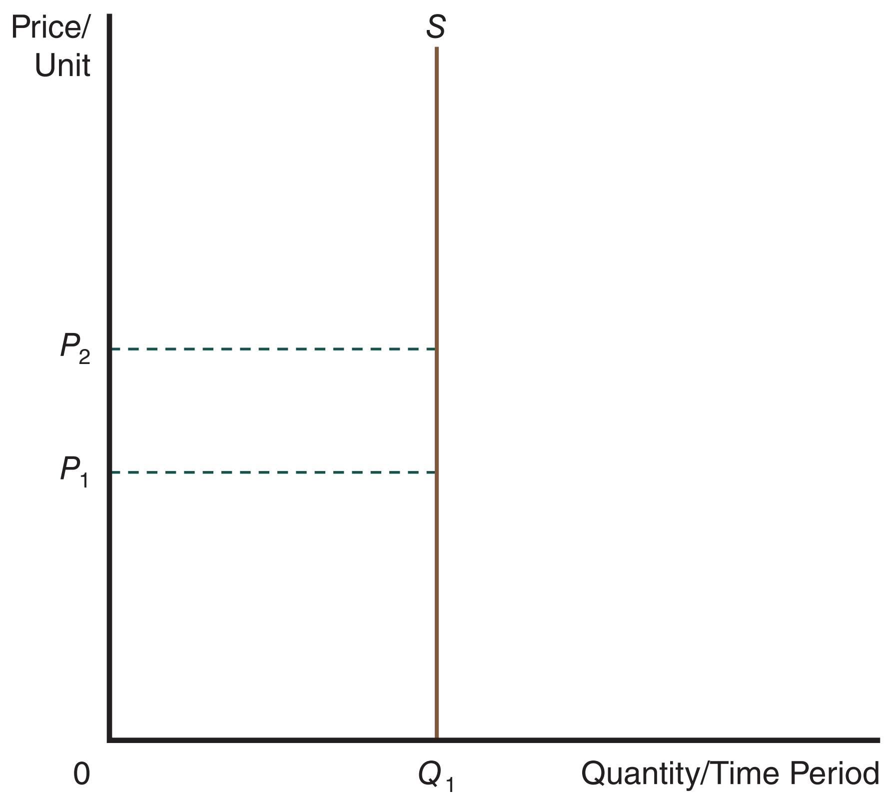
Or, in a more workable form:

$$E_s = \frac{\Delta Q^s / Q^s}{\Delta P / P}$$

As with the price elasticity of demand, when $E_s = 1$, supply is unit elastic. If $E_s > 1$, supply is elastic. If $E_s < 1$, supply is inelastic. The analogy to price elasticity of demand stops there. The coefficient of price elasticity of supply is usually positive because supply curves normally have positive slopes. Since supply curves are positively sloped, the relationship between elasticity and total revenue established for price elasticity of demand doesn't hold. Higher prices result in higher total revenue, regardless of whether supply is elastic or inelastic.

Special cases of supply curves are classified as perfectly inelastic, unit elastic, or perfectly elastic. With the vertical supply curve in Figure 4.8, the quantity supplied is totally unresponsive to changes in price. It is perfectly inelastic. Examples of perfectly inelastic supply curves are rare. In the short run, however, it is often impossible to produce more of a good regardless of what happens to price. This inability to produce more will affect the supply curve, which shows the amount producers are willing to supply at various prices. Consider the supply of Rembrandt paintings, for example, or of Rose Bowl tickets. A rise in the price of Rembrandt paintings (even in the long run) or Rose Bowl tickets (in the short run) does not cause the quantity supplied to increase. These supply curves are perfectly inelastic.

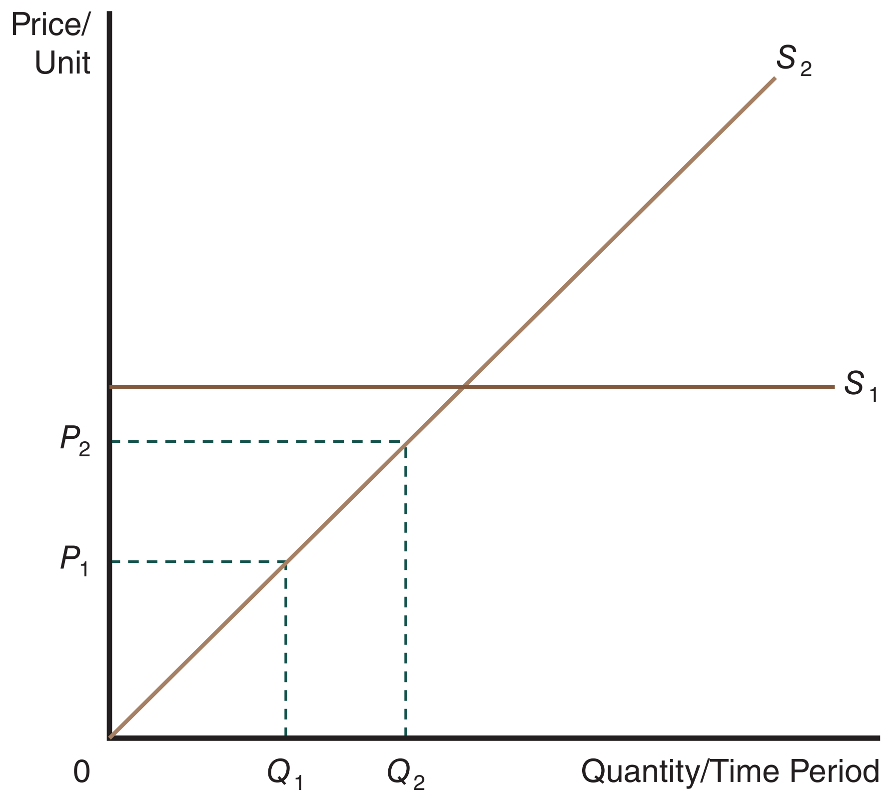
## Figure 4.8: Perfectly inelastic supply curve




**A perfectly inelastic supply curve is a vertical line. It would exist if suppliers offered a fixed amount of a good, regardless of any changes in its price.**

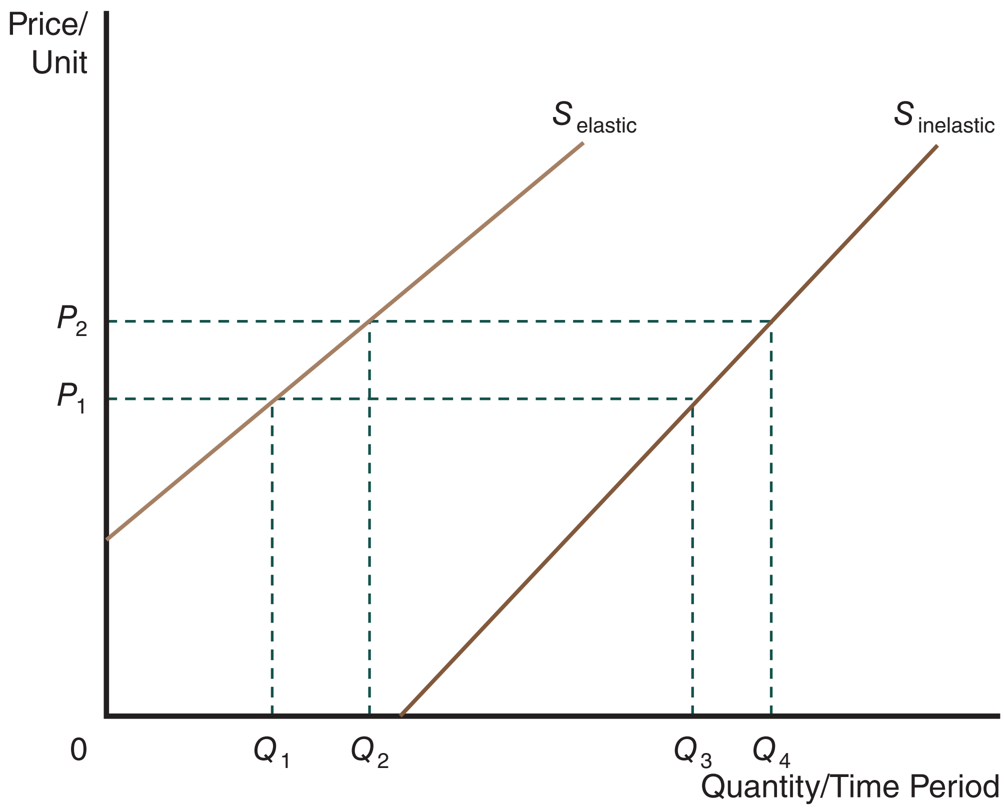
Figure 4.9 shows both a perfectly elastic supply curve and a unit elastic supply curve. $S_1$, a horizontal line, is a perfectly elastic supply curve. Any straight-line supply curve that is drawn through the origin, as is $S_2$ in Figure 4.9, is unit elastic over its entire range. Along such a curve, the percent changes of the two variables will always be equal to each other. Other linear supply curves are elastic at every price if they intersect the price (vertical) axis above the origin and inelastic at every price if they intersect the quantity (horizontal) axis to the right of the origin. This is true even though elasticity changes along both curves. Examples are shown in Figure 4.10.

## Figure 4.9: Unit elastic supply curve and perfectly elastic supply curve




**A perfectly elastic supply curve ($S_1$) is a horizontal line. With such a curve, a change in price produces an infinite response in the quantity supplied. A straight-line supply curve drawn through the origin ($S_2$) has a unitary coefficient of elasticity along the entire curve.**

## Figure 4.10: Inelastic and elastic supply curves




**A straight-line supply curve that intersects the price (vertical) axis will be elastic over its entire length. A straight-line supply curve that intersects the quantity (horizontal) axis will be inelastic over its entire length.**

## Resource Availability and Time

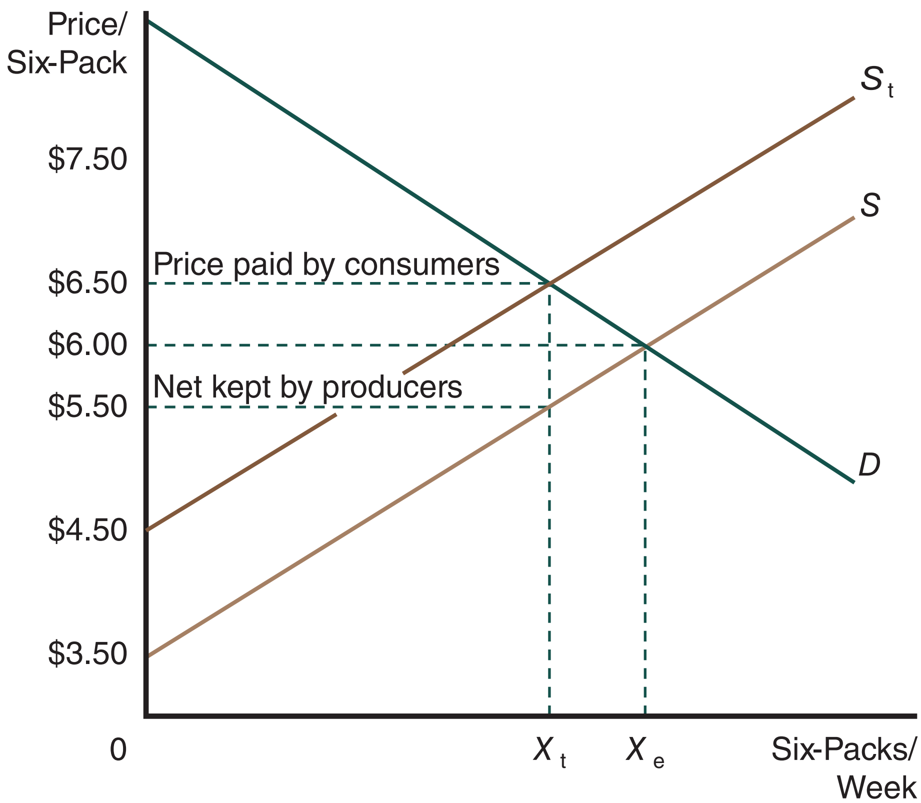
Elasticity of supply is the measure of responsiveness of quantity supplied to changes in price. The major factor affecting this responsiveness is the availability of resources that can be attracted away from other uses. Another factor is the time period under consideration. As the time period increases, the possibility of obtaining new and different inputs to increase the supply increases. For the two earlier examples of fixed supply, you will recognize that in the long run the stadium could be expanded and the quantity of Rose Bowl tickets increased. These two factors—availability of inputs and time—affect elasticity of supply. Normally the elasticity of supply coefficient becomes larger with time and is larger for products that use relatively unspecialized or abundant inputs.

## 4.8 Who Pays the Excise Tax—An Exercise in the Elasticity of Supply and Demand

Debates over tax policy can be quite confusing. Consumers are often convinced that they ultimately pay all taxes, yet business firms often fight hard to prevent tax increases on their products. If consumers pay all taxes, why should a business firm care if its product is taxed or not? The answer is not simple. The correct answer to the question of who ultimately pays such a tax is, "It depends on supply and demand in the relevant market." This problem is an exercise that involves elasticity of both supply and demand.

An **excise tax** is a tax on the purchase of a particular good, such as liquor, cigarettes, or electricity, or a broad class of goods, such as food. Let's look at an example with normally sloped supply and demand curves. Figure 4.11 illustrates the effect of an excise tax on the market for beer. Beer is a good example because excise taxes are often placed on items such as alcohol and cigarettes. These taxes are sometimes called "sin taxes."

### Figure 4.11: An excise tax on beer



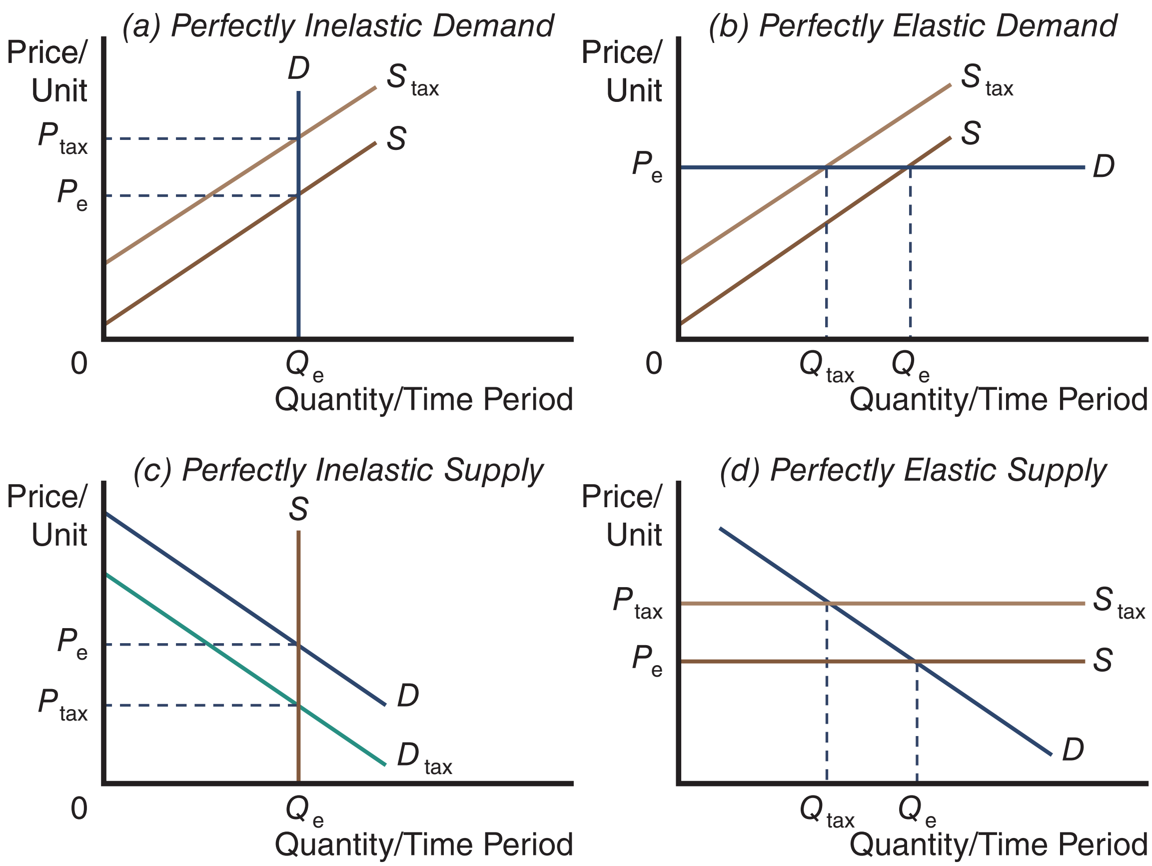

**An excise tax on beer causes its supply curve to shift upward by the amount of the tax (from *S* to $S_t$). Less of the commodity is purchased at the higher price. Part of the tax is borne by consumers, and part of the tax is borne by producers.**

Assume that the market settles on a price of $6.00 per six-pack, with $X_e$ representing the equilibrium quantity of six-packs per week. Now suppose the government places an excise tax of $1.00 per six-pack of beer and collects this tax from producers. The costs of production have been increased by $1.00 per six-pack. The supply curve will shift up by the amount of the tax. One way to view the tax is that the producer must pay $1.00 per six-pack for the permission to produce beer. In terms of Figure 4.11, the supply curve shifts up at all points by $1.00. The post-tax supply curve is $S_t$. The equilibrium price will rise to $6.50 per six-pack, and the new equilibrium quantity is $X_t$.

Note that the new price is less than the sum of the old price and the tax. If the entire tax had been shifted onto consumers, the consumer would end up paying the old price of $6.00 plus the tax of $1.00, or $7.00 per six-pack. It is also clear that the amount of money the producer actually receives has fallen. Before the tax, the producer received $6.00 per six-pack, but now the producer receives $5.50 per six-pack ($6.50 price minus the $1.00 tax). The tax caused prices to rise, which caused the quantity demanded to fall. Because supply is relatively inelastic in this case, beer producers did not pass along the full amount of the tax in order to try to maintain sales. As a result, the producers sell a smaller quantity at a lower price than before. In this example, then, part of the tax was paid by consumers and part was paid by producers. Each paid half of the excise tax.

The amount of a tax paid by consumers or producers depends on the supply and demand elasticities for the goods being taxed. Figure 4.12 shows clearly how the elasticity of supply and the elasticity of demand affect the tax incidence. Tax incidence is the economist's term for who really pays the tax. **Tax incidence** is the place where the burden of a tax actually falls. It identifies those who pay the tax after all shifting has occurred.

## Figure 4.12: Elasticity and tax incidence




**Tax incidence, or where the tax burden falls, depends on the elasticity of demand or supply. (a) With perfectly inelastic demand, the consumer pays the entire tax. (b) With perfectly elastic demand, the producer pays the entire tax. (c) With perfectly inelastic supply, the producer pays the entire tax. (d) With perfectly elastic supply, the consumer pays the entire tax.**

Part (a) of Figure 4.12 shows a normally sloped supply curve and a perfectly inelastic demand curve. When the excise tax is placed on the good, the supply curve facing consumers shifts from $S$ to $S_{tax}$. The result is that price rises from $P_e$ to $P_{tax}$. Price has risen by the full amount of the tax, and the equilibrium quantity is unchanged. In this case, the incidence of the excise tax falls fully on the consumers of this good. The tax has been shifted forward to consumers by the full amount of the tax.

Part (b) of Figure 4.12 shows a normally sloped supply curve and a perfectly elastic demand curve. The post-tax supply curve is again $S_{tax}$. After the tax is imposed, price is unchanged at $P_e$, but the equilibrium quantity has fallen from $Q_e$ to $Q_{tax}$. Since the price to consumers is unchanged, the producer is paying the entire tax. The incidence of the tax falls fully on the suppliers of this good.

The principle demonstrated by the first two parts of Figure 4.12 is clear. The more inelastic the demand for a good, the more any excise tax placed on the good will fall on consumers of that good. Conversely, the more elastic the demand, the more any excise tax placed on the good will fall on the producers.

In order to see the effects of different supply elasticities, it is necessary to refer to another graph. The usual way to represent a tax increase on a graph is by an upward shift in the supply curve. However, we can also represent a tax increase by a downward shift of the demand curve. In the case of perfectly inelastic supply, it is necessary to shift the demand curve because it is impossible to shift the supply curve.

In part (c) of Figure 4.12, $D$ still shows what consumers are willing to pay for various quantities, including the tax. However, $D_{tax}$ is the demand curve as the producer sees it, after the tax has been subtracted. The tax does not affect the quantity, which is determined by the perfectly inelastic supply curve. The industry views the demand curve as the curve with the amount of the tax subtracted from the price. The equilibrium quantity is unchanged by the shift. The price the firm receives falls from $P_e$ to $P_{tax}$. In other words, the entire amount of the tax has been paid by the suppliers of the good.

Part (d) of Figure 4.12 shows a perfectly elastic supply curve. An excise tax shifts the supply curve from $S$ to $S_{tax}$ to account for the higher price at each output. After the shift, the price of the item has increased from $P_e$, to $P_{tax}$, by the exact amount of the tax. In this case, consumers are paying the entire tax. Less is being sold, so some producers may be worse off in that sense. However, consumers are paying more for $Q_{tax}$, and this increased amount is exactly equal to the amount of the tax.

The complete answer to the question of who pays the excise tax should now be clear. The answer is, "It depends on the relative elasticities of supply and demand for the good on which the tax is placed." These elasticities depend on whether substitutes are available and on how consumers choose among competing goods when prices change. The next chapter will develop a theory of consumer choice that explains this process of adjustment.

### **Policy Focus:** Price Elasticity of Demand and Policy Choices—Smoking

For many years, the U.S. government, primarily through the office of the Surgeon General, has pursued a policy of trying to discourage cigarette smoking. Many state and some local governments require public places, such as restaurants, to set up no-smoking sections and prohibit smoking in hospitals, doctors' offices, and public buildings. Most recently, the revenue from taxes on cigarettes has been suggested as a primary source of revenue for expanded national health care.

According to the American Lung Association, "Increasing taxes on cigarettes are a win-win proposition: significantly increasing cigarette taxes results in fewer kids starting to smoke and in more adults quitting, while at the same time providing substantial revenue to the federal government for important health programs." (American Lung Association [ALA], n.d.) In 2009, President Obama signed a re-authorization and expansion of the Children's Health Insurance Program. The program provides health insurance to millions of uninsured children in the U.S., and its expansion extended that insurance to over 4 million additional children, including those with asthma. The expansion was funded by increasing taxes on tobacco products, including raising the federal tax on a pack of cigarettes by $.62, which brought the total federal tax on cigarettes to $1.01 (ALA, n.d.). ***(continued)***

## **Policy Focus:** Price Elasticity of Demand and Policy Choices—Smoking ***(continued)***

What impact did this tax increase have on the number of smokers? According to a study published by the National Bureau of Economic Research, the tax increase had a substantial impact on smoking among 8th, 10th, and 12th grade students. The authors estimated that approximately 220,000 to 287,000 students would have become smokers in May of 2009 if the federal tax had not increased in April 2009 (Huang & Chaloupka, 2012).

How do price elasticities play a role? Prior estimates had pegged the price elasticity of smoking prevalence somewhere between −0.3 and −0.5, meaning that a 10 percent increase in the price of cigarettes would reduce smoking by approximately 3 to 5 percent. The study by Huang and Chaloupka found a larger estimate for the price elasticity of smoking cigarettes, with estimates somewhere between −0.44 and −0.60, meaning that a 10 percent increase in the price of cigarettes would reduce smoking by approximately 4.4 to 6 percent.

It is also important to consider the long-term impact of this tax increase on smoking behavior. As the higher cigarette prices deter more and more children from initiating smoking, over time the long-term health impact of the tax increase will be even more substantial than its short-term impact.

Overall, the 2009 federal tobacco excise tax increased federal government revenues from 7.1 billion to 17.5 billion annually, which amounts to an increase in revenues of about 147 percent, even with the reduction in the number of smokers. The authors of the study conclude by stating that, ". . .a well-designed, across-the-board tobacco tax policy can deliver both economic and health benefits, and has implications for policymakers at all levels when considering effective tobacco control policies to reduce tobacco use among youth" (Huang & Chaloupka, 2012, p. 30).

*Exactostock/SuperStock*

**A tax increase for cigarettes can impact cigarette sales, but can higher costs discourage cigarette smoking?**

## **Check Point:** Incidence of an Excise Tax

- The more inelastic the demand, the more price rises. The tax falls more heavily on consumers.
- The more elastic the demand, the less price rises. The tax falls more heavily on producers.
- The more inelastic the supply, the more the tax is paid by producers.
- The more elastic the supply, the more price rises. The tax is then paid mostly by consumers.

## Summary

**Consider again. . .** How would you price your smartphones? Having read Cournot's solution, you recognize that a price change has two (opposite) effects on total revenue. The first effect is that a price decrease, by itself, will decrease total revenue. The other effect is that a price decrease causes quantity demanded to increase, thus increasing total revenue. The net effect of these two changes on total revenue depends on whether the relative price decrease exceeds the relative increase in quantity demanded, or vice versa. This is exactly the information that the price elasticity of demand provides.

You now know how to be as rich as possible. First, thank the genie. Second, set the price of your smartphones where the elasticity coefficient is 1.

### Key Points

1. Movements along demand and supply curves are in response to a change in price. Shifts in demand and supply curves are in response to changes in ceteris paribus conditions.
2. Elasticity is the measure of the sensitivity or responsiveness of quantity demanded or quantity supplied to changes in price (and to changes in other ceteris paribus conditions).
3. Straight-line demand curves, except for those that are perfectly vertical or horizontal, have points on them that range from elastic to inelastic and one point that is unit elastic.
4. Price elasticity of demand is higher when a good has many substitutes. The more substitutes an item has, the more elastic demand for it will be. Consumers will have more options and respond more readily to changes in price. Elasticity of demand is greater when the time period is longer because consumers have more opportunity to substitute between goods.
5. Total revenue is closely related to elasticity because a demand curve is a price-quantity relationship, and total revenue is price times quantity. When price changes, the quantity demanded changes. This change affects total revenue. The amount of the change in total revenue will depend on the responsiveness of consumers to changes in price, or elasticity.
6. Income elasticity of demand measures the responsiveness of demand to changes in income. Cross elasticity of demand measures the responsiveness of changes in the demand of one good to changes in the price of another good.
7. Price elasticity of supply is the measure of the responsiveness of changes in quantity supplied to changes in price. As time passes, the elasticity of supply increases. The longer the time period, the more chance there is for adjustments to take place.
8. The concepts of supply, demand, and elasticity can be used to determine tax incidence. The more inelastic the demand for a good or service and the more elastic the supply, the greater is the amount of an excise tax on the good or service paid by consumers. The more elastic the demand and the more inelastic the supply, the greater is the amount of the tax paid by producers.

## Key Terms

**arc elasticity** The elasticity at the mid-point between two points on a demand curve.

**coefficient of price elasticity of demand ($E_d$)** The numerical measure of price elasticity of demand, equal to the percent change in quantity demanded of a good divided by the percent change in its price.

**coefficient of price elasticity of supply ($E_s$)** The numerical measure of price elasticity of supply, equal to the percent change in the quantity supplied of a good divided by the percent change in its price.

**cross elasticity of demand** The measure of the responsiveness of changes in the demand for one good to changes in the price of another.

**elasticity** The measure of the sensitivity or responsiveness of quantity demanded or quantity supplied to changes in price (or other factors).

**excise tax** A tax on the purchase of a particular good, such as liquor, cigarettes, or electricity, or a broad class of goods, such as food.

**income elasticity of demand** The measure of the responsiveness of demand to changes in income.

**midpoint method** A way to calculate coefficients of price elasticity of demand using the average value of two points on the demand curve to represent percent change.

**perfectly elastic demand** Demand represented by a horizontal demand curve with a coefficient of price elasticity of demand that is equal to infinity. The quantity demanded is infinitely responsive to a change in price.

**perfectly inelastic demand** Demand represented by a vertical demand curve with a coefficient of price elasticity of demand that is equal to zero. There is no response in quantity demanded to changes in price.

**point elasticity** The elasticity at a particular point on a demand curve.

**price elasticity of demand** The measure of the responsiveness of the quantity demanded to changes in price.

**price elasticity of supply** The measure of the responsiveness of the quantity supplied to changes in the price.

**tax incidence** The place where the burden of a tax actually falls after all shifting has occurred.

**total revenue** The amount of money a firm takes in, equal to the quantity of the good or service sold multiplied by its price.

**unit elastic demand** The situation where the coefficient of price elasticity of demand is unitary (equal to 1).

## Critical Thinking and Discussion Questions

1. How does the price elasticity of demand differ from the slope of the demand curve?
2. Why is it important to use the midpoint method when calculating elasticity?
3. If the price elasticity of demand for good $X$ is 0.3 and the price elasticity of demand for good $Y$ is 3.5, what does that say about the demand for each good?

4. How can elasticity of demand be used to predict a change in total revenue?
5. If the coefficient of the cross elasticity of demand for good *X* and good *Y* is infinite, what kind of goods are *A* and *B*?
6. In Table 2, the price elasticity of salt is 0.1 and the price elasticity of airline travel is 2.4. Why is the demand for salt more inelastic than the demand for airline travel?
7. If the price of good *X* increased from $8.50 to $10.00 and the quantity demanded decreased from 725 to 700, what is the price elasticity of demand?
8. Suppose a Venice surf shop raises the prices of surfboards by 12 percent and the quantity demanded decreases by 8 percent. From this, you know the demand for surfboards from this surf shop is (elastic/inelastic) and the shop's total revenue will (increase/decrease).
9. Would the elasticity of demand for Coke be higher or lower than that for soft drinks in general? Why?
10. If the income elasticity for a particular good is $-0.8$, what type of good is it?
11. If the government wanted to place a tax on a good in order to generate revenue, would it be better to choose a good with elastic demand or inelastic demand?
12. How could a government policy aimed at reducing the number of smokers use the price elasticity of demand for cigarettes to accomplish its goal?
13. Why is the coefficient of the price elasticity of demand higher for those aged twelve to seventeen than for all smokers?
14. Why is public policy aimed at decreasing the quantity of imported oil frustrated by the fact that gasoline is income elastic and price inelastic?
15. If the federal government decided to place a tax on all food items, how would that influence behavior?