chapter 5

Elasticity

section 5.1

Price Elasticity of Demand

- What is price elasticity of demand?
- How do we measure consumers' responses to price changes?
- How do we use the "midpoint method" in calculating price elasticities of demand?
- What determines the price elasticity of demand?

WHAT IS PRICE ELASTICITY OF DEMAND?

In learning and applying the law of demand, we have established the basic fact that quantity demanded changes inversely with changes in price, *ceteris paribus*. But how much does quantity demanded change? The extent to which a change in price impacts quantity demanded may vary considerably from product to product and over the various price ranges for the same product. The **price elasticity of demand** measures the responsiveness of quantity demanded to a change in price. More specifically, price elasticity is defined as the percentage change in quantity demanded divided by the percentage change in price:

price elasticity of demand
a measure of the responsiveness of quantity demanded to a change in price

$$\text{Price elasticity of demand } (E_D) = \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in price}}$$

Note that, following the law of demand, there is an inverse relationship between price and quantity demanded. For this reason, price elasticity of demand is, in theory, always negative. In practice, however, this quantity is always expressed in absolute value terms, as a positive number, for simplicity.

HOW DO WE MEASURE CONSUMERS' RESPONSES TO PRICE CHANGES?

It is important to understand the basic intuition behind elasticities. This can be best understood by initially focusing on the percentage changes in quantity demanded and price.

Think of elasticity as an elastic rubber band. If the quantity demanded is very responsive to even a small change in price, we call it *elastic*. On the other hand, if even a huge change in price results in only a small change in quantity demanded, then the demand is said to be *inelastic*. For example, if a 10 percent increase in the price leads to a 50 percent reduction in the quantity demanded, we say that demand is *elastic* because the quantity demanded is very sensitive to the price change.

$$E_D = \frac{\%\Delta\ Q_D}{\%\Delta\ P} = \frac{50\%}{10\%} = 5$$

Demand is elastic in this case because a 10 percent change in price led to a larger (50 percent) change in quantity demanded.

elastic demand segment
a portion of the demand curve where the percentage change of quantity demanded is greater than the percentage change in price ($E_D > 1$)

Alternatively, if a 10 percent increase in the price leads to a 1 percent reduction in quantity demanded, we say that demand is *inelastic* because the quantity demanded did not respond much to the price reduction.

$$E_D = \frac{\%\Delta\ Q_D}{\%\Delta\ P} = \frac{1\%}{10\%} = 0.10$$

Demand is inelastic in this case because a 10 percent change in price led to a smaller (1 percent) change in quantity demanded.

The Ranges of the Price Elasticity of Demand

Economists refer to a variety of demand curves based on the magnitude of their elasticity. A demand curve or a portion of a demand curve can be elastic, or inelastic, or unit elastic. A demand curve is

Elastic ($E_D > 1$) if Percentage change in $Q_D >$ Percentage change in P

Inelastic ($E_D < 1$) if Percentage change in $Q_D <$ Percentage change in P

Unit elastic ($E_D = 1$) if Percentage change in $Q_D =$ Percentage change in P

If bus fares increase, will ridership fall a little or a lot? It all depends on the price elasticity of demand. If the price elasticity of demand is elastic, a $0.50 price increase will lead to a relatively large reduction in bus travel as riders find viable substitutes. If the price elasticity of demand is inelastic, a $0.50 price increase will lead to a relatively small reduction in bus ridership as riders are not able to find good alternatives to bus transportation.

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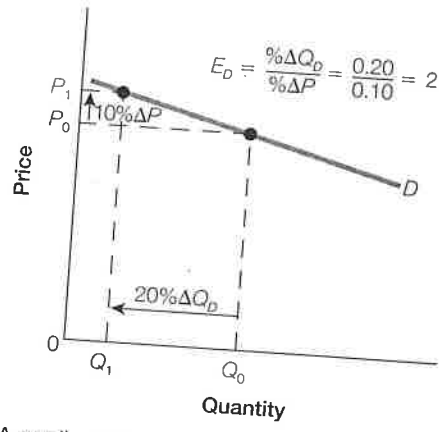
Elastic Demand Segments

An **elastic demand segment** is a portion of the demand curve where the percentage change in quantity demanded is greater than the percentage change in price ($E_D > 1$). In this case, a given percentage increase in price, say 10 percent, leads to a larger percentage change in quantity demanded, say 20 percent, as seen in Exhibit 1(a). If the curve was perfectly elastic, a small percentage increase in price would cause the quantity demanded to fall dramatically to zero. For example, say there were two side-by-side roadside fruit stands selling the same quality of apples. If one stand had lower prices, then the higher-priced fruit stand would soon be selling no apples. In Exhibit 1(b), a perfectly elastic demand curve (horizontal) is illustrated. Economists define the elasticity of demand in this case as infinity, because the quantity demanded is infinitely responsive to even a very small percentage change in price.

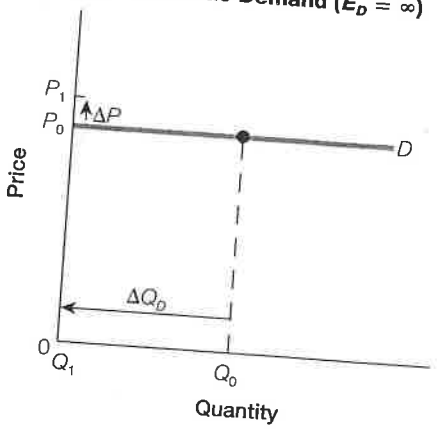
section 5.1 Exhibit 1 **Elastic Demand**

a. Elastic Demand ($E_D > 1$)



A small percentage change in price leads to a larger percentage change in quantity demanded.

b. Perfectly Elastic Demand ($E_D = \infty$)



A small percentage change in price will change quantity demanded by an infinite amount.

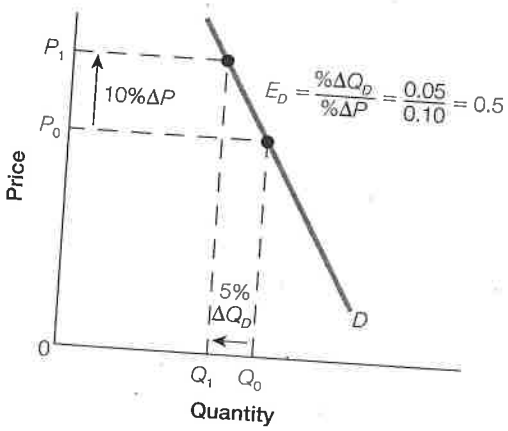
Inelastic Demand Segments

An **inelastic demand segment** is a portion of the demand curve where the percentage change in quantity demanded is less than the percentage change in price ($E_D < 1$). In this case, a given percentage (e.g., 10 percent) change in price is accompanied with a smaller (e.g., 5 percent) reduction in quantity demanded, as seen in Exhibit 2(a). If the demand curve is perfectly inelastic, the quantity demanded is the same regardless of the price, as illustrated in Exhibit 2(b).

inelastic demand segment
a portion of the demand curve where the percentage change in quantity demanded is less than the percentage change in price ($E_D < 1$)

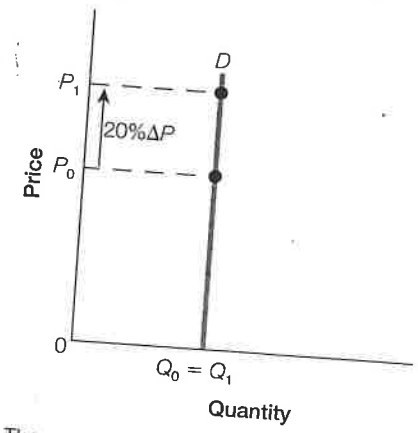
section 5.1 Exhibit 2 **Inelastic Demand**

a. Inelastic Demand ($E_D < 1$)



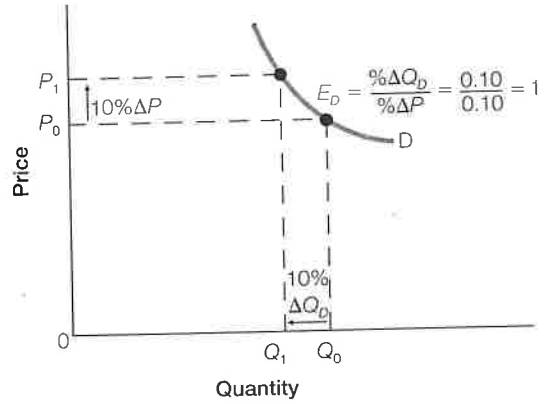
A change in price leads to a smaller percentage change in quantity demanded.

b. Perfectly Inelastic Demand ($E_D = 0$)



The quantity demanded does not change regardless of the percentage change in price.

section 5.1 Exhibit 3 **Unit Elastic Demand**



The percentage change in quantity demanded is the same as the percentage change in price that caused it ($E_D = 1$).

unit elastic demand
demand with a price elasticity of 1; the percentage change in quantity demanded is equal to the percentage change in price

Unit Elastic Demand Segments

Goods for which E_D equals one ($E_D = 1$), that is, where the percentage change in quantity demanded is equal to the percentage change in price, are said to have **unit elastic demand.** In this case, the percentage change in quantity demanded is the same as the percentage change in price that caused it. For example, as illustrated in Exhibit 3, a 10 percent increase in price will lead to a 10 percent reduction in quantity demanded.

HOW DO WE USE THE "MIDPOINT METHOD" IN CALCULATING PRICE ELASTICITIES OF DEMAND?

Now that we have looked at the basic theory of elasticities by focusing on the percentage changes in quantity demanded and price, suppose we wanted to perform the same calculation using points from a demand curve. What we would soon realize is that the direction of the calculation has an impact on our answer! To help understand this potential problem, consider the following example:

Point	Price	Quantity
A	$2	100
B	$4	40

When going from point A to point B, the percentage increase in price is 100 percent and the percentage decline in quantity is 60 percent, giving us a price elasticity of demand coefficient of 0.6 (60/100). However, when we go from point B to point A, the percentage decrease in price is 50 percent, and the percentage increase in quantity is 150 percent, giving us a price elasticity of demand coefficient of 3 (150/50).

The reason for the different answers in the above case was due to the traditional method for calculating percentage. According to the traditional approach, the change in the given values is divided by the initial value in determining percentage change. However, since this initial value can be different depending on whether you are starting from point A or from point B, you can, and often do, get different answers. To solve this problem, a technique known as the *midpoint method* is used in place of the traditional approach. The midpoint method uses a midpoint (or average) of the initial and final values in calculating percentage change, as opposed to an initial value. And since this midpoint value is the same regardless of the direction of the calculation, we always get the same answer. Consider the same example again, now using the midpoint method.

Point	Price	Quantity
A	$2	100
B	$4	40
Midpoint	*$3*	*70*

According to the midpoint method, when going from point A to point B, the percentage increase in price is 67 percent ($2/$3) and the percentage decline in quantity is 86 percent (60/70), giving us a price elasticity of demand coefficient of 1.3 (86/67). Conveniently, when we go from point B to point A, the percentage decrease in price is 67 percent and the percentage increase in quantity is 86 percent, giving us a price elasticity of demand coefficient of 1.3 (86/67). Problem solved!

Price elasticity of demand between two points (Q_A, P_A) and (Q_B, P_B), can then be expressed in terms of the midpoint method with the following formula:

$$E_D = \frac{\%\Delta Q_D}{\%\Delta P} = \frac{\dfrac{Q_A - Q_B}{\dfrac{(Q_A + Q_B)}{2}}}{\dfrac{P_A - P_B}{\dfrac{(P_A + P_B)}{2}}}$$

WHAT DETERMINES THE PRICE ELASTICITY OF DEMAND?

As you have learned, the elasticity of demand for a specific good refers to movements along its demand curve as its price changes. A lower price will increase quantity demanded, and a higher price will reduce quantity demanded. But what factors will influence the magnitude of the change in quantity demanded in response to a price change? That is, what will make the demand curve relatively more elastic (where Q_D is responsive to price changes), and what will make the demand curve relatively less elastic (where Q_D is less responsive to price changes)?

For the most part, the price elasticity of demand depends on the following factors: (1) the availability of close substitutes, (2) the proportion of income spent on the good, and (3) the amount of time that has elapsed since the price change.

Availability of Close Substitutes

Goods *with* close substitutes tend to have more elastic demands. Why? Because if the price of such a good increases, consumers can easily switch to other, now relatively lower-priced substitutes. There are many examples, such as butter and margarine, one brand of root beer as opposed to another, or different brands of gasoline, where the ease of substitution will make demand quite elastic for most individuals. Goods *without* close substitutes, such as insulin for diabetics, cigarettes for chain smokers, or heroin for addicts, tend to have inelastic demands.

The degree of substitutability may also depend on whether the good is a necessity or a luxury. Goods that are necessities, like food, cannot be easily substituted for and thus tend to have lower elasticities than luxury items, like jewellery.

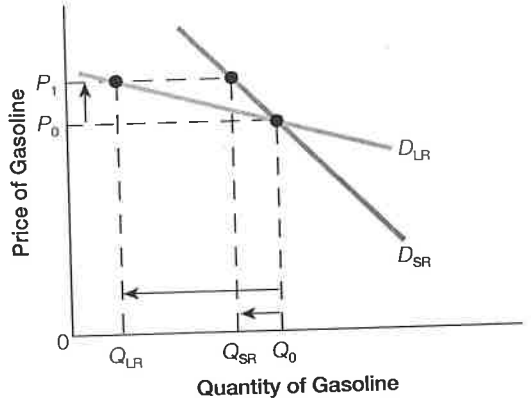
Narrowly Defined Goods

When the demand for a good is broadly defined, it tends to be less elastic than when it is narrowly defined. For example, the elasticity of demand for food, a very broad category, tends to be inelastic because there are very few substitutes for food. But for a certain type of food, like pizza, a narrowly defined good, it is much easier to find a substitute—perhaps tacos, burgers, or french fries. That is, the demand for a particular type of food is more elastic because there are more and better substitutes than for food as an entire category.

Proportion of Income Spent on the Good

The smaller the proportion of income spent on a good, the lower its elasticity of demand. If the amount spent on a good relative to income is small, then the impact of a change in its price on one's budget will also be small. As a result, consumers will respond less to price changes for these goods than for similar percentage changes in large-ticket items, where a price change could have a potentially large impact on the consumer's budget. For example, a 50 percent increase in the price of salt will have a much smaller impact on consumers' behaviour than a similar percentage increase in the price of a new automobile. Similarly, a 50 percent increase in the cost of university tuition will have a greater impact on students' (and sometimes parents') budgets than a 50 percent increase in beer prices.

section 5.1 Exhibit 4 **Short-Run and Long-Run Demand Curves**



For many goods, like gasoline, price is much more elastic in the long run than the short run because buyers take time to change their consumption patterns. In the short run, the increase in price from P_0 to P_1 has only a small effect on the quantity demanded for gasoline. In the long run, the effect of the price increase will be much larger.

Time

For many goods, the more time that people have to adapt to a new price change, the greater the elasticity of demand. Immediately after a price change, consumers may be unable to locate very good alternatives or easily change their consumption patterns. But the more time that passes, the more time consumers have to find or develop suitable substitutes and to plan and implement changes in their patterns of consumption. For example, drivers may not respond immediately to an increase in gas prices, perhaps believing it to be temporary. However, if the price persists over a longer period, we would expect people to drive less, buy more fuel-efficient cars, move closer to work, carpool, take the bus, or even bike to work. Hence, for many goods, especially nondurable goods (goods that do *not* last a long time), the short-run demand curve is generally less elastic than the long-run demand curve, as illustrated by Exhibit 4.

Estimated Price Elasticities of Demand

Because of shifts in supply and demand curves, researchers have a difficult task when trying to estimate empirically the price elasticity of demand for a particular good or service. Despite this difficulty, Exhibit 5 presents some estimates for the price elasticity of demand for certain goods. As you would expect, certain goods like air travel, gasoline, and legal services are all relatively price inelastic in the short run because buyers have fewer substitutes. On the other hand, air travel in the long run is much more sensitive to price (elastic) because the available substitutes are much more plentiful. Exhibit 5 shows that the price elasticity of demand for air travel is 2.4, which means that a 1 percent increase in price will lead to a 2.4 percent reduction in quantity demanded. Notice, in each case where the data is available, the estimates of the long-run price elasticities of demand are greater than the short-run price elasticities of demand. In short, the price elasticity of demand is greater when the price change persists over a longer time period.

section 5.1
Exhibit 5

Price Elasticities of Demand for Selected Goods

Good	Short Run	Long Run
Salt	–	0.1
Air travel	0.1	2.4
Gasoline	0.2	0.7
Jewellery and watches	0.4	0.7
Legal services	0.4	–
Alcohol	0.9	3.6
Movies	0.9	3.7
China, glassware	1.5	2.6
Automobiles	1.9	2.2
Chevrolets	–	4.0

SOURCES: Adapted from Robert Archibald and Robert Gillingham, "An Analysis of the Short-Run Consumer Demand for Gasoline Using Household Survey Data," *Review of Economics and Statistics 62* (November 1980), pp. 622–628; Hendrik S. Houthakker and Lester D. Taylor, *Consumer Demand in the United States: Analyses and Projections* (Cambridge, MA: Harvard University Press, 1970), pp. 56–149; and Richard Voith, "The Long-Run of Demand for Consumer Rail Transportation," *Journal of Urban Economics 30* (November 1991), pp. 360–371.

SECTION CHECK

- Price elasticity of demand measures the percentage change in quantity demanded divided by the percentage change in price.
- If the demand for a good is price elastic in the relevant range, quantity demanded is very responsive to a price change. If the demand for a good is relatively price inelastic, quantity demanded is not very responsive to a price change.
- The "midpoint method" for calculating percentage change involves using the average of the changing values, thereby eliminating the direction bias found in the traditional approach.
- The price elasticity of demand depends on (1) the availability of close substitutes, (2) the proportion of income spent on the good, and (3) the amount of time that buyers have to respond to a price change.

section 5.2

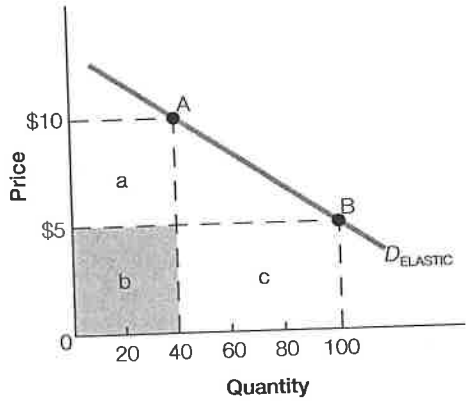
Total Revenue and Price Elasticity of Demand

- How does the price elasticity of demand impact total revenue?
- How does price elasticity of demand change along a linear demand curve?

HOW DOES THE PRICE ELASTICITY OF DEMAND IMPACT TOTAL REVENUE?

The price elasticity of demand for a good also has implications for total revenue. Total revenue (TR) is simply the price of the good (P) times the quantity of the good sold (Q): $TR = P \times Q$. In Exhibit 1, we see that when the demand is price elastic ($E_D > 1$), total revenues will rise as the price declines because the percentage increase in the quantity demanded is greater than the percentage reduction in price. For example, if the price of a good is cut in half (say from \$10 to \$5) and the quantity demanded more than doubles (say from 40 to 100), total revenue will rise from \$400 (\$10 × 40 = \$400) to \$500 (\$5 × 100 = \$500). Equivalently, if the price rises from \$5 to \$10 and the quantity demanded falls from 100 to 40 units, then total revenue falls from \$500 to \$400. As this example illustrates, if the demand curve is relatively elastic, total revenue varies inversely with a price change.

section 5.2 Exhibit 1 Elastic Demand and Total Revenue



At point A, total revenue is \$400 (\$10 × 40), or area a + b. At point B, the total revenue is \$500 (\$5 × 100), or area b + c. Total revenue has increased by \$100. We can also see in the graph that total revenue has increased because the area b + c is greater than area a + b, or c > a.

You can see from the following what happens to total revenue when demand is price elastic. (Note: The sizes of the price and quantity arrows represent the sizes of the percentage changes.)

When Demand Is Price Elastic

$$\downarrow TR = \uparrow P \times \downarrow Q$$

or

$$\uparrow TR = \downarrow P \times \uparrow Q$$

On the other hand, if demand for a good is relatively inelastic ($E_D < 1$), the total revenue will be lower at lower prices than at higher prices because a given price reduction will be accompanied by a proportionately smaller increase in quantity demanded. For example, as seen in Exhibit 2, if the price of a good is cut, say from \$10 to \$5, and the quantity demanded less than doubles—say it increases from 30 to 40—total revenue will fall from \$300 (\$10 × 30 = \$300) to \$200 (\$5 × 40 = \$200). Equivalently, if the price increases from \$5 to \$10 and the quantity demanded falls from 40 to 30, total revenue will increase from \$200 to \$300. To summarize, then, if the demand curve is inelastic, total revenue will vary directly with a price change.

When Demand Is Price Inelastic

$$\uparrow TR = \uparrow P \times \downarrow Q$$

or

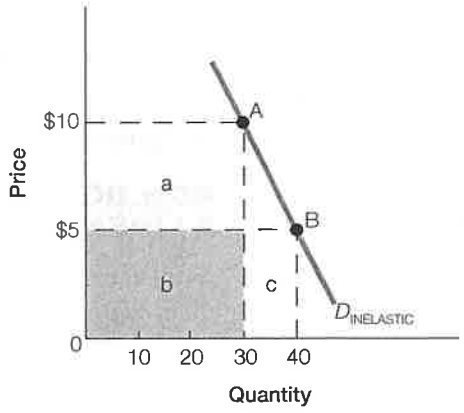
$$\downarrow TR = \downarrow P \times \uparrow Q$$

In this case, the net effect on total revenue is reversed but easy to see. (Again, the sizes of the price and quantity arrows represent the sizes of the percentage changes.)

An example will help us appreciate the relationship we have just established between price elasticity of demand and total revenue: Is a poor wheat harvest bad for all farmers? Is a great wheat harvest good for all farmers? The answers to these questions may seem obvious at first, but elasticity will reveal to us some interesting solutions.

As shown in Exhibit 3(a), if demand for wheat is inelastic, a reduction in supply without a simultaneous reduction in demand will result in a higher price for wheat and a rise in total revenues for farmers. The increase in price will cause farmers to lose the revenue indicated by area c; however, they will gain the area indicated by area a. The net result will be an overall increase in revenue equal to the area a – c. Clearly, if some farmers lose their entire crop due to, say, bad weather, they are worse off; but *collectively* farmers can profit from events that reduce crop size—and they do, because the demand for most agricultural products is inelastic. Interestingly, if all farmers were hurt equally, say, losing one-third of their crop, each farmer would be better off. Of course, consumers would be worse off because the price of agricultural products would be higher.

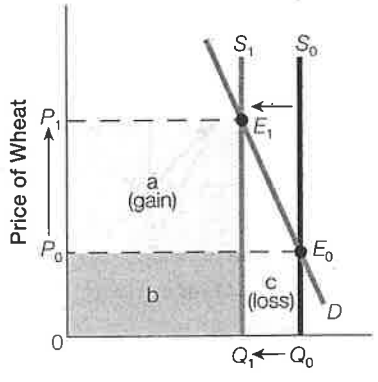
section 5.2 Exhibit 2 **Inelastic Demand and Total Revenue**



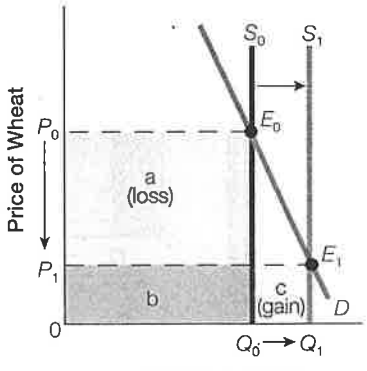
At point A, total revenue is \$300 (\$10 × 30), or area a + b. At point B, the total revenue is \$200 (\$5 × 40), or area b + c. Total revenue has fallen by \$100. We can also see in the graph that total revenue has decreased because area a + b is greater than area b + c, or a > c.

section 5.2 Exhibit 3 **Elasticities and Total Revenue**

a. Total Revenue and Inelastic Demand: A Reduction in Supply



b. Total Revenue and Inelastic Demand: An Increase in Supply



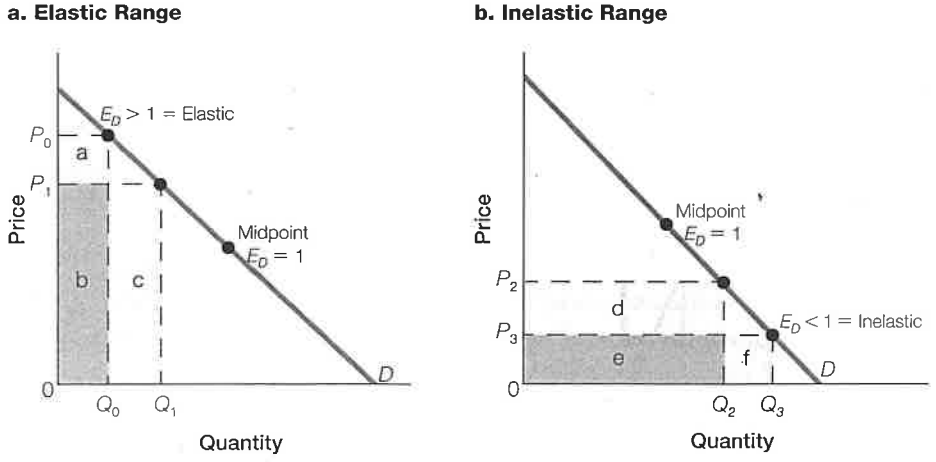
Alternatively, what if phenomenal weather has led to record wheat harvests or a technological advance has led to more productive wheat farmers? Either event would increase the supply from S_0 to S_1 in Exhibit 3(b). The increase in supply leads to a lower price, from P_0 to P_1. Because the demand for wheat is inelastic, the quantity sold of wheat rises proportionately less than the fall in the price. That is, in percentage terms, the price falls more than the quantity demanded rises. Each farmer is selling a few more bushels of wheat but the price of each bushel has fallen even more, so collectively wheat farmers will experience a decline in total revenue despite the good news.

HOW DOES PRICE ELASTICITY OF DEMAND CHANGE ALONG A LINEAR DEMAND CURVE?

As we showed earlier in the chapter, the slopes of demand curves can be used to estimate their *relative* elasticities of demand: The steeper that one demand curve is relative to another, the more inelastic it is relative to the other. However, beyond the extreme cases of perfectly elastic and perfectly inelastic curves, great care must be taken when trying to estimate the degree of elasticity of one demand curve from its slope. In fact, as we will see, a straight-line demand curve with a constant slope will change elasticity continuously as you move up or down it.

We can easily demonstrate that the elasticity of demand varies along a linear demand curve by using what we already know about the interrelationship between price and total revenue. Exhibit 4 shows a linear (constant slope) demand curve. In Exhibit 4(a), we see that when the price falls on the upper half of the demand curve from P_0 to P_1, and quantity demanded increases from Q_0 to Q_1, total revenue increases. That is, the new area of total revenue (area b + c) is larger than the old area of total revenue (area a + b). It is also true that if price increased in this region (from P_1 to P_0), total revenue would fall, because b + c is greater than a + b. In this region of the demand curve, then, there is a negative relationship between price and total revenue. As we discussed earlier, this is a characteristic of an elastic demand curve ($E_D > 1$).

section 5.2 Exhibit 4 — **Price Elasticity along a Linear Demand Curve**

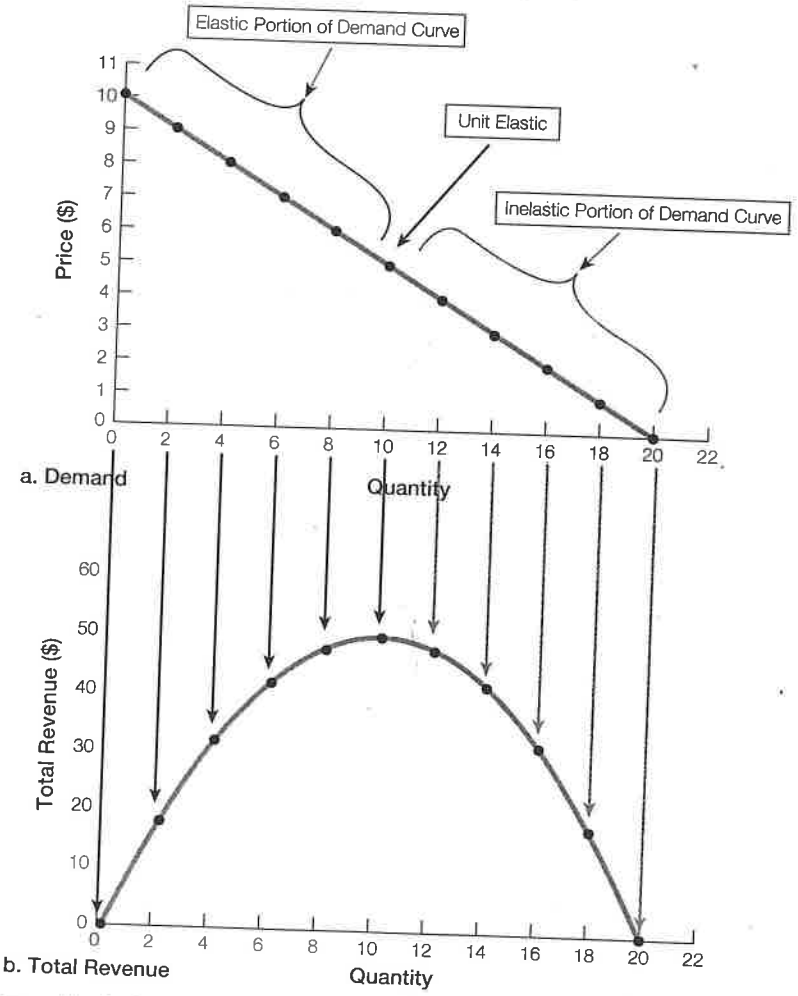


The slope is constant along a linear demand curve, but the elasticity varies. Moving down along the demand curve, the elasticity is elastic at higher prices and inelastic at lower prices. It is unit elastic at its midpoint, the boundary between the inelastic and elastic ranges.

Exhibit 4(b) illustrates what happens to total revenue on the lower half of the same demand curve. When the price falls from P_2 to P_3 and the quantity demanded increases from Q_2 to Q_3, total revenue actually decreases because the new area of total revenue (area e + f) is less than the old area of total revenue (area d + e). Likewise, it is clear that an increase in price from P_3 to P_2 would increase total revenue. In this case, there is a positive relationship between price and total revenue, which, as we discussed, is characteristic of an inelastic demand curve ($E_D < 1$). Together, parts (a) and (b) of Exhibit 4 illustrate that, although the slope remains constant, the elasticity of a linear demand curve changes along the length of the curve—from relatively elastic at higher price ranges to relatively inelastic at lower price ranges.

In summary, Exhibit 5 illustrates how total revenue behaves over the entire range of demand. For example, when the price increases from \$2 to \$3, total revenue increases from \$32 to \$42—an increase in price increases total revenue, so demand is inelastic in

section 5.2
Exhibit 5 **Elasticity Varies Along a Linear Demand Curve**



When demand is elastic, in the price range from \$10 to \$5, a decrease in price [part (a)] brings an increase in total revenue [part (b)]. When demand is inelastic, in the price range from \$5 to \$0, a decrease in price [part (a)] brings a decrease in total revenue [part (b)]. When demand is unit elastic, at a price of \$5 [part (a)], total revenue is at a maximum [part (b)].

this portion of the demand curve. But when the price increases from \$8 to \$9, the total revenue falls from \$32 to \$18, so demand is elastic in this portion of the demand curve.

Specifically, when the price is high and the quantity demanded is low, this portion of the demand curve is elastic. Why? It is because a \$1 reduction in price is a smaller percentage change when the price is high than when it is low. Similarly, an increase in 2 units of output is a larger percentage change when quantity demanded is lower. So we have a relatively small change in price leading to a proportionately greater change in quantity demanded—that is, demand is elastic on this portion of the demand curve.

Of course, the opposite is true when the price is low and the quantity demanded is high. Why? It is because a \$1 change in price is a larger percentage change when the price is low and an increase in 2 units of output is a smaller percentage change when the quantity demanded is larger. That is, a relatively larger percentage change in price will lead to a relatively smaller change in quantity demanded—demand is relatively inelastic on this portion of the demand curve.

Business CONNECTION

IN BUSINESS, PRICING ISN'T EVERYTHING, BUT IT'S VERY POWERFUL!

Consumers faced with buying a product often consider many factors. If a major purchase is involved, such as an appliance, a car, or a condominium, the buyer is more likely to seriously mull over the price. If the decision is to acquire the item, the next step is often to conduct a search for various sellers to find the lowest price at which the product can be bought. If the identical product can be obtained from a number of competing suppliers, all other factors remaining equal, *ceteris paribus*, the buyer will usually purchase the product from the supplier offering the lowest price. Given what we know of the demand curve, the outcome is predictable: Suppliers that charge a lower price for identical products can expect to sell more units.

Since the goal of business is to earn a profit, business operators must consider revenues as well as costs. In many competitive markets, if one supplier lowers the price and the other suppliers do not also respond with a lower price, the supplier taking the initiative to lower the price will invariably sell more units, Q. For normal products, a lower price, P, results in a greater Q. However, selling more units, Q, does not always lead to more revenue and does not always lead to greater profits. This fact seems a bit odd, yet it is one of those very important business concepts that if the business operator is unaware of it, could lead to serious pricing errors resulting in losses and in many cases, business failure. This fact is fully explained by the price elasticity of demand.

There is more. Since the price elasticity of demand can be measured, it can be used to predict the percentage increase or decrease in quantity demand, and therefore total revenue, due to a percentage change in price. Successful businesses, including car dealerships, supermarkets, department stores, and electronics retail stores, all rely on this concept to guide product pricing strategies. In business, making a profit depends on managing the top line—total revenue, which depends on price and quantity. With an understanding of the price elasticity of demand, many businesses can avoid failure with better product pricing strategies.

SECTION CHECK

- If demand is price elastic ($E_D > 1$), total revenue will vary inversely with a change in price. If demand is price inelastic ($E_D < 1$), total revenue will vary in the same direction as a change in price.
- A linear demand curve is more price elastic at higher price ranges and more price inelastic at lower price ranges, and it is unit elastic at the midpoint: $E_D = 1$.

section 5.3

Other Demand Elasticities

- What is the cross-price elasticity of demand?
- What is the income elasticity of demand?

WHAT IS THE CROSS-PRICE ELASTICITY OF DEMAND?

Price elasticities of demand are not the only elasticity calculation that economists use to better understand buyer behaviour. Sometimes the quantity of the good demanded is affected by the price of a related good (substitutes and complements). For example, if the price of potato chips falls, what is the impact, if any, on the quantity of soda (a complement) demanded? Or if the price of soda increases, to what degree will iced tea (a substitute) sales be affected? The **cross-price elasticity of demand** is a measure of the impact that a price change of one good will have on the quantity demanded of another good at a given price. Specifically, the cross-price elasticity of demand is defined as the percentage change in the quantity demanded of one good (good A) divided by the percentage change in price of another good (good B), or

cross-price elasticity of demand
a measure of the impact that a price change of one good will have on the quantity demanded of another good at a given price

$$\text{Cross-price elasticity of demand } (E_{AB}) = \frac{\text{Percentage change in quantity demanded of A}}{\text{Percentage change in the price of B}}$$

The cross-price elasticity of demand indicates not only the degree of the connection between the two variables but also whether the goods in question are substitutes or complements to one another.

Calculating the Cross-Price Elasticity of Demand

Let's calculate the cross-price elasticity of demand between soda and iced tea, where a 10 percent increase in the price of soda results in a 20 percent increase in the quantity of iced tea demanded. In this case, the cross-price elasticity of demand would be +2 (+20 percent ÷ +10 percent = +2). Consumers responded to the soda price increase by buying less soda (moving along the demand curve for soda) and increasing the quantity demanded of iced tea at every price (shifting the demand curve for iced tea). In general, if the cross-price elasticity is positive, we can conclude that the two goods are substitutes because the price of one good and the demand for the other move in the same direction.

As another example, let's calculate the cross-price elasticity of demand between potato chips and soda, where a 10 percent decrease in the price of potato chips results in a 30 percent increase in the quantity of soda demanded. In this case, the cross-price elasticity of demand is −3 (+30 percent ÷ −10 percent = −3). The quantity demanded of potato chips increases as a result of the price decrease, and consumers then purchase additional soda to wash down those extra bags of salty chips. Potato chips and soda, then, are complements. In general, if the cross-price elasticity is negative, we can conclude that the two goods are complements because the price of one good and the demand for the other move in opposite directions.

WHAT IS THE INCOME ELASTICITY OF DEMAND?

Even though the most widely employed demand relationship is that between price and quantity demanded, it is also sometimes useful to relate quantity demanded to income. The **income elasticity of demand** is a measure of the responsiveness of the quantity demanded

income elasticity of demand
a measure of the responsiveness of the quantity demanded of a good to a change in income

of a good to a change in income. The income elasticity of demand coefficient not only expresses the degree of the connection between the two variables, but it also indicates whether the good in question is normal or inferior. Specifically, the income elasticity of demand is defined as the percentage change in the quantity demanded at a given price divided by the percentage change in income, or

$$\text{Income elasticity of demand } (E_I) = \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in income}}$$

Calculating the Income Elasticity of Demand

Let's calculate the income elasticity of demand for lobster, where a 10 percent increase in income results in a 15 percent increase in the quantity of lobster demanded at a given price. In this case, the income elasticity of demand is +1.5 (+15 percent ÷ +10 percent = +1.5). Lobster, then, is a normal good because an increase in income results in an increase in demand. In general, if the income elasticity is positive, then the good in question is a normal good because income and demand move in the same direction.

In comparison, let's calculate the income elasticity of demand for beans, where a 10 percent increase in income results in a 15 percent decrease in the demand for beans at each price. In this case, the income elasticity of demand is −1.5 (−15 percent ÷ +10 percent = −1.5). In this example, then, beans are an inferior good because an increase in income results in a decrease in the purchase of beans at a given price. If the income elasticity is negative, then the good in question is an inferior good because the change in income and the change in demand move in opposite directions.

SECTION CHECK

- The cross-price elasticity of demand is the percentage change in the quantity demanded of one good divided by the percentage change in the price of another related good (complements and substitutes).
- The income elasticity of demand is the percentage change in quantity demanded divided by the percentage change in income (normal and inferior goods).

section 5.4 Price Elasticity of Supply

- What is the price elasticity of supply?
- How does time affect the supply elasticity?

WHAT IS THE PRICE ELASTICITY OF SUPPLY?

price elasticity of supply *the measure of the sensitivity of the quantity supplied to changes in the price of a good*

According to the law of supply, there is a positive relationship between price and quantity supplied, *ceteris paribus*. But by how much does quantity supplied change as price changes? It is often helpful to know the degree to which a change in price changes the quantity supplied. The **price elasticity of supply** measures the sensitivity of the quantity supplied to changes in the price of a good. In other words, it measures how responsive

the quantity that sellers are willing and able to sell is to changes in the price. Specifically, the price elasticity of supply (E_S) is defined as the percentage change in the quantity supplied divided by the percentage change in price, or

$$\text{Price elasticity of supply } (E_S) = \frac{\text{Percentage change in quantity supplied}}{\text{Percentage change in price}}$$

Calculating the Price Elasticity of Supply

The price elasticity of supply is calculated in much the same manner as the price elasticity of demand. Consider, for example, the case in which it is determined that a 10 percent increase in the price of carrots results in a 25 percent increase in the quantity of carrots supplied after, say, a few harvest seasons. In this case, the price elasticity is +2.5 (+25 percent ÷ +10 percent = +2.5). This coefficient indicates that each 1 percent increase in the price of carrots induces a 2.5 percent increase in the quantity of carrots supplied.

The Ranges of the Price Elasticity of Supply

Economists delineate several ranges of the price elasticity of supply. As with the elasticity of demand, these ranges centre on whether the elasticity coefficient is greater than or less than one. Goods with a supply elasticity that is greater than one ($E_S > 1$) are said to be relatively elastic in supply. With that, a 1 percent change in price will result in a greater than 1 percent change in quantity supplied. In our earlier example, carrots were elastic in supply, because a 1 percent price increase resulted in a 2.5 percent increase in quantity supplied. An example of an elastic supply curve is shown in Exhibit 1(a).

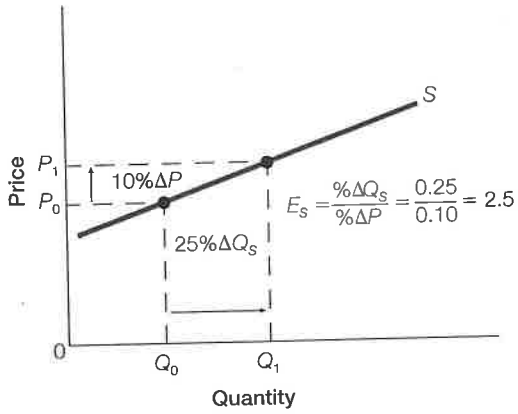
Goods with a supply elasticity that is less than one ($E_S < 1$) are said to be inelastic in supply. This means that a 1 percent change in the price of these goods will induce a proportionately smaller change in the quantity supplied. This situation is shown in the supply curve in Exhibit 1(b).

Finally, there are two extreme cases of price elasticity of supply: perfectly inelastic supply and perfectly elastic supply. In a condition of perfectly inelastic supply, an increase in price will not change the quantity supplied. For example, in a sports arena in the short run (i.e., in a period too brief to adjust the structure), the number of seats available will be almost fixed, say at 20 000 seats. Additional portable seats might be available, but for the most part, even if there is a higher price, there will be only 20 000 seats available. We say that the elasticity of supply is zero, which describes a perfectly inelastic supply curve. Famous paintings, like Van Gogh's *Starry Night,* provide another example; there is only one original in existence and, therefore, only one can be supplied, regardless of price. An example of this condition is shown in Exhibit 1(c).

At the other extreme is a perfectly elastic supply curve, where the elasticity equals infinity, as seen in Exhibit 1(d). In a condition of perfectly elastic supply, nothing will be supplied at any price up to a certain level, but at some higher price, sellers would be willing to supply whatever quantity buyers wished to buy. In this case, if the price is below the market price at P_0, the quantity supplied will fall to zero. But at P_1, sellers will sell all that buyers wish to buy. However, most cases fall somewhere between the two extremes of perfectly elastic and perfectly inelastic.

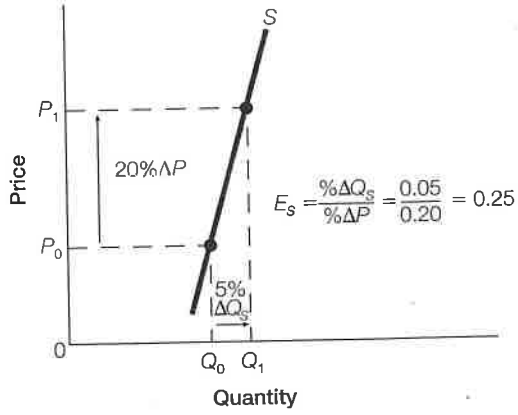
section 5.4 Exhibit 1 The Price Elasticity of Supply

a. Elastic Supply ($E_S > 1$)



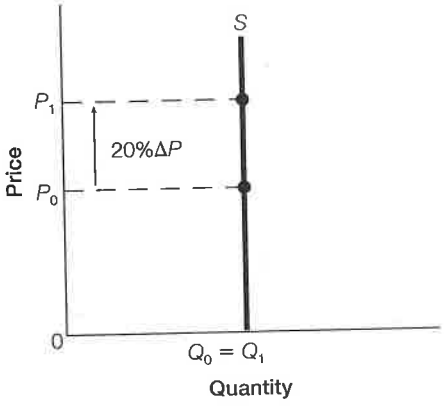
A change in price leads to a larger percentage change in quantity supplied.

b. Inelastic Supply ($E_S < 1$)



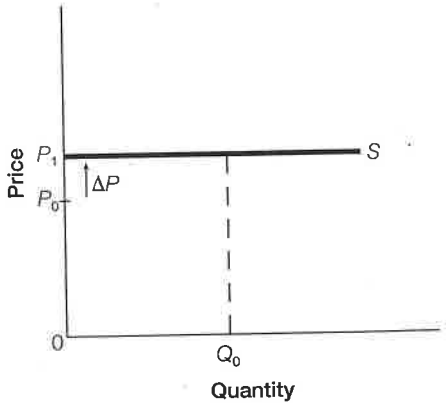
A change in price leads to a smaller percentage change in quantity supplied.

c. Perfectly Inelastic Supply ($E_S = 0$)



The quantity supplied does not change regardless of the change in price.

d. Perfectly Elastic Supply ($E_S = \infty$)



Even a small percentage change in price will change quantity supplied by an infinite amount.

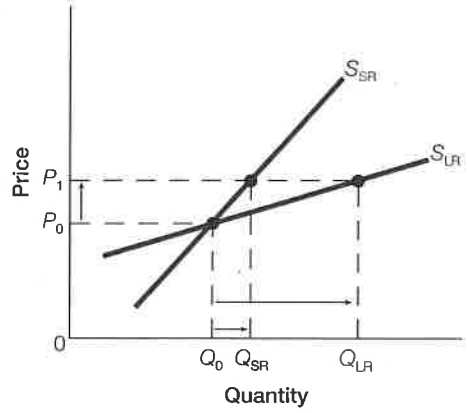
HOW DOES TIME AFFECT THE SUPPLY ELASTICITY?

Time is usually critical in supply elasticities (as well as in demand elasticities) because it is more costly for producers to bring forth and release resources in a shorter period of time. For example, the higher wheat prices may cause farmers to grow more wheat, but big changes cannot occur until the next growing season. That is, immediately after harvest season, the supply of wheat is relatively inelastic, but over a longer period that extends over the next growing period, the supply curve becomes much more elastic. Hence, supply tends to be more elastic in the long run than the short run, as shown in Exhibit 2.

Another example of a good whose supply is highly inelastic in the short run is rental units in most urban areas without rent controls. There is generally only a fixed number of rental units available in the short run. Thus, in the short run, an increase in demand

section 5.4
Exhibit 2

Short-Run and Long-Run Supply Curves



For most goods, supply is more elastic in the long run than in the short run. For example, if price increases, firms have an incentive to produce more but are constrained by the size of their plants. In the long run, they can increase their capacity and produce more.

will lead only to higher prices (rents). However, in the long run, these same higher prices (rents) provide an incentive to renovate and build new rental units.

In the short run, firms can increase output by using their existing facilities to a greater capacity, paying workers to work overtime and hiring additional workers. However, firms will be able to increase output much more in the long run when they can build new factories. In addition, some new firms can enter in the long run. In other words, the quantity supplied will be much more elastic in the long run than in the short run.

SECTION CHECK

- The price elasticity of supply measures the relative change in the quantity supplied that results from a change in price.
- Supply tends to be more elastic in the long run than the short run.

section 5.5

Elasticity and Taxes

- What is tax incidence?
- How does the relative elasticity of supply and demand determine the tax burden?

WHAT IS TAX INCIDENCE?

To varying degrees, all levels of government (federal, provincial/territorial, and municipal) use taxes to generate needed revenue. Although the legislation that accompanies a tax designates who is required to pay the particular tax, for example, the harmonized sales tax (HST) is a consumption-based tax paid by consumers, the ultimate impact of the tax—also known as the *tax burden*—is less certain. In economics, the term **tax incidence** refers to the analysis of the effect of a particular tax on the distribution of economic welfare. In other words, tax incidence looks at the ultimate burden of a tax.

tax incidence
the analysis of the effect of a particular tax on the distribution of economic welfare

HOW DOES THE RELATIVE ELASTICITY OF SUPPLY AND DEMAND DETERMINE THE TAX BURDEN?

The relative elasticity of supply and demand determines the distribution of the tax burden for a good. As we will see, if demand has a lower elasticity than supply in the relevant tax region, the largest portion of the tax is paid by the consumer. However, if demand is relatively more elastic than supply in the relevant tax region, the largest portion of the tax is paid by the producer.

In Exhibit 1, the pre-tax equilibrium price is \$1 and the pre-tax equilibrium quantity is Q_{BT}—the quantity before tax. If the government imposes a \$0.50 tax on the seller, the supply curve shifts vertically by the amount of the tax (just as if an input price rose by \$0.50).

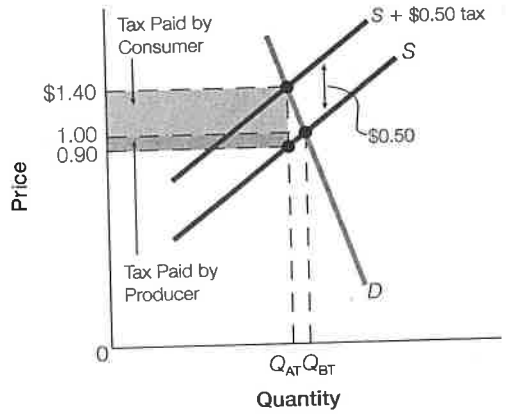
In the case where demand is relatively less elastic than supply in the relevant region, almost the whole tax is passed on to the consumer, *ceteris paribus*. For example, in Exhibit 1(a), sellers are very responsive to changes in the price of the good (explaining the relatively flat supply curve), whereas consumers are relatively less responsive (explaining the relatively steep demand curve). In response to the tax, the price paid by consumers rises substantially, indicating that consumers bear most of the burden of the tax. With a post-tax equilibrium price of \$1.40, consumers end up paying 40 cents more per unit compared to the per-tax equilibrium price. The price received by producers, however, does not fall by very much, indicating that sellers bear only a small burden of the tax. At 90 cents per unit (\$1.40 − \$0.50 = \$0.90), the producer burden amounts to only 10 cents.

In Exhibit 1(b), demand is relatively more elastic than the supply in the relevant region. Here, we see that the greater burden of the same 50-cent tax falls on the producer, *ceteris paribus*. In response to the tax, the price paid by consumers does not rise very much, but the price received by producers falls substantially. With a post-tax equilibrium price of \$1.10, the producer will receive only 60 cents per unit (\$1.10 − \$0.50 = \$0.60), resulting in a 40 cent per-unit tax burden. Consumers, on the other hand, end up paying 10 cents more per unit compared to the pre-tax equilibrium price.

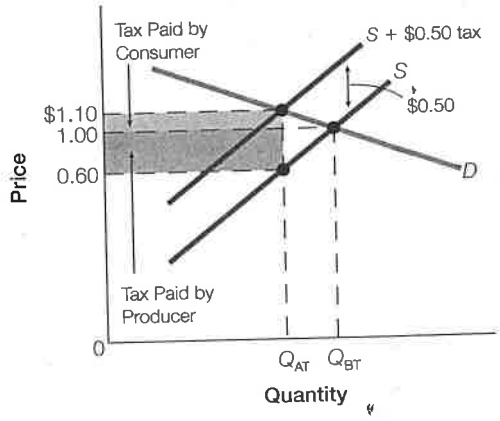
In general, then, the tax burden falls on the side of the market that is less elastic. Note that who actually pays the tax at the time of the purchase has nothing to do with who incurs the ultimate burden of the taxation—that depends on the relative elasticity.

section 5.5 Exhibit 1 — **Elasticity and the Burden of Taxation**

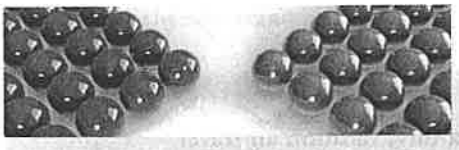
a. Demand Is Relatively Less Elastic than Supply



b. Demand Is Relatively More Elastic than Supply



When demand is less elastic (or more inelastic) than supply, the tax burden falls primarily on consumers, as shown in Exhibit 1(a). When demand is more elastic than supply, as shown in Exhibit 1(b), the tax burden falls primarily on producers.



DEBATE

WHAT IS THE BEST WAY TO CURB SMOKING?

As minister of health, you are given the mandate to lower the smoking rates in Canada. You have a number of options: You can raise the price of cigarettes through taxation, you can limit the access for younger smokers by selling cigarettes only in liquor stores, you can increase public awareness of the harmful effects of smoking through increased advertisements, or you can limit the quantity of cigarettes produced by suppliers, which would produce a shortage and probably cause a price increase. As health minister, you would prefer the more traditional method of raising the taxes on cigarettes. Naturally, the Opposition Party would probably oppose your approach and suggest any method other than raising taxes. Both sides of government would expect an impact on overall government revenues. Should the government raise the taxes?

Raising Taxes:

Smoking rates can be impacted through the tax system—increased taxes on cigarettes generally decrease consumption. The critical question is, by how much? If the policy is to work, should prices be elastic or inelastic? The government needs to know what impact increased taxes would have on the government's general revenue: Using the concept of elasticity, how would raising taxes impact revenue? Would there be any negative impact on general revenues if the government opts to raise cigarette taxes?

Keeping Taxes the Same:

The Opposition Party will not support raising taxes—its position is that taxes are already too high. What are some of the arguments the Opposition Party can use to persuade the government not to raise the taxes on cigarettes? With respect to overall government revenues, how can the opposition defend keeping the same tax rate on cigarettes? If taxes are not raised, is there an alternative that the parties could agree on that would achieve the same goal?

SECTION CHECK

- Tax incidence refers to the analysis of the effect of particular taxes of the distribution of economic welfare.
- If demand is more elastic than supply, producers bear the greater burden of the tax; however, if supply is more elastic than demand, consumers bear the greater burden of the tax.

For Your Review

Section 5.1

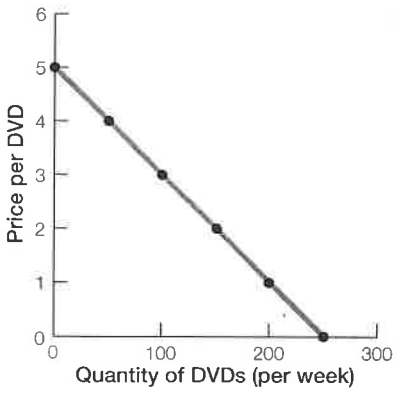
1. In each case below, indicate which good you think has a relatively *more* price elasticity of demand and identify the most likely reason, in terms of the determinants of the elasticity of demand (more substitutes, greater share of budget, or more time to adjust).
   a. cars or Chevrolets
   b. salt or housing
   c. natural gas this month or over the course of a year
2. How might your elasticity of demand for copying and binding services vary if your work presentation is next week versus in two hours?

3. For each of the following pairs, identify which one of the pair is likely to exhibit more elastic demand:
   a. shampoo; Paul Mitchell Shampoo
   b. air travel prompted by an illness in the family; vacation air travel
   c. paper clips; an apartment rental
   d. prescription heart medication; generic aspirin
4. Using the midpoint formula for calculating the elasticity of demand, if the price of a good fell from $42 to $38, what would be the elasticity of demand if the quantity demanded changed from
   a. $19 to $21?
   b. $27 to $33?
   c. $195 to $205?
5. Explain why using the midpoint formula for calculating the elasticity of demand gives the same result whether price increases or decreases, but using the initial price and quantity instead of the average does not.
6. Why is a more narrowly defined good (e.g., pizza) likely to have a greater elasticity of demand than a more broadly defined good (e.g., food)?
7. If the elasticity of demand for hamburgers equals −1.5 and the quantity demanded equals 40 000, predict what will happen to the quantity demanded of hamburgers when the price increases by 10 percent? If the price falls by 5 percent, what will happen?
8. Good weather produces a bumper crop of apples. As a result, the price falls from $6 to $3 a basket and the quantity demanded increases from 600 to 1100 baskets a week. Over this price range calculate the price elasticity of demand (using the midpoint method).
9. Bad weather spoils the orange crop. As a result, the price rises from $3 to $5 a basket and the quantity demanded decreases from 1500 to 900 baskets a week. Over this price range, calculate the price elasticity of demand (using the midpoint method).
10. Isabella always spends $50 on red roses each month and simply adjusts the quantity she purchases as the price changes. What can you say about Isabella's elasticity of demand for roses?

Section 5.2

11. The Winnipeg Blue Bombers want to boost revenues from ticket sales next season. You are hired as an economic consultant and asked to advise the Blue Bombers whether to raise or lower ticket prices next year. If the elasticity of demand for Blue Bomber game tickets is estimated to be −1.6, what would you advise? If the elasticity of demand equals −0.4?
12. Evaluate the following statement: "Along a downward-sloping linear demand curve, the slope and therefore the elasticity of demand are both 'constant.'"
13. If the midpoint on a straight-line demand curve is at a price of $7, what can we say about the elasticity of demand for a price change from $12 to $10? What about from $6 to $4?
14. If the local bus company raises its price per rider from $2.50 to $2.75 and its total revenues rise, what can we say about its elasticity of demand? What if total revenues fall as a result of the price increase?

15. Assume the following weekly demand schedule for Sunshine DVD Rentals in Moncton.



   a. When Sunshine DVD Rentals lowers its rental price from $4 to $3, what happens to its total revenue?
   b. Between a price of $4 and a price of $3, is the demand for Sunshine DVD rentals elastic or inelastic?
   c. Between a price of $2 and a price of $1, is the demand for Sunshine DVD rentals elastic or inelastic?

16. A movie production company faces a linear demand curve for its film, and it seeks to maximize total revenue from the film's distribution. At what level should the price be set? Where is demand elastic, inelastic, or unit elastic? Explain.

Section 5.3

17. If a 10 percent decline in the price of cameras increases the quantity of film demanded by 20 percent and increases the quantity of cameras demanded by 15 percent, calculate the cross-price elasticity of demand between cameras and film.
18. Indicate whether a pair of products are substitutes, complements, or neither based on the following estimates for the cross-price elasticity of demand:
   a. 0.5
   b. −0.5
19. Indicate whether the products are normal, inferior, or neither based on the following estimates for the income elasticity of demand:
   a. 1.7
   b. −1.7
20. If a 10 percent rise in the price of coffee increases the quantity of tea demanded by 25 percent and decreases the quantity of coffee demanded by 20 percent, calculate the cross-elasticity of demand between coffee and tea.

Section 5.4

21. Using the midpoint formula for calculating the elasticity of supply, if the price of a good rose from $95 to $105, what would be the elasticity of supply if the quantity supplied changed from
   a. 38 to 42?
   b. 78 to 82?
   c. 54 to 66?

22. Elasticity of demand in the market for one-bedroom apartments is 2.0, elasticity of supply is 0.5, the current market price is $1000, and the equilibrium number of one-bedroom apartments is 10 000. If the government imposes a price ceiling of $800 on this market, predict the size of the resulting apartment shortage.

Section 5.5

23. Mayor George Henry has a problem. He doesn't want to anger voters by taxing them because he wants to be re-elected, but the town of Gapville needs more revenue for its schools. He has a choice between taxing tickets to professional basketball games or food. If the demand for food is relatively inelastic while the supply is relatively elastic, and if the demand for professional basketball games is relatively elastic while the supply is relatively inelastic, in which case would the tax burden fall primarily on consumers? In which case would the tax burden fall primarily on producers?
24. If both supply curves and demand curves are more elastic in the long run than in the short run, how does the incidence of a tax change from the short run to the long run as a result? What happens to the revenue raised from a given tax over time, *ceteris paribus*?

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