CHAPTER 6


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ELASTICITY

Introduction In New York City, a Broadway play is performed in a theater with 1,500 seats. Will the play take in more revenue if the average ticket price for a performance is $70 or if it is $120? If you said $120, consider some other questions: Will the play take in more revenue if the average price is $120 or $180? Will it take in more revenue if the average price is $180 or $250? Are you beginning to get suspicious? Perhaps the highest ticket price won't generate the greatest amount of revenue, but which ticket price will? The answer may surprise you.

ELASTICITY: PART 1

The law of demand states that price and quantity demanded are inversely related, *ceteris paribus.* But it doesn't tell us by what percentage the quantity demanded changes as price changes. Suppose price rises by 10 percent. As a result, quantity demanded falls, but by what percentage does it fall? The notion of price elasticity of demand can help answer this question. The general concept of elasticity provides a technique for estimating the response of one variable to changes in another. It has numerous applications in economics.

Price Elasticity of Demand

The law of demand states that there is a *directional relationship* between price and quantity demanded: price and quantity demanded are inversely related. The law of demand does not tell us how much quantity demanded declines as price rises. The *magnitudinal relationship* between price and quantity demanded brings us to a discussion of price elasticity of demand, which is a measure of the responsiveness of quantity demanded to changes in price. More specifically, it addresses the percentage change in quantity demanded for a given percentage change in price. (Keep in mind "percentage change," not just "change.")

Price Elasticity of Demand
A measure of the responsiveness of quantity demanded to changes in price.

Let's say that a seller of a good—a computer—raises the price by 10 percent, and as a result the quantity demanded for the computer falls by 20 percent. The percentage change in quantity demanded (Q_d)—20 percent—divided by the percentage change in price (P)—10 percent—is called the *coefficient of price elasticity of demand* (E_d).

$$E_d = \frac{\text{Percentage change in quantity demanded}}{\text{Perentage change in price}} = \frac{\%\Delta Q_d}{\%\Delta P}$$

In the formula, E_d = coefficient of price elasticity of demand, or simply elasticity coefficient, % = percentage, and Δ stands for "change in."

If we apply the calculation to our simple example—where quantity demanded changes by 20 percent and price changes by 10 percent—we get 2. An economist would say either, "The coefficient of price elasticity of demand is 2" or, more simply, "Price elasticity of demand is 2." Either expression means that the percentage change in quantity demanded will be 2 times any percentage change in price.[1] If price changes 5 percent, the quantity demanded will change 10 percent; if price changes 10 percent, the quantity demanded will change 20 percent.

WHERE IS THE MISSING MINUS SIGN? Price and quantity demanded move in opposite directions: When price rises, quantity demanded falls; when price falls, quantity demanded rises. In our example, when price rises by 10 percent, the quantity demanded falls by 20 percent. When you divide a *minus 20 percent* by a *positive 10 percent,* you don't get 2; you get −2. Instead of saying that the price elasticity of demand is 2, you might think the price elasticity of demand is −2. However, by convention, economists usually simplify things by using the absolute value of the price elasticity of demand; thus they drop the minus sign.

FORMULA FOR CALCULATING PRICE ELASTICITY OF DEMAND Using percentage changes to calculate price elasticity of demand can lead to conflicting results depending on whether price rises or falls. Therefore, economists use the following formula to calculate price elasticity of demand:[2]

$$E_d = \frac{\dfrac{\Delta Q_d}{Q_{d\ \text{average}}}}{\dfrac{\Delta P}{P_{\text{average}}}}$$

In the formula, ΔQ_d stands for the absolute change in Q_d. For example, if Q_d changes from 50 units to 100 units, then ΔQ_d is 50 units. ΔP stands for the absolute change in price. For example, if price changes from \$12 to \$10, then ΔP is \$2. $Q_{d\ average}$ stands for the average of the two quantities demanded, and $P_{average}$ stands for the average of the two prices.

For the price and quantity demanded data in Exhibit 1, the calculation is:

$$E_d = \frac{\dfrac{50}{75}}{\dfrac{2}{11}} = 3.67$$

Because we use the average price and average quantity demanded in the price elasticity of demand equation, 3.67 may be considered the price elasticity of demand at a point *midway between the two points identified on the demand curve.* For example, in Exhibit 1, 3.67 is the price elasticity of demand between points *A* and *B* on the demand curve.

1. This assumes we are changing price from its current level.
2. This formula is sometimes called the midpoint formula for calculating price elasticity of demand.

EXHIBIT 1

Calculating Price Elasticity of Demand

We identify two points on a demand curve. At point *A*, price is \$12 and quantity demanded is 50 units. At point *B*, price is \$10 and quantity demanded is 100 units. When calculating price elasticity of demand, we use the *average* of the two prices and the *average* of the two quantities demanded. The formula for price elasticity of demand is:

$$E_d = \frac{\dfrac{\Delta Q_d}{Q_{d\ \text{average}}}}{\dfrac{\Delta P}{P_{\text{average}}}}$$

For example, the calculation is:

$$E_d = \frac{\dfrac{50}{75}}{\dfrac{2}{11}} = 3.67$$

Elasticity Is Not Slope

Some tend to think that slope and price elasticity of demand are the same, but they are not. Suppose we identify a third point on the demand curve in Exhibit 1.The following table shows the price and quantity demanded for our three points.

Point	Price	Quantity Demanded
A	\$12	50
B	10	100
C	8	150

To calculate the *price elasticity of demand* between points *A* and *B,* we divide the percentage change in quantity demanded (between the two points) by the percentage change in price (between the two points). Using the price elasticity of demand formula, we get 3.67.

The *slope of the demand curve* between points *A* and *B* is the ratio of the change in the variable on the vertical axis to the change in the variable on the horizontal axis. The slope of the demand curve reflects the change, not a percentage change.

$$\text{Slope} = \frac{\Delta\text{Variable on vertical axis}}{\Delta\text{Variable on horizontal axis}} = \frac{-2}{50} = -0.04$$

Now let's calculate the price elasticity of demand and the slope between points *B* and *C.* The price elasticity of demand is 1.80; the slope is still −0.04.

From Perfectly Elastic to Perfectly Inelastic Demand

Look back at the equation for the elasticity coefficient and think of it as

$$E_d = \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in price}} = \frac{\text{Numerator}}{\text{Denominator}}$$

Focusing on the numerator and denominator, we realize that the numerator can be (1) greater than, (2) less than, or (3) equal to the denominator. These three cases, along with two peripherally related cases, are discussed in the following paragraphs. Exhibits 2 and 3 provide summaries of the discussion.

EXHIBIT 2

Price Elasticity of Demand

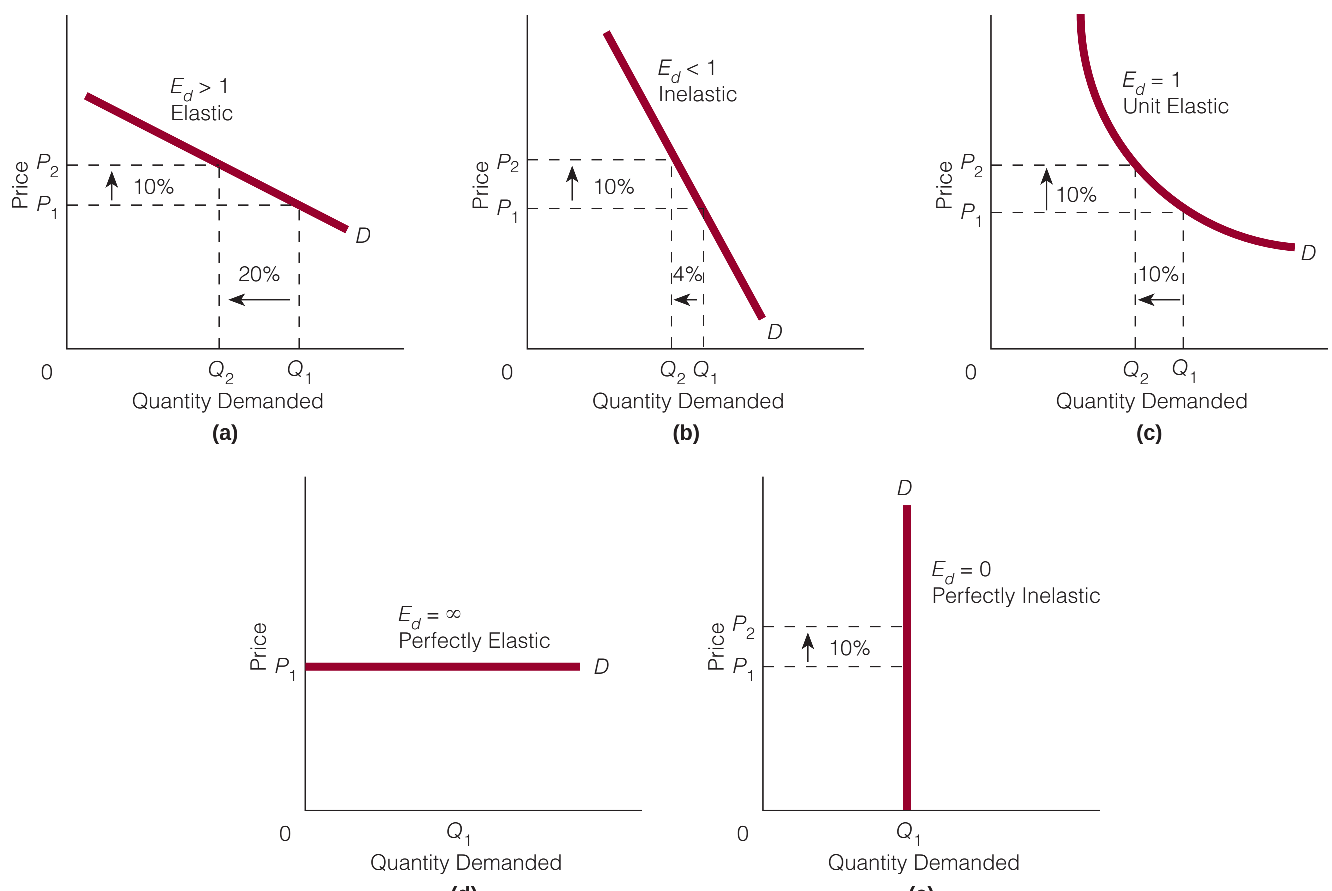
Demand may be elastic, inelastic, unit elastic, perfectly elastic, or perfectly inelastic.

Elasticity Coefficient	Responsiveness of Quantity Demanded to a Change in Price	Terminology
$E_d > 1$	Quantity demanded changes proportionately more than price changes: $\%\Delta Q_d > \%\Delta P$.	Elastic
$E_d < 1$	Quantity demanded changes proportionately less than price changes: $\%\Delta Q_d < \%\Delta P$.	Inelastic
$E_d = 1$	Quantity demanded changes proportionately to price change: $\%\Delta Q_d = \%\Delta P$.	Unit elastic
$E_d = \infty$	Quantity demanded is extremely responsive to even very small changes in price.	Perfectly elastic
$E_d = 0$	Quantity demanded does not change as price changes.	Perfectly inelastic

EXHIBIT 3

Graphical Representation of Price Elasticity of Demand

(a) The percentage change in quantity demanded is greater than the percentage change in price: $E_d > 1$ and demand is elastic. (b) The percentage change in quantity demanded is less than the percentage change in price: $E_d < 1$ and demand is inelastic. (c) The percentage change in quantity demand is equal to percentage change in price: $E_d = 1$ and demand is unit elastic. (d) A small change in price reduces quantity demanded to zero: $E_d = \infty$ and demand is perfectly elastic. (e) A change in price does not change quantity demanded: $E_d = 0$ and demand is perfectly inelastic.



(a) (b) (c) (d) (e)

Elastic Demand
The demand when the percentage change in quantity demanded is greater than the percentage change in price. The quantity demanded changes proportionately more than price changes.

ELASTIC DEMAND ($E_d > 1$) See Exhibit 3(a). If the numerator (percentage change in quantity demanded) is greater than the denominator (percentage change in price), the elasticity coefficient is greater than 1, and demand is elastic. This is elastic demand; that is, the quantity demanded changes proportionately more than price changes. A 10 percent increase in price causes, say, a 20 percent reduction in quantity demanded ($E_d = 2$).

$$\text{Percentage change in quantity demanded} > \text{Percentage change in price} \rightarrow$$
$$E_d > 1 \rightarrow \text{Demand is elastic}$$

Inelastic Demand
The demand when the percentage change in quantity demanded is less than the percentage change in price. The quantity demanded changes proportionately less than price changes.

INELASTIC DEMAND ($E_d < 1$) See Exhibit 3(b). If the numerator (percentage change in quantity demanded) is less than the denominator (percentage change in price), the elasticity coefficient is less than 1, and demand is inelastic. This is inelastic demand; that is, the quantity demanded changes proportionately less than price changes. A 10 percent increase in price causes, say, a 4 percent reduction in the quantity demanded ($E_d = 0.4$).

$$\text{Percentage change in quantity demanded} < \text{Percentage change in price} \rightarrow$$
$$E_d < 1 \rightarrow \text{Demand is inelastic}$$

Unit Elastic Demand
The demand when the percentage change in quantity demanded is equal to the percentage change in price. The quantity demanded changes proportionately to price changes.

UNIT ELASTIC DEMAND ($E_d = 1$) See Exhibit 3(c). If the numerator (percentage change in quantity demanded) equals the denominator (percentage change in price), the elasticity coefficient is 1. This is unit elastic demand; that is, the quantity demanded changes proportionately to price changes. For example, a 10 percent increase in price causes a 10 percent decrease in quantity demanded ($E_d = 1$). In this case, demand exhibits unitary elasticity, or is unit elastic.

$$\text{Percentage change in quantity demanded} = \text{Percentage change in price} \rightarrow$$
$$E_d = 1 \rightarrow \text{Demand is unit elastic}$$

Perfectly Elastic Demand
The demand when a small percentage change in price causes an extremely large percentage change in the quantity demanded (from buying all to buying nothing).

PERFECTLY ELASTIC DEMAND ($E_d = \infty$) See Exhibit 3(d). If quantity demanded is extremely responsive to changes in price, the result is perfectly elastic demand. For example, buyers are willing to buy all units of a seller's good at \$5 per unit but nothing at \$5.10. A small percentage change in price causes an extremely large percentage change in quantity demanded (from buying all to buying nothing). The percentage is so large, in fact, that economists say it is infinitely large.

Perfectly Inelastic Demand
The demand when the quantity demanded does not change as price changes.

PERFECTLY INELASTIC DEMAND ($E_d = 0$) See Exhibit 3(e). If quantity demanded is completely unresponsive to changes in price, the result is perfectly inelastic demand. A change in price causes no change in quantity demanded. For example, suppose the price of *Dogs Love It* dog food rises 10 percent (from \$2 to \$2.20), and Jeremy doesn't buy any less of it per week for his dog. Jeremy's demand for *Dogs Love It* dog food is thus perfectly inelastic between a price of \$2 and \$2.20.

PERFECTLY ELASTIC AND PERFECTLY INELASTIC DEMAND CURVES Even though you are used to seeing a downward sloping demand curve, Exhibit 3 shows two demand curves that are not downward sloping. But aren't all demand curves supposed to be downward sloping because, according to the law of demand, an inverse relationship exists between price and quantity demanded? In the real world, no demand curves are perfectly elastic (horizontal) or perfectly inelastic (vertical) at all prices. Thus, the perfectly elastic and perfectly inelastic demand curves in Exhibit 3 should be viewed as representations of the extreme limits between which all real-world demand curves fall.

However, a few real-world demand curves do *approximate* the perfectly elastic and inelastic demand curves in Exhibit 3(d) and (e); that is, they come very close. For example, the demand for a particular farmer's wheat approximates the perfectly elastic demand curve in panel (d). A later chapter discusses the perfectly elastic demand curve for firms in perfectly competitive markets.

finding ECONOMICS

At the Local Coffee Bar You buy 7 coffees at the local coffee bar each week when the price of a cup of coffee is $2, and you buy 5 coffees a week when the price is $2.50. Where is the economics?

Actually, economics appears in two places. First, the law of demand is visible because you buyer *fewer* cups of coffee at the higher price. Second, calculating your price elasticity of coffee between the lower and higher prices is easy. It is 1.5, which means your demand for coffee is *elastic.*

Price Elasticity of Demand and Total Revenue (Total Expenditure)

Total Revenue (*TR*)
Price times quantity sold.

Total revenue (*TR*) of a seller equals the price of a good times the quantity of the good sold.[3] For example, if the hamburger stand down the street sells 100 hamburgers today at $1.50 each, its total revenue is $150.

Suppose the hamburger vendor raises the price of a hamburger to $2. What do you predict will happen to total revenue? Most people say it will increase in the widespread belief that higher prices bring higher total revenue. However, total revenue may increase, decrease, or remain constant. Suppose price rises to $2, but because of the higher price, the quantity of hamburgers sold falls to 50. Total revenue is now $100 (whereas it was $150). Whether total revenue rises, falls, or remains constant after a price change depends on whether the percentage change in the quantity demanded is less than, greater than, or equal to the percentage change in price. Thus, price elasticity of demand influences total revenue.

Elastic Demand and Total Revenue

If demand is elastic, the percentage change in quantity demanded is greater than the percentage change in price. Given a price rise of, say, 5 percent, the quantity demanded falls by more than 5 percent—say, 8 percent—having an effect on total revenue. Because quantity demanded falls, or sales fall off, by a greater percentage than the percentage rise in price, total revenue decreases. In short, if demand is elastic, a price rise decreases total revenue.

$$\text{Demand is elastic: } P\uparrow \rightarrow TR\downarrow$$

If demand is elastic and price falls, the quantity demanded rises (price and quantity demanded are inversely related) by a greater percentage than the percentage fall in price, causing total revenue to increase. In short, if demand is elastic, a price fall increases total revenue.

$$\text{Demand is elastic: } P\downarrow \rightarrow TR\uparrow$$

3. In this discussion, "total revenue" and "total expenditure" are equivalent terms. *Total revenue* equals price times the quantity sold. *Total expenditure* equals price times the quantity purchased. If something is sold, it must be purchased, making total revenue equal to total expenditure. The term "total revenue" is used when looking at things from the point of view of the sellers in a market. The term "total expenditure" is used when looking at things from the point of view of the buyers in a market. Buyers make expenditures; sellers receive revenues.

EXHIBIT 4

Price Elasticity of Demand and Total Revenue

In (a) demand is elastic between points *A* and *B*. A fall in price, from P_1 to P_2, will increase the size of the total revenue rectangle from $0P_1AQ_1$ to $0P_2BQ_2$. A rise in price, from P_2 to P_1, will decrease the size of the total revenue rectangle from $0P_2BQ_2$ to $0P_1AQ_1$. In other words, when demand is elastic, price and total revenue are inversely related. In (b) demand is inelastic between points *A* and *B*. A fall in price, from P_1 to P_2, will decrease the size of the total revenue rectangle from $0P_1AQ_1$ to $0P_2BQ_2$. A rise in price, from P_2 to P_1, will increase the size of the total revenue rectangle from $0P_2BQ_2$ to $0P_1AQ_1$. In other words, when demand is inelastic, price and total revenue are directly related.

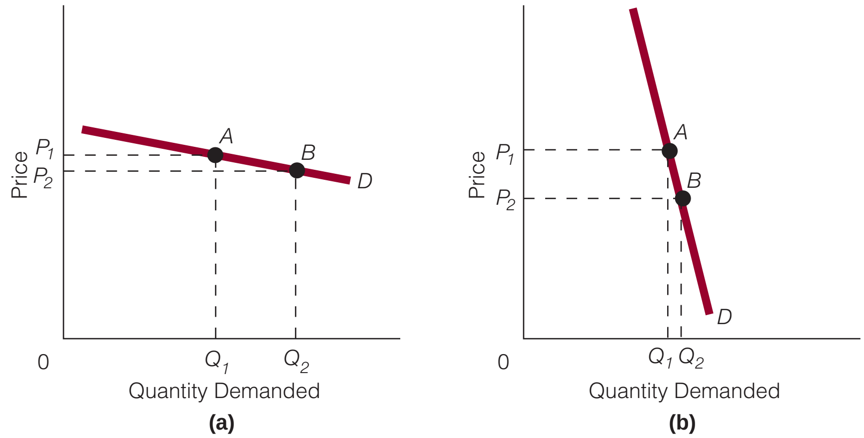


Exhibit 4(a) shows the relationship between a change in price and total revenue if demand is elastic. Between points *A* and *B* on the demand curve, demand is elastic. At point *A*, price is P_1 and the quantity demanded is Q_1. Total revenue is equal to the rectangle $0P_1AQ_1$. Now suppose we lower price to P_2. After the price decline, total revenue is now the rectangle $0P_2BQ_2$, which, as you can see, is larger than rectangle $0P_1AQ_1$. In other words, if demand is elastic and price declines, total revenue will rise.

Of course, when price moves in the opposite direction, rising from P_2 to P_1, then the total revenue rectangle becomes smaller. In other words, if demand is elastic and price rises, total revenue will fall.

INELASTIC DEMAND AND TOTAL REVENUE If demand is inelastic, the percentage change in quantity demanded is less than the percentage change in price. If price rises, quantity demanded falls but by a smaller percentage than the percentage rise in price. As a result, total revenue increases. So if demand is inelastic, a price rise increases total revenue. However, if price falls, the quantity demanded rises by a smaller percentage than the percentage fall in price, and total revenue decreases. If demand is inelastic, a price fall decreases total revenue; price and total revenue are directly related.

Demand is inelastic: $P\uparrow \rightarrow TR\uparrow$

Demand is inelastic: $P\downarrow \rightarrow TR\downarrow$

You can see the relationship between inelastic demand and total revenue in Exhibit 4(b), where demand is inelastic between points *A* and *B* on the demand curve. If we start at P_1 and lower price to P_2, the total revenue rectangle goes from $0P_1AQ_1$ to the smaller total revenue rectangle $0P_2BQ_2$. In other words, if demand is inelastic and price falls, total revenue will fall.

Drug Busts and Crime

AP PHOTO/CP, NATHAN DENETTE

Most people agree that the sale or possession of drugs such as cocaine and heroin should be illegal, but sometimes laws may have unintended effects. Do drug laws have unintended effects? Let's analyze the enforcement of drug laws in terms of supply, demand, and price elasticity of demand.

Suppose for every $100 of illegal drug sales, 60 percent of the $100 paid is obtained by illegal means. That is, buyers of $100 worth of illegal drugs obtain $60 of the purchase price from criminal activities such as burglaries, muggings, and similar illegal acts.

In Exhibit 5, the demand for and supply of cocaine in a particular city are represented by D_1 and S_1. The equilibrium price of $50 an ounce and the equilibrium quantity of 1,000 ounces give cocaine dealers a total revenue of $50,000. If 60 percent of this total revenue is obtained by the criminal activities of cocaine buyers, then $30,000 worth of crime has been committed to purchase the $50,000 worth of cocaine.

A drug bust in the city reduces the supply of cocaine. The supply curve shifts leftward from S_1 to S_2, the equilibrium price rises to $120 an ounce, and the equilibrium quantity falls to 600 ounces. The demand for cocaine is inelastic between the two prices, at 0.607. When demand is inelastic, an increase in price will raise total revenue. The total revenue received by cocaine dealers is now $72,000. If, again, we assume that 60 percent of the total revenue paid comes from criminal activity, then $43,200 worth of crime has been committed to purchase the $72,000 worth of cocaine.

Therefore, if the demand for cocaine is inelastic and people commit crimes to buy drugs, then a drug bust can actually increase the amount of drug-related crime. Obviously, this is an unintended effect of the enforcement of drug laws.

EXHIBIT 5

Drug Busts and Drug-Related Crime

In the exhibit, P = price of cocaine, Q = quantity of cocaine, and TR = total revenue from selling cocaine. At a price of $50 for an ounce of cocaine, equilibrium quantity is 1,000 ounces and total revenue is $50,000. If $60 of every $100 cocaine purchase is obtained through crime, then $30,000 worth of crime is committed to purchase $50,000 worth of cocaine. As a result of a drug bust, the supply of cocaine shifts leftward; the price rises and the quantity falls. Because we have assumed the demand for cocaine is inelastic, total revenue rises to $72,000. Sixty percent of this comes from criminal activities, or $43,200.

	P	Q	TR	Dollar Amount of TR Obtained Through Crime
Before Drug Bust	$50	1,000	$50,000	$30,000
After Drug Bust	120	600	72,000	43,200

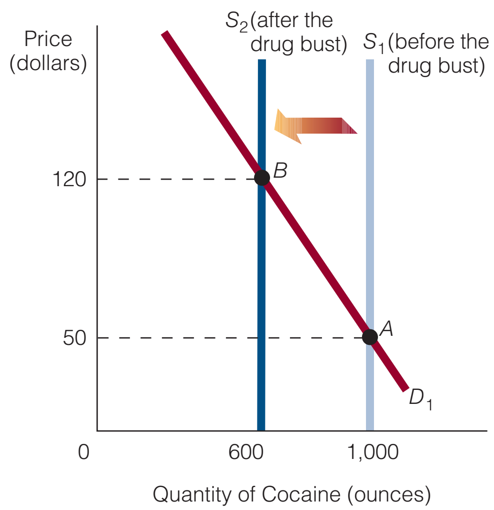
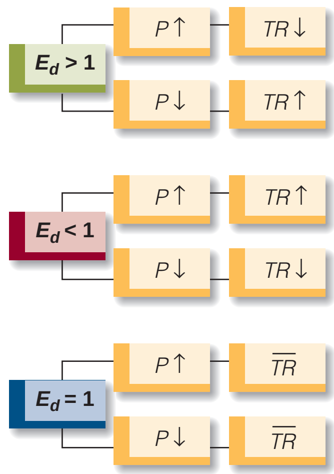


EXHIBIT 6

Elasticities, Price Changes, and Total Revenue

If demand is elastic, a price rise leads to a decrease in total revenue (*TR*), and a price fall leads to an increase in total revenue. If demand is inelastic, a price rise leads to an increase in total revenue and a price fall leads to a decrease in total revenue. If demand is unit elastic, a rise or fall in price does not change total revenue.



Moving from the lower price, P_2, to the higher price, P_1, does just the opposite. If demand is inelastic and price rises, the total revenue rectangle becomes larger; that is, total revenue rises.

UNIT ELASTIC DEMAND AND TOTAL REVENUE If demand is unit elastic, the percentage change in quantity demanded equals the percentage change in price. If price rises, the quantity demanded falls by the same percentage as the percentage rise in price. Total revenue does not change. If price falls, the quantity demanded rises by the same percentage as the percentage fall in price. Again, total revenue does not change. If demand is unit elastic, a rise or fall in price leaves total revenue unchanged.

For a review of the relationship between price elasticity of demand and total revenue, see Exhibit 6.

thinking Like AN ECONOMIST

Price and Total Revenue Ask some people what will happen if a seller raises the selling price of a product, and they will tell you that total revenue is bound to rise: "Sellers want higher prices because they take in more money at higher prices than at lower prices." As you have just learned, this is not always true. If demand is inelastic and price rises, then total revenue rises too. But if demand is elastic and price rises, then total revenue falls. Finally, if demand is unit elastic and price rises, then total revenue remains unchanged. Simply put, saying that total revenue always rises as sellers raise prices is a myth.

finding ECONOMICS

In an Earthquake Suppose an earthquake in Los Angeles destroys 10 percent of the apartment stock. Where is the economics?

As a result of the earthquake, we can expect the average rent for an apartment in the city to rise. Some people go further and argue that because of the earthquake, landlords will take in more total revenue than they did before the earthquake, but this is not necessarily true. Suppose the rent before the earthquake is $2,000 and 100,000 apartments are rented. The monthly total revenue is $200 million. Now suppose the earthquake reduces the number of apartments to 90,000. As a result of a lower supply of apartments, the average rent rises to, say, $2,100 a month. At this higher rent per month, the monthly total revenue from apartments is $189 million. Total revenue is lower because the demand for apartments between the lower rent and the higher rent is elastic. If demand is elastic and price rises, then total revenue falls.

SELF-TEST

(Answers to Self-Test questions are in Answers to Self-Test Questions at the back of the book.)

1. On Tuesday, the price and quantity demanded are $7 and 120 units, respectively. Ten days later, the price and quantity demanded are $6 and 150 units, respectively. What is the price elasticity of demand between the $7 and $6 prices?
2. What does a price elasticity of demand of 0.39 mean?
3. Identify what happens to total revenue as a result of each of the following:
   a. Price rises and demand is elastic.
   b. Price falls and demand is inelastic.
   c. Price rises and demand is unit elastic.
   d. Price rises and demand is inelastic.
   e. Price falls and demand is elastic.
4. Alexi says, "When a seller raises his price, his total revenue rises." What is Alexi implicitly assuming?

ELASTICITY: PART 2

This section discusses the elasticity ranges of a straight-line downward-sloping demand curve and the determinants of price elasticity of demand.

Price Elasticity of Demand Along a Straight-Line Demand Curve

The price elasticity of demand for a straight-line downward-sloping demand curve varies from highly elastic to highly inelastic. Consider the price elasticity of demand at the upper range of the demand curve in Exhibit 7(a). Whether the price falls from $9 to $8 or rises from $8 to $9, using the price elasticity of demand formula, we calculate the price elasticity of demand as 5.66.[4]

Now consider the price elasticity of demand at the lower range of the demand curve in Exhibit 7(a). Whether the price falls from $3 to $2 or rises from $2 to $3, we calculate the price elasticity of demand as 0.33.

In other words, along the range of the demand curve identified, price elasticity goes from being greater than 1 (5.66) to being less than 1 (0.33). Obviously, on its way from being greater than 1 to being less than 1, price elasticity of demand must be equal to 1. In Exhibit 7(a), we have identified the price elasticity of demand as equal to 1 at the *midpoint* of the demand curve.[5]

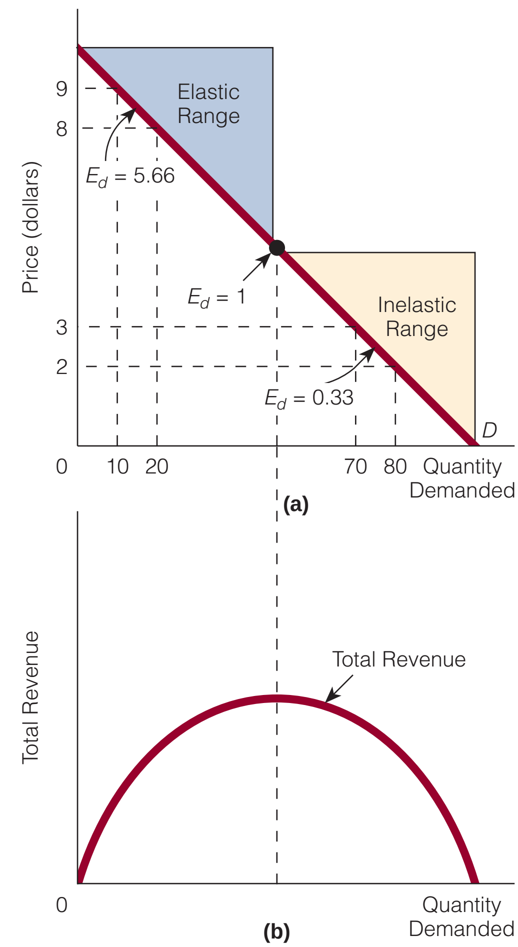
The elastic and inelastic ranges along the straight-line downward-sloping demand curve can be related to a total revenue curve [Exhibit 7(b)]. If we start in the elastic range of the demand curve in Exhibit 7(a) and lower price, total revenue rises, as shown in Exhibit 7(b). That is, as price is coming down within the elastic range of the demand curve in part (a), total revenue is rising in part (b).

When price has fallen enough that we move into the inelastic range of the demand curve in part (a), further price declines simply lower total revenue, as shown in part (b). Therefore, total revenue is at its highest—its peak—when price elasticity of demand equals 1.

EXHIBIT 7

Price Elasticity of Demand Along a Straight-Line Demand Curve

In (a), the price elasticity of demand varies along the straight-line downward-sloping demand curve. There is an elastic range to the curve (where E_d . 1) and an inelastic range (where E_d , 1). At the midpoint of any straight-line downward-sloping demand curve, price elasticity of demand is equal to 1 (E_d = 1). Part (b) shows that in the elastic range of the demand curve, total revenue rises as price is lowered. In the inelastic range of the demand curve, further price declines result in declining total revenue. Total revenue reaches its peak when price elasticity of demand equals 1.



4. Keep in mind that our formula uses the average of the two prices and the average of the two quantities demanded. You may want to look back at the formula to refresh your memory.
5. For any straight-line downward-sloping demand curve, price elasticity of demand equals 1 at the midpoint of the curve.

Determinants of Price Elasticity of Demand

Four factors are relevant to the determination of price elasticity of demand:

1. Number of substitutes
2. Necessities versus luxuries
3. Percentage of one's budget spent on the good
4. Time

Because all four factors interact, we hold all other things constant as we discuss each.

NUMBER OF SUBSTITUTES Suppose good A has 2 substitutes and good B has 15 substitutes. Assume that each of the 2 substitutes for good A is as good a substitute (or a good enough substitute) for that good as each of the 15 substitutes is for good B.

Let the price of each good rise by 10 percent. The quantity demanded of each good decreases. Will the percentage change in the quantity demanded of good A be greater or less than the percentage change in quantity demanded of good B? In other words, will the quantity demanded be more responsive to the 10 percent price rise for the good that has 2 substitutes (good A) or for the good that has 15 substitutes (good B)? The answer is the good with 15 substitutes, good B. The reason is that the greater the opportunities are for substitution (good B has more substitutes than good A), the greater the cutback in the quantity of the good purchased will be as its price rises. When the price of good A rises 10 percent, people can turn to 2 substitutes. The quantity demanded of good A falls, but not by as much as if 15 substitutes had been available, as there are for good B.

The relationship between the availability of substitutes and price elasticity is clear:

- The more substitutes a good has, the higher the price elasticity of demand will be.
- The fewer substitutes a good has, the lower the price elasticity of demand.

For example, the price elasticity of demand for Chevrolets is higher than for all cars because there are more substitutes for Chevrolets than there are for cars. Everything that is a substitute for a car (taking a bus, getting on a train, walking, bicycling, etc.) is also a substitute for a specific type of car, such as a Chevrolet, but some substitutes for a Chevrolet (Ford, Toyota, Chrysler, Mercedes-Benz, etc.) are not substitutes for a car. They are simply types of cars. There are more substitutes for this economics textbook than there are for textbooks. There are more substitutes for Coca-Cola than there are for soft drinks.

Thus, this relationship can be restated as:

- The more broadly defined the good is, the fewer the substitutes it will have.
- The more narrowly defined the good, the more the substitutes.

NECESSITIES VERSUS LUXURIES Generally, the more that a good is considered a luxury (a good that we can do without) rather than a necessity (a good that we cannot do without), the higher the price elasticity of demand will be. For example, consider two goods: jewelry and a medicine for controlling high blood pressure. If the price of jewelry rises, cutting back on purchases is easy; no one really needs jewelry to live. However, if the price of the medicine for controlling one's high blood pressure rises, cutting back is not so easy. We expect the price elasticity of demand for jewelry to be higher than for high blood pressure medicine.

PERCENTAGE OF ONE'S BUDGET SPENT ON THE GOOD Claire Rossi has a monthly budget of $3,000. Of this monthly budget, she spends $3 per month on pens and $400 per month on dinners at restaurants. In terms of percentages, she spends 0.1 percent of her monthly budget on pens and 13 percent of her monthly budget on dinners at restaurants. Suppose both the price of pens and the price of dinners at restaurants double. Claire is likely to be more responsive to the change in the price of restaurant dinners than to the change in the price of pens. Claire feels the pinch of a doubling in the price of a good on which she spends 0.1 percent of her budget a lot less than a doubling in price of a good on which she spends 13 percent. Claire is more likely to ignore the increased price of pens than she is to ignore the heightened price of restaurant dinners. Buyers are (and thus the quantity demanded is) more responsive to price as the percentage of their budget that goes for the purchase of the good increases.

- The greater the percentage of one's budget that goes to purchase a good, the higher the price elasticity of demand will be.
- The smaller the percentage of one's budget that goes to purchase a good, the lower the price elasticity of demand will be.

TIME As time passes, buyers have greater opportunities to be responsive to a price change. If the price of electricity went up today and you knew about it, you probably would not change your consumption of electricity today as much as you would three months from today. As time passes, you have more chances to change your consumption by finding substitutes (natural gas), changing your lifestyle (buying more blankets and turning down the thermostat at night), and so on.

- The more time that passes (since the price change), the higher the price elasticity of demand for the good will be.
- The less time that passes, the lower the price elasticity of demand for the good will be.

In other words, the price elasticity of demand for a good is higher in the long run than in the short run.

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In Apples and Pens Parker buys a lot more apples when their price falls, but he doesn't buy many more pens when the price of pens falls. Where is the economics?

Obviously, Parker's price elasticity of demand is different for apples than for pens. Even without percentage changes, from the little information given, Parker's price elasticity of demand for apples seems to be greater than his price elasticity of demand for pens.

SELF-TEST

1. If good X has 7 substitutes and demand is inelastic, then if there are 9 substitutes for good X, will demand be elastic? Explain your answer.
2. Price elasticity of demand is predicted to be higher for which good of the following combinations of goods? Explain your answers.
   a. Dell computers or computers
   b. Heinz ketchup or ketchup
   c. Perrier water or water

Mad Men and Price Elasticity of Demand

The AMC television show *Mad Men* is about people who work in a Madison Avenue advertising agency in the early 1960s. The creative talent behind the success of the agency is Don Draper. If you watch Don Draper at work, you soon learn that one of his talents is his ability to make the consumer feel some connection to the product he is advertising. In other words, the product he is advertising—whether it is potato chips, a camera, or a cigarette brand—is unique in that it "makes" the consumer feel some special connection to it. For example, here is what Don Draper says in a meeting about the Kodak slide projector:


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> Well, technology is a glittering lure. But there is the rare occasion when the public can be engaged on a level beyond flash, if they have a *sentimental bond* with the product.
>
> [In] my first job, I was in-house at a fur company, with this old-pro copywriter, a Greek named Teddy. Teddy told me the most important idea in advertising is new. Creates an itch. You simply put your product in there as a kind of calamine lotion.
>
> But he also talked about a deeper bond with the product. Nostalgia. It's delicate, but potent. *(lights switch off) (changes slide on the slide projector)*
>
> Teddy told me that in Greek, "nostalgia" literally means "the pain from an old wound." *(changes slide)*
>
> It's a twinge in your heart far more powerful than memory alone. *(changes slide)*
>
> This device [Kodak slide projector] isn't a spaceship, it's a time machine. *(changes slide)*
>
> It goes backwards, forwards, *(changes slide)* takes us to a place where we ache to go again. *(changes slide)*
>
> It's not called the wheel. It's called the carousel. *(changes slide)*
>
> It lets us travel the way a child travels. *(changes slide)*
>
> Round and around, and back home again. *(changes slide)*
>
> To a place where we know we are loved. *(changes slide)*

What is the economic logic behind designing an ad campaign that makes the consumer feel some connection to the product being advertised? If the campaign is successful, it can change the price elasticity of demand of the product. Suppose10 products (A–J) are close substitutes for one other. Don Draper is hired to think up an ad campaign for product A. If Draper can come up with a campaign that gets consumers feeling some special connection to product A, he can differentiate product A from its substitutes. In other words, consumers may come to think that product B or C aren't really good substitutes for product A, because they don't have the same connection to B and C as they do to A.

At that point, we know that the fewer substitutes a product has (even if only in the minds of buyers), the lower its price elasticity of demand will be. If Draper can effectively eliminate the substitutes for product A, he effectively lowers the price elasticity of demand for product A.

Now if he can lower it enough to bring it below 1, then the demand for the good is *inelastic*. And if demand is inelastic, you can raise the price of the product and have greater total revenue too.

But will profit rise? At a higher price for the product, fewer units will be sold, and if fewer units are sold, then fewer need to be produced; so total costs will decline.

In the end, the story goes like this: (1) Don Draper advertises the product so that consumers feel some connection to the product. (2) Because consumers feel a connection to the product, they don't see as many substitutes for the product as they once did. (3) Because consumers see fewer substitutes for the product, the price elasticity of demand for the product declines. (4) If it declines enough to make the demand for the product inelastic, then the seller of the product can raise the price and increase total revenue. (5) Fewer units of the product will be sold at the higher price, which means fewer units have to be produced; so total costs decline; (6) If total revenue rises and total costs decline, profit rises.

Other Elasticity Concepts

This section looks at three other elasticities:

- Cross elasticity of demand
- Income elasticity of demand
- Price elasticity of supply

Cross Elasticity of Demand

Cross elasticity of demand measures the responsiveness in the quantity demanded of one good to changes in the price of another good. It is calculated by dividing the percentage change in the quantity demanded of one good by the percentage change in the price of another.

Cross Elasticity of Demand
A measure of the responsiveness in quantity demanded of one good to changes in the price of another good.

$$E_c = \frac{\text{Percentage change in quantity demanded of one good}}{\text{Percentage change in price of another good}}$$

where E_c stands for the coefficient of cross elasticity of demand, or elasticity coefficient.

This concept is often used to determine whether two goods are substitutes or complements and the degree to which one good is a substitute for or a complement to the other. Consider Skippy peanut butter and Jif peanut butter. Suppose that when the price of Jif increases by 10 percent, the quantity demanded of Skippy increases by 45 percent. The cross elasticity of demand for Skippy with respect to the price of Jif is:

$$E_c = \frac{\text{Percentage change in quantity demanded of Skippy}}{\text{Percentage change in price of Jif}}$$

$$E_c = \frac{45}{10} = 4.5$$

In this case, the cross elasticity of demand is a positive 4.5. When the cross elasticity of demand is positive, the percentage change in the quantity demanded of one good (in the numerator) moves in the same direction as the percentage change in the price of the other good (in the denominator). This is a characteristic of goods that are substitutes. As the price of Jif rises, the demand curve for Skippy shifts rightward, causing the quantity demanded of Skippy to increase at every price. So if E_c . 0, the two goods are substitutes.

$$E_c\ .\ \ 0 \rightarrow \text{Goods are substitutes}$$

If the elasticity coefficient is negative, E_c , 0, then the two goods are complements.

$$E_c\ ,\ \ 0 \rightarrow \text{Goods are complements}$$

A negative cross elasticity of demand occurs when the percentage change in the quantity demanded of one good (numerator) and the percentage change in the price of another good (denominator) move in opposite directions. For example, suppose the price of cars increases by 5 percent, and the quantity demanded of car tires decreases by 10 percent. Calculating the cross elasticity of demand, we have 2 10 percent ÷ 5 percent = 2 2. Cars and car tires are complements.

The concept of cross elasticity of demand can be very useful. A company that sells cheese might ask what goods are substitutes for cheese. The answer would help the company identify its competitors. The company could identify substitutes for cheese by calculating the cross elasticity of demand between cheese and other goods. A positive cross elasticity of demand would indicate that the two goods were substitutes, and the higher the cross elasticity of demand is, the greater the degree of substitution will be.

Income Elasticity of Demand

Income Elasticity of Demand
A measure of the responsiveness of quantity demanded to changes in income.

Income elasticity of demand measures the responsiveness of quantity demanded to changes in income. It is calculated by dividing the percentage change in quantity demanded of a good by the percentage change in income.

$$E_y = \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in income}}$$

where E_y = coefficient of income elasticity of demand, or elasticity coefficient.

Income elasticity of demand is positive, E_y . 0, for a *normal good.* Recall that a normal good is one whose demand and thus whose quantity demanded increase, given an increase in income. Thus, for a normal good, the variables in the numerator and denominator in the income elasticity of demand formula move in the same direction.

$$E_y \;.\; 0 \rightarrow \text{Normal good}$$

In contrast to a normal good, the demand for an *inferior good* decreases as income increases. Income elasticity of demand for an inferior good is negative, E_y , 0.

$$E_y \;,\; 0 \rightarrow \text{Inferior good}$$

We calculate the income elasticity of demand for a good using the same approach we used to calculate price elasticity of demand.

$$E_y = \frac{\dfrac{Q_d}{Q_{d\ \text{average}}}}{\dfrac{Y}{Y_{\text{average}}}}$$

where $Q_{d\ \text{average}}$ is the average quantity demanded, and Y_{average} is the average income.

Suppose income increases from \$500 to \$600 per month, and as a result quantity demanded of good X increases from 20 units to 30 units per month. We have

$$E_y = \frac{\dfrac{10}{25}}{\dfrac{100}{550}} = 2.2$$

Income Elastic
The condition when the percentage change in quantity demanded of a good is greater than the percentage change in income.

Income Inelastic
The condition when the percentage change in quantity demanded of a good is less than the percentage change in income.

Income Unit Elastic
The condition when the percentage change in quantity demanded of a good is equal to the percentage change in income.

E_y is a positive number; so good X is a normal good. Also:

- Because E_y . 1, demand for good X is said to be **income elastic**. In other words, the percentage change in quantity demanded of the good is greater than the percentage change in income.
- If E_y , 1, the demand for the good is said to be **income inelastic**.
- If E_y = 1, then the demand for the good is **income unit elastic**.

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Greenhouse Gases and Gas-Efficient Cars

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Here is an often heard argument: (1) Greenhouse gases generated by human activity, such as driving cars, are causing global warming. (2) If the car industry were forced to produce more gas-efficient cars, we would burn less gas. (3) Therefore, fewer greenhouses gases would be emitted.

To this argument an economist might respond, "It's not guaranteed to turn out that way." Suppose that the price of a gallon of gasoline is \$3.80, that one car gets 16 miles to a gallon, and that another car gets 32 miles a gallon. Lyle, who owns the car that gets 16 miles to a gallon, travels an average of 160 miles a week; so he needs to buy 10 gallons of gasoline each week for a total cost of \$38. His price for driving each mile is 24¢ (10 gallons × \$3.80 = \$38 and \$38 ÷ 160 miles = 24¢ per mile).

Lyle trades in his car for one that gets 32 miles a gallon. If he continues to travel an average of 160 miles a week, he now needs to buy only 5 gallons of gasoline each week. With less gas purchased, less gas is used (to drive his car), and fewer greenhouse gases are emitted. Things work out just as intended.

But one thing is being overlooked. The cost of driving a mile is lower for Lyle when he drives the 32-mile-per-gallon car than when he drives the 16-mile-per-gallon car. When he drives the 16-mile-per-gallon car, he pays 24¢ to drive a mile. When he drives the 32-mile-per-gallon car, he pays only 12¢ to drive a mile (5 gallons × \$3.80 = \$19 and \$19 ÷ 160 miles = 12¢ per mile). Lyle must still drive 160 miles to and from work each week, but he doesn't necessarily continue to drive *only* 160 miles each week when the price of driving a mile drops to 12¢. If Lyle's demand curve for driving is downward sloping, we can expect him to drive more miles at the lower price per mile.

Suppose Lyle's demand for driving is elastic. In other words, the percentage change in the miles Lyle drives is greater than the percentage change in the price of driving. Let's say that as the price of driving falls from 24¢ to 12¢ a mile, Lyle increases his driving from 160 miles a week to 370 miles a week. At 24¢ a mile and 160 miles a week, Lyle used to purchase and use 10 gallons of gas. At 12¢ a mile and 370 miles a week, Lyle purchases and uses 11.56 gallons of gas (370 miles ÷ 32 miles per gallon = 11.56 gallons). Because more greenhouse gases are emitted using 11.56 gallons of gas a week than when using 10 gallons of gas a week, we can see that Lyle's gas-efficient car doesn't really lower greenhouse gas emissions. In fact, if everyone is like Lyle, gas-efficient cars will actually increase greenhouse gases in the atmosphere. (Obviously, things don't have to turn out this way. Lyle's demand for driving could be inelastic.)

Price Elasticity of Supply

Price elasticity of supply measures the responsiveness of quantity supplied to changes in price. It is calculated by dividing the percentage change in quantity supplied of a good by the percentage change in the price of the good.

Price Elasticity of Supply
A measure of the responsiveness of quantity supplied to changes in price.

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

where E_s stands for the coefficient of price elasticity of supply, or elasticity coefficient. We use the same approach to calculate the price elasticity of supply that we used to calculate the price elasticity of demand.

In addition, supply can be classified as elastic, inelastic, unit elastic, perfectly elastic, or perfectly inelastic (Exhibit 8).

- Elastic supply (E_s . 1) refers to a percentage change in quantity supplied that is greater than the percentage change in price.

Percentage change in quantity supplied . Percentage change in price →

E_s . 1 → Elastic supply

- Inelastic supply (E_s , 1) refers to a percentage change in quantity supplied that is less than the percentage change in price.

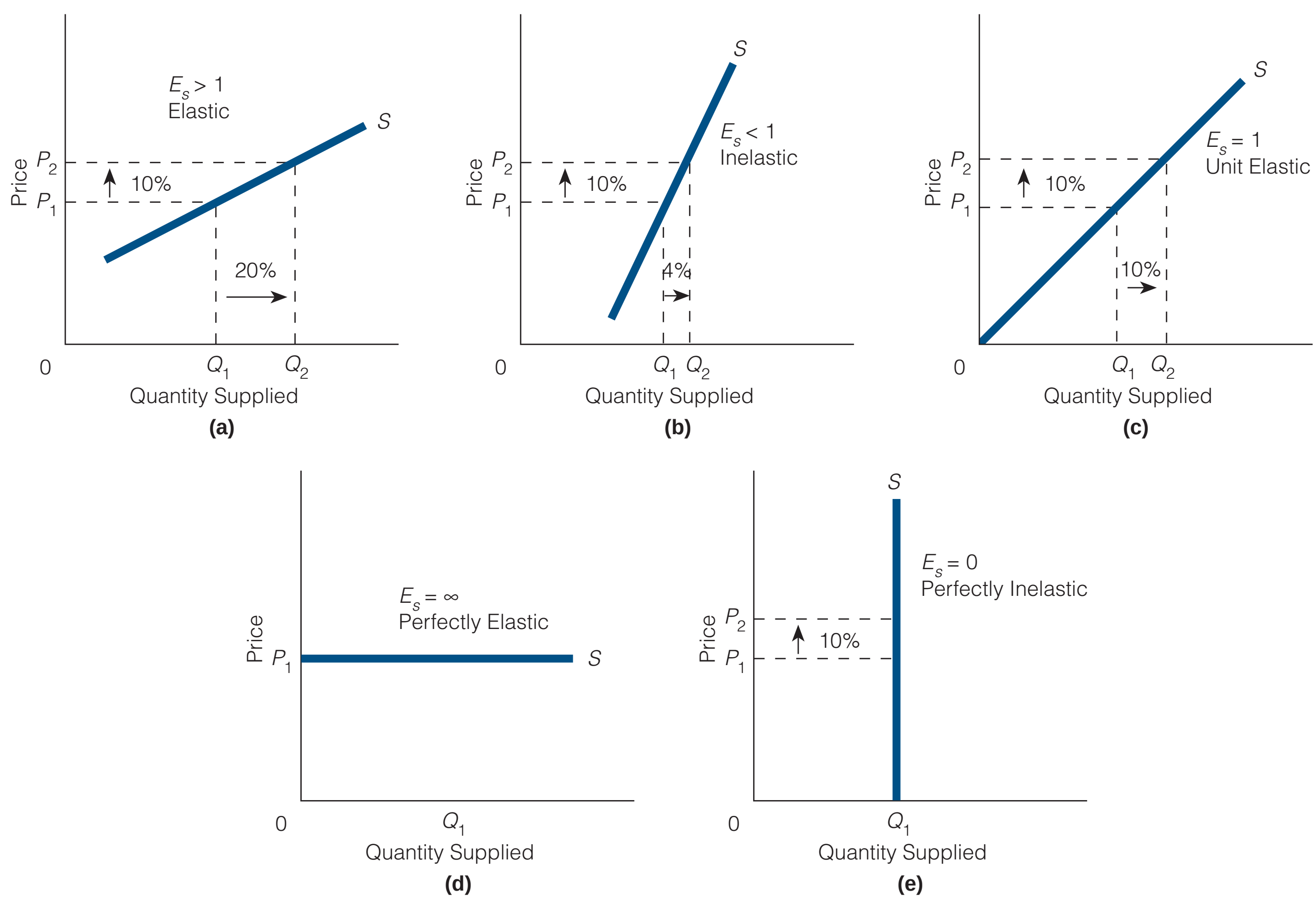
Percentage change in quantity supplied , Percentage change in price →

E_s , 1 → Inelastic supply

EXHIBIT 8

Price Elasticity of Supply

(a) The percentage change in quantity supplied is greater than the percentage change in price: E_s . 1 and supply is elastic. (b) The percentage change in quantity supplied is less than the percentage change in price: E_s , 1 and supply is inelastic. (c) The percentage change in quantity supplied is equal to the percentage change in price: E_s = 1 and supply is unit elastic. (d) A small change in price changes quantity supplied by an infinite amount: $E_s = \infty$ and supply is perfectly elastic. (e) A change in price does not change quantity supplied: E_s = 0 and supply is perfectly inelastic.



- Unit elastic supply ($E_s = 1$) refers to a percentage change in quantity supplied that is equal to the percentage change in price.

$$\text{Percentage change in quantity supplied} = \text{Percentage change in price} \rightarrow$$
$$E_s = 1 \rightarrow \text{Unit elastic supply}$$

- In the case of perfectly elastic supply ($E_s = \infty$), a small change in price changes the quantity supplied by an infinitely large amount (and thus the supply curve, or a portion of the overall supply curve, is horizontal).
- In the case of perfectly inelastic supply ($E_s = 0$), a change in price brings no change in quantity supplied (and thus the supply curve, or a portion of the overall supply curve, is vertical).

See Exhibit 9 for a summary of the elasticity concepts.

Price Elasticity of Supply and Time

The longer the period of adjustment is to a change in price, the higher the price elasticity of supply will be. (We are referring to goods whose quantity supplied can increase with time, a characteristic of most goods. It does not, however, cover, say, original Picasso paintings.) The obvious reason is that additional production takes time or may be impossible.

For example, suppose that the demand for new housing increases in your city and that the increase occurs all at once on Tuesday, placing upward pressure on the price of housing. The number of houses supplied will not be much different on Saturday than it was on Tuesday. It will take time for suppliers to determine whether the increase in demand is permanent. If they decide it is temporary, not much will change. If contractors decide it

EXHIBIT 9

Summary of the Four Elasticity Concepts

Type	Calculation	Possibilities	Terminology
Price elasticity of demand	$\dfrac{\text{Percentage change in quantity demanded}}{\text{Percentage change in price}}$	E_d . 1	Elastic
		E_d , 1	Inelastic
		$E_d = 1$	Unit elastic
		$E_d = \infty$	Perfectly elastic
		$E_d = 0$	Perfectly inelastic
Cross elasticity of demand	$\dfrac{\text{Percentage change in quantity demanded of one good}}{\text{Percentage change in price of another good}}$	E_c , 0	Complements
		E_c . 0	Substitutes
Income elasticity of demand	$\dfrac{\text{Percentage change in quantity demanded}}{\text{Percentage change in income}}$	E_y . 0	Normal good
		E_y , 0	Inferior good
		E_y . 1	Income elastic
		E_y , 1	Income inelastic
		$E_y = 1$	Income unit elastic
Price elasticity of supply	$\dfrac{\text{Percentage change in quantity supplied}}{\text{Percentage change in price}}$	E_s . 1	Elastic
		E_s , 1	Inelastic
		$E_s = 1$	Unit elastic
		$E_s = \infty$	Perfectly elastic
		$E_s = 0$	Perfectly inelastic