CHAPTER 5: ELASTICITY

5.1 - ELASTICITY IN AREAS OTHER THAN PRICE

Learning Objectives

- Calculate the income elasticity of demand and the cross-price elasticity of demand
- Calculate the elasticity in labour and financial capital markets through an understanding of the elasticity of labour supply and the elasticity of savings
- Apply concepts of price elasticity to real-world situations

The basic idea of elasticity—how a percentage change in one variable causes a percentage change in another variable—does not just apply to the responsiveness quantity supplied and quantity demanded to changes in the price of a product. Recall that quantity demanded (Qd) depends on income, tastes and preferences, the prices of related goods, and so on, as well as price. Similarly, quantity supplied (Qs) depends on factors such as the cost of production, as well as price. We can measure elasticity for any determinant of quantity supplied and quantity supplied and quantity demanded, not just the price.

Income Elasticity of Demand

The income elasticity of demand is the percentage change in quantity demanded divided by the percentage change in income.

Income elasticity of demand = $\frac{\% \text{ change in quantity demanded}}{\% \text{ change in income}}$

For most products, most of the time, the income elasticity of demand is positive: that is, a rise in income will cause an increase in the quantity demanded. This pattern is common enough that we refer to these goods as normal goods. However, for a few goods, an increase in income means that one might purchase less of the

good. For example, those with a higher income might buy fewer hamburgers, because they are buying more steak instead, or those with a higher income might buy less cheap wine and more imported beer. When the income elasticity of demand is negative, we call the good an inferior good.

We introduced the concepts of normal and inferior goods in Demand and Supply. A higher level of income causes a demand curve to shift to the right for a normal good, which means that the income elasticity of demand is positive. How far the demand shifts depends on the income elasticity of demand. A higher income elasticity means a larger shift. However, for an inferior good, that is, when the income elasticity of demand is negative, a higher level of income would cause the demand curve for that good to shift to the left. Again, how much it shifts depends on how large the (negative) income elasticity is.

Cross-Price Elasticity of Demand

A change in the price of one good can shift the quantity demanded for another good. If the two goods are complements, like bread and peanut butter, then a drop in the price of one good will lead to an increase in the quantity demanded of the other good. However, if the two goods are substitutes, like plane tickets and train tickets, then a drop in the price of one good will cause people to substitute toward that good, and to reduce consumption of the other good. Cheaper plane tickets lead to fewer train tickets, and vice versa.

The cross-price elasticity of demand puts some meat on the bones of these ideas. The term "cross-price" refers to the idea that the price of one good is affecting the quantity demanded of a different good. Specifically, the cross-price elasticity of demand is the percentage change in the quantity of good A that is demanded as a result of a percentage change in the price of good B.

 $\text{Cross-price elasticity of demand} = \frac{\% \text{ change in } Q_d \text{ of good } A}{\% \text{ change in price of good B}}$

Substitute goods have positive cross-price elasticities of demand: if good A is a substitute for good B, like coffee and tea, then a higher price for B will mean a greater quantity consumed of A. Complement goods have negative cross-price elasticities: if good A is a complement for good B, like coffee and sugar, then a higher price for B will mean a lower quantity consumed of A.

Elasticity in Labour and Financial Capital Markets

The concept of elasticity applies to any market, not just markets for goods and services. In the labour market, for example, the **wage elasticity of labour supply**—that is, the percentage change in hours worked divided by the percentage change in wages—will reflect the shape of the labour supply curve. Specifically:

$\label{eq:Elasticity} \mbox{ flabour supply} = \frac{\% \mbox{ change in quantity of labour supplied}}{\% \mbox{ change in wage}}$

The wage elasticity of labour supply for teenage workers is generally fairly elastic: that is, a certain percentage change in wages will lead to a larger percentage change in the quantity of hours worked. Conversely, the wage elasticity of labour supply for adult workers in their thirties and forties is fairly inelastic. When wages move up or down by a certain percentage amount, the quantity of hours that adults in their prime earning years are willing to supply changes but by a lesser percentage amount.

In markets for financial capital, the **elasticity of savings**—that is, the percentage change in the quantity of savings divided by the percentage change in interest rates—will describe the shape of the supply curve for financial capital. That is:

$\label{eq:Elasticity of savings} \text{Elasticity of savings} = \frac{\% \text{ change in quantity of financial savings}}{\% \text{ change in interest rate}}$

Sometimes laws are proposed that seek to increase the quantity of savings by offering tax breaks so that the return on savings is higher. Such a policy will have a comparatively large impact on increasing the quantity saved if the supply curve for financial capital is elastic, because then a given percentage increase in the return to savings will cause a higher percentage increase in the quantity of savings. However, if the supply curve for financial capital is highly inelastic, then a percentage increase in the return to savings will cause only a small increase in the quantity of savings. The evidence on the supply curve of financial capital is controversial but, at least in the short run, the elasticity of savings with respect to the interest rate appears fairly inelastic.

Expanding the Concept of Elasticity

The elasticity concept does not even need to relate to a typical supply or demand curve at all. For example, imagine that you are studying whether the Internal Revenue Service should spend more money on auditing tax returns. We can frame the question in terms of the elasticity of tax collections with respect to spending on tax enforcement; that is, what is the percentage change in tax collections derived from a given percentage change in spending on tax enforcement?

With all of the elasticity concepts that we have just described, some are listed below under under Formulas for Calculating Elasticity, the possibility of confusion arises. When you hear the phrases "elasticity of demand" or "elasticity of supply," they refer to the elasticity with respect to price. Sometimes, either to be extremely clear or because economists are discussing a wide variety of elasticities, we will call the elasticity of demand or the demand elasticity the price elasticity of demand or the "elasticity of demand with respect to price." Similarly, economists sometimes use the term elasticity of supply or the supply elasticity, to avoid any possibility of confusion, the **price elasticity of supply** or "the elasticity of supply with respect to price." However, in whatever context, the idea of elasticity always refers to percentage change in one variable, almost always a price or money variable, and how it causes a percentage change in another variable, typically a quantity variable of some kind.

Formulas for Calculating Elasticity:

Income elasticity of demand $= rac{\% ext{ change in } ext{Q}_d}{\% ext{ change in income}}$

 $\label{eq:cross-price} \mbox{cross-price elasticity of demand} = \frac{\% \mbox{ change in } \mathbf{Q}_d \mbox{of good A}}{\% \mbox{change in price of good B}}$

Wage elasticity of labour supply = $\frac{\% \text{ change in quantity of labour supplied}}{\% \text{ change in wage}}$

Wage elasticity of labour demand = $\frac{\% \text{ change in quantity of labour demanded}}{\% \text{ change in wage}}$

 $\text{Interest rate elasticity of savings} = \frac{\% \text{ change in quantity of savings}}{\% \text{ change in interest rate}}$

 $\text{Interest rate elasticity of borrowing} = \frac{\% \text{ change in quantity of borrowing}}{\% \text{ change in interest rate}}$

Bring It Home

That Will Be How Much?

How did the 60% price increase in 2011 end up for Netflix? It has been a very bumpy ride.

Before the price increase, there were about 24.6 million U.S. subscribers. After the price increase, 810,000 infuriated U.S. consumers canceled their Netflix subscriptions, dropping the total number of subscribers to 23.79 million. Fast forward to June 2013, when there were 36 million streaming Netflix subscribers in the United States. This was an increase of 11.4 million subscribers since the price increase—an average per quarter growth of about 1.6 million. This growth is less than the 2 million per quarter increases Netflix experienced in the fourth quarter of 2010 and the first quarter of 2011.

During the first year after the price increase, the firm's stock price (a measure of future expectations for the firm) fell from about \$33.60 per share per share to just under \$7.80. By the end of 2016, however, the stock price was at \$123 per share. Today, Netflix has more than 86 million subscribers million subscribers in fifty countries.

What happened? Obviously, Netflix company officials understood the law of demand. Company officials reported, when announcing the price increase, this could result in the loss of about 600,000 existing subscribers. Using the elasticity of demand formula, it is easy to see company officials expected an inelastic response:

=	-600,000/[(24 million+24.6 million)/2]
	6/[(10+16)/2]
=	-600,000/24.3 million
	6/\$13
=	$\frac{-0.025}{0.46}$
=	-0.05

In addition, Netflix officials had anticipated the price increase would have little impact on attracting new customers. Netflix anticipated adding up to 1.29 million new subscribers in the third quarter of 2011. It is true this was slower growth than the firm had experienced—about 2 million per quarter.

Why was the estimate of customers leaving so far off? In the more than two decades since Netflix had been founded, there was an increase in the number of close, but not perfect, substitutes. Consumers now had choices ranging from Vudu, Amazon Prime, Hulu, and Redbox, to retail stores. Jaime Weinman reported in *Maclean's* that Redbox kiosks are "a five-minute drive for less from 68 percent of Americans, and it seems that many people still find a five-minute drive more convenient than loading up a movie online." It seems that in 2012, many consumers still preferred a physical DVD disk over streaming video.

What missteps did the Netflix management make? In addition to misjudging the elasticity of demand, by failing to account for close substitutes, it seems they may have also misjudged customers' preferences and tastes. Yet, as the population increases, the preference for streaming video may

overtake physical DVD disks. Netflix, the source of numerous late night talk show laughs and jabs in 2011, may yet have the last laugh.

Key Concepts and Summary

Elasticity is a general term, that reflects responsiveness. It refers to the change of one variable divided by the percentage change of a related variable that we can apply to many economic connections. For instance, the income elasticity of demand is the percentage change in quantity demanded divided by the percentage change in income. The cross-price elasticity of demand is the percentage change in the quantity demanded of a good divided by the percentage change in the price of another good. Elasticity applies in labour markets and financial capital markets just as it does in markets for goods and services. The wage elasticity of labour supply is the percentage change in the quantity of hours supplied divided by the percentage change in the quantity of savings with respect to interest rates is the percentage change in the quantity of savings divided by the percentage change in interest rates.

Attribution

Except where otherwise noted, this chapter is adapted from "<u>Elasticity in Areas Other Than Price</u> (https://openstax.org/books/principles-microeconomics-2e/pages/5-4-elasticity-in-areas-other-than-price)" and "<u>Key Concepts and Summary</u>" In <u>Principles of Microeconomics 2e (https://openstax.org/books/principlesmicroeconomics-2e/pages/1-introduction</u>) (OpenStx) by Steven A. Greenlaw & David Shapiro, licensed under <u>CC BY 4.0</u>.\Adaptations include addition of chapter key concepts and summary.

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5.2 - CALCULATING ELASTICITY

Learning Objectives

- Calculate the price elasticity of demand
- Calculate the price elasticity of supply
- Calculate the income elasticity of demand and the cross-price elasticity of demand
- Apply concepts of price elasticity to real-world situations



Figure 5.2a. Netflix DVD, sleeve and mailing envelope (https://www.flickr.com/photos/melomcc/5266923264/) by Mel McC, licensed under <u>CC BY-NC-ND 2.0.</u>

That Will Be How Much?

Imagine going to your favorite coffee shop and having the waiter inform you the pricing has changed. Instead of \$3 for a cup of coffee with cream and sweetener, you will now be charged \$2 for a black coffee, \$1 for creamer, and \$1 for your choice of sweetener. If you want to pay your usual \$3 for a cup of coffee, you must choose between creamer and sweetener. If you want both, you now face an extra charge of \$1. Sound absurd? Well, that is the situation Netflix customers found themselves in 2011 – a 60% price hike to retain the same service.

In early 2011, Netflix consumers paid about \$10 a month for a package consisting of streaming video and DVD rentals. In July 2011, the company announced a packaging change. Customers wishing to retain both streaming video and DVD rental would be charged \$15.98 per month – a price increase of about 60%. In 2014, Netflix also raised its streaming video subscription price from \$7.99 to \$8.99 per month for new U.S. customers. The company also changed its policy of 4K streaming content from \$9.00 to \$12.00 per month that year.

How did customers of the 18-year-old firm react? Did they abandon Netflix? How much will this price change affect the demand for Netflix's products? The answers to those questions will be explored in this chapter with a concept economists call elasticity.



Figure 5.2b Take a look at <u>Undoing the mess [New Tab] (https://www.economist.com/schumpeter/</u> 2011/10/10/undoing-the-mess) to read the rest of the Netflix story.

Anyone who has studied economics knows the law of demand: a higher price will lead to a lower quantity demanded. What you may not know is how much lower the quantity demanded will be. Similarly, the law of supply shows that a higher price will lead to a higher quantity supplied. The question is: How much higher? This topic will explain how to answer these questions and why they are critically important in the real world.

To find answers to these questions, we need to understand the concept of **elasticity**. **Elasticity** is an economics concept that measures the responsiveness of one variable to changes in another variable. Suppose

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you drop two items from a second-floor balcony. The first item is a tennis ball, and the second item is a brick. Which will bounce higher? Obviously, the tennis ball. We would say that the tennis ball has greater elasticity.

But how is this degree of responsiveness seen in our models? Both the demand and supply curve show the relationship between price and quantity, and elasticity can improve our understanding of this relationship.

The **own price elasticity of demand** is the percentage change in the quantity *demanded* of a good or service divided by the percentage change in the price. This shows the responsiveness of the quantity demanded to a change in price.

The **own price elasticity of supply** is the percentage change in quantity *supplied* divided by the percentage change in price. This shows the responsiveness of quantity supplied to a change in price.

Our formula for elasticity, $\frac{\% \Delta \text{Quantity}}{\% \Delta \text{Price}}$, can be used for most elasticity problems, we just use different prices and quantities for different situations.

Why percentages are counter-intuitive

Recall that the simplified formula for percentage change is $\frac{\text{New Value} - \text{Old Value}}{\text{Old Value}}$. Suppose there is an increase in quantity demanded from 4 coffees to 6 coffees. Calculating percentage change $(\frac{(6-4)}{4})$ there has been a 50% increase in quantity demanded. Using the same numbers, consider what happens when quantity demanded decreases from 6 coffees to 4 coffees, $(\frac{(4-6)}{6})$ this change results in a 33% decrease in quantity demanded. Right away, this should raise a red flag about calculating the elasticity between at two points, if percentage change is dependant on the direction (A to B or B to A) then how can we ensure a consistent elasticity value?



Figure 5.2c. Figure by University of Victoria, licensed under <u>CC BY 4.0</u>.

Let's calculate elasticity from both perspectives:

Moving from A to B:

%ΔPrice: The coffee price falls from \$4.50 to \$3.00, meaning the percentage change is

 $\frac{(3.00-4.50)}{4.50} = -33\%$. Price has fallen by 33%.

%Quantity: The quantity of coffee sold increases from 4 to 6, meaning the percentage change is $\frac{(6-4)}{4} = 50\%$ Quantity has risen by 50%

 $ext{Elasticity:} \quad rac{\%\Delta ext{ Quantity}}{\%\Delta ext{ Price}} = -rac{50\%}{33\%} = -1.5\,^{\star}$

*Note that elasticity is an absolute value, meaning it is not affected by positive of negative values.

Moving from B to A:

 $\frac{\text{ΦPrice: The coffee price rises from $3.00 to $4.50, meaning the percentage change is}}{\frac{(4.50 - 3.00)}{3.00}} = 50\%$. Price has risen by 50%.

%Quantity: The quantity of coffee sold falls from 6 to 4, meaning the percentage change is $\frac{(4-6)}{6} = -33\%$ Quantity has fallen by 33%
Elasticity: $\frac{\%\Delta \text{ Quantity}}{\%\Delta \text{ Price}} = -\frac{33\%}{50\%} = 0.67$ These two calculations give us different numbers. This type of analysis would make elasticity subject to direction which adds unnecessary complication. To avoid this, we will instead rely on averages.

Mid-point Method

To calculate elasticity, instead of using simple percentage changes in quantity and price, economists use the average percent change. This is called the mid-point method for elasticity, and is represented in the following equations:

 $\% \ change \ in \ quantity = \ \ {Q_2-Q_1\over (Q_2+Q_1)/2} imes 100$

$$\% \ change \ in \ price \quad rac{P_2-P_1}{(P_2+P_1)/2} imes 100$$

The advantage of the **mid-point method** is that one obtains the same elasticity between two price points whether there is a price increase or decrease. This is because the denominator is an average rather than the old value.

Using the mid-point method to calculate the elasticity between Point A and Point B:

$$\% \ change \ in \ quantity = \frac{6-4}{(6+4)/2} \times 100$$

$$= \frac{2}{5} \times 100$$

$$= 40\%$$
% \ change \ in \ price = \frac{3.00-4.50}{(3.00+4.50)/2} \times 100
$$= \frac{-1.50}{3.75} \times 100$$

$$= -40\%$$
Price Elasticity of Demand = $\frac{40\%}{40\%}$

$$= 1$$

This method gives us a sort of average elasticity of demand over two points on our curve. Notice that our elasticity of 1 falls in-between the elasticities of 0.67 and 1.52 that we calculated in the previous example.

Point-Slope Formula

Point Slope Method is a method of calculating elasticity between two points. Involves calculating the percentage change of price and quantity with respect to an average of the two points.

In Figure 4.1a we were given two points and looked at elasticity as movements along a curve. As we will see in Topic 4.3, it is often useful to view elasticity at a single point. To calculate this, we have to derive a new equation.

 $rac{\% \ \Delta {
m Quantity}}{\% \ \Delta {
m Price}} = {
m Elasticity}$

Since we know that a percentage change in price can be rewritten as

 $\Delta \operatorname{Price}$ Price

and a percentage change in quantity to

$\frac{\Delta \text{ Quantity}}{\text{ Quantity}}$

we can rearrange the original equation as

 $\frac{\Delta \text{ Quantity}}{\text{Quantity}}$ $\frac{\Delta \text{ Price}}{\text{Price}}$

which is the same as saying

$$\frac{\Delta \text{ Quantity } \cdot \text{ Price}}{\Delta \text{ Price } \cdot \text{ Quanity}} = \frac{\Delta \text{ Q}}{\Delta \text{ P}} \cdot \frac{\text{ P}}{\text{ Q}}$$

This gives us our **point-slope formula**. How do we use it to calculate the elasticity at Point A? The P/Q portion of our equation corresponds to the values at the point, which are \$4.5 and 4. The $\Delta Q/\Delta P$ corresponds to the **inverse slope of the curve.** Recall slope is calculated as rise/run.

In Figure 4.1, the slope is $\frac{3-4.5}{6-4} = 0.75$, which means the inverse is 1/0.75 = 1.33. Plugging this information into our equation, we get:

$$\frac{\Delta Q}{\Delta P} \cdot \frac{P}{Q}$$

$$1.33 \cdot \frac{4.5}{4}$$

$$= 1.5$$

This analysis gives us elasticity as a single point. Notice that this gives us the same number as calculating elasticity from Point A to B. This is not a coincidence. When we are calculating from Point A to Point B, we are actually just calculating the elasticity at Point A, since we are using the values on Point A as the denominator for our percentage change. Likewise from Point B to Point A, we are calculating the elasticity at Point B. When we use the mid-point method, we are just taking an average of the two points. This solidifies the fact that there is a different elasticity at every point on our line, a concept that will be important when we discuss revenue.

Not Really So Different

Even though mid-point and Point-Slope appear to be fairly different formulas, mid-point can be rewritten to show how similar the two really are.

Δ Quantity		$\Delta~{ m Q}$
$\overline{\mathrm{(Q1+Q2)/2}}$		$\overline{Q1 + Q}$
Δ Price	=	ΔΡ

Remember that when a fraction is divided by a fraction, you can rearrange it to a fraction multiplied by the inverse of the denominator fraction.

$$=rac{\Delta ext{ Q}}{\Delta ext{ P}} ~\cdot~ rac{(ext{P1}~+~ ext{P2})}{(ext{Q1}~+~ ext{Q2})}$$

Notice that compared to point-slope: $\frac{\Delta Q}{\Delta P} \cdot \frac{P}{Q}$, the only difference is that point-slope is the inverse of the slope multiplied by a single point, whereas mid-point is the inverse of the slope multiplied by multiple points. This reinforces the conclusion that mid-point represents an average.

Other Elasticities

Remember, elasticity is the responsiveness of one variable to changes in another variable. This means it can be applied to more that just the price-quantity relationship of our market model. In Topic 3 we discussed how goods can be inferior/normal or substitutes/complements. We will examine this even further when we introduce consumer theory, but for now we can develop our understanding by applying what we know about elasticities.

Own-price elasticity of supply (ep^S)

Our analysis of elasticity has been centred around demand, but the same principles apply to the supply curve. Whereas elasticity of demand measures responsiveness of quantity demanded to a price change, **own-price elasticity of supply** measures the responsiveness of quantity supplied. The more elastic a firm, the more it can increase production when prices are rising, and decrease its production when prices are falling. Our equation is as follows:

$$\frac{\%\;\Delta Q\; \text{Supplied}}{\%\;\Delta P}$$

Own-price elasticity of supply can be calculated using mid-point and point-slope formula in the same way as for ep^D.

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Cross-price elasticity of demand (e_{XP}^{D})

Whereas the **own-price elasticity of demand** measures the responsiveness of quantity to a goods own price, **cross-price elasticity of demand** shows us how quantity demand responds to changes in the price of *related* goods. Whereas before we could ignore positives and negatives with elasticities, with cross-price, this matters. Our equation is as follows:

$\frac{\% \ \Delta Q \ Good \ A}{\% \ \Delta P \ Good \ A}$

Consider our discussion of complements and substitutes in Topic 3.3. We defined complements as goods that individuals prefer to consume with another good, and substitutes as goods individuals prefer to consume instead of another good. If the price of a complement rises our demand will fall, if the price of a substitute rises our demand will rise. For cross-price elasticity this means:

A complement will have a negative cross-price elasticity, since if the % change in price is positive, the % change in quantity will be negative and vice-versa.

A substitute will have a positive cross-price elasticity, since if the % change in price is positive, the % change in quantity will be positive and vice-versa.

This adds another dimension to our discussion of complements/substitutes. Now we can comment on the strength of the relationship between two goods. For example, a cross-price elasticity of -4 suggests an individual strongly prefers to consume two goods together, compared to a cross-price elasticity of -0.5. This could represent the cross-price elasticity of a consumer for a hot dog, with respect to ketchup and relish. The consumer might strongly prefer to consume hot dogs with ketchup, and loosely prefers relish.

Income elasticity of demand (e_N^D)

In Topic 3 we also explained how goods can be normal or inferior depending on how a consumer responds to a change in income. This responsiveness can also be measured with elasticity by the **income elasticity of demand.** Our equation is as follows:

$\frac{\% \Delta \rm{Q}}{\% \Delta \rm{Income}}$

As with cross-price elasticity, whether our elasticity is positive or negative provides valuable information about how the consumer views the good: **A normal good** will have a **positive income elasticity**, since if the % change in income is positive, the % change in quantity will be positive and vice-versa.

A inferior good will have a negative income elasticity, since if the % change in income is positive, the % change in quantity will be negative and vice-versa.

The value of our elasticity will indicate how responsive a good is to a change in income. A good with an income elasticity of 0.05, while technically a normal good (since demand increases after an increase in income) is not nearly as responsive as one with an income elasticity of demand of 5.

Summary

Elasticity is a measure of responsiveness, calculated by the percentage change in one variable divided by the percentage change in another.

Both mid-point and point-slope formulas are important for calculating elasticity in different situations. Midpoint gives an average of elasticities between two points, whereas point-slope gives the elasticity at a certain point. These can be calculated with the following formulas:

Formulas to Calculate Points to Determine Elasticity

 $\begin{array}{l} \text{Base Formula} = & \frac{\% \ \Delta \text{Quantity}}{\% \ \Delta \text{Price}} \\ \\ \text{Mid-Point Formula} = & \frac{\Delta \ \text{Q}}{\Delta \ \text{P}} \ \cdot \ \frac{(\text{P1} \ + \ \text{P2})}{(\text{Q1} \ + \ \text{Q2})} \\ \\ \text{Point-Slope Formula} = & \frac{\Delta \ \text{Q}}{\Delta \ \text{P}} \ \cdot \ \frac{\text{P}}{\Omega} \end{array}$

Since elasticity measures responsiveness, it can also be used to measure the own-price elasticity of supply, the cross-price elasticity of demand, and the income elasticity of demand. These can be calculated with the following formulas:

Formulas to Calculate Elasticity

$$ext{Own-Price Elasticity of Supply} = rac{\% \Delta ext{Q Supplied}}{\% \Delta ext{P}}$$

$$\begin{array}{l} \text{Cross-Price Elasticity of Demand} = & \frac{\% \ \Delta \text{Q} \ \text{Good} \ \text{A}}{\% \ \Delta \text{P} \ \text{Good} \ \text{A}} \\ \text{Income Elasticity of Demand} = & \frac{\% \ \Delta \text{Q}}{\% \ \Delta \text{Income}} \end{array}$$



Figure 5.2d Demand curve diagram (Text Version)

The graph has the vertical axis price (\$) increasing in increments of 2 and the horizontal axis is quantity (Q) increasing in increments of 4. The demand curve (D) is straight downward sloping from left to right. Table for Exercises 4.1 contains data for the figure above.

Points	Location on graph (Quantity, Price)
1	(0 quantity , \$8)
2	(4 quantity , \$6)
3	(8 quantity , \$4)
4	(12 quantity , \$2)
5	(16 quantity , \$0)

Table for Exercises 5.2a

- 1. Use the demand curve diagram above to answer the following question. What is the ownprice elasticity of demand as price increases from \$2 per unit to \$4 per unit? Use the midpoint formula in your calculation.
 - a. 1/3
 - b. 6/10
 - c. 2/3
 - d. None of the above
- 2. Suppose that a 2% increase in price results in a 6% decrease in quantity demanded. Ownprice elasticity of demand is equal to:
 - a. 1/3
 - b. 6
 - c. 2
 - d. 3
- 3. **3.** If own-price elasticity of demand equals 0.3 in absolute value, then what percentage change in price will result in a 6% decrease in quantity demanded?
 - a. 3%
 - b. 6%
 - c. 20%.
 - d. 50%
- 4. Suppose you are told that the own-price elasticity of supply equal 0.5. Which of the following is the correct interpretation of this number?
 - a. A 1% increase in price will result in a 50% increase in quantity supplied.
 - b. A 1% increase in price will result in a 5% increase in quantity supplied.

- c. A 1% increase in price will result in a 2% increase in quantity supplied.
- d. A 1% increase in price will result in a 0.5% increase in quantity supplied.
- 5. Suppose that a 10 increase in price results in a 50 percent decrease in quantity demanded. What does (the absolute value of) own price elasticity of demand equal?
 - a. 0.5
 - b. 0.2
 - c. 5
 - d. 10
- 6. If goods X and Y are *substitutes*, then which of the following could be the value of the cross price elasticity of demand for good Y?
 - a. -1
 - b. -2
 - c. Neither a) nor b)
 - d. Both a) and b)
- 7. If pizza is a normal good, then which of the following could be the value of income elasticity of demand?
 - a. 0.2.
 - b. 0.8.
 - с. 1.4
 - d. All of the above.
- 8. If goods X and Y are *complements*, the which of the following could be the value of cross price elasticity of demand?
 - a. 0
 - b. 1
 - с. -1
 - d. All of the above could be the value of cross price elasticity of demand.

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5.3 - PRICE ELASTICITY OF DEMAND AND PRICE ELASTICITY OF SUPPLY

Learning Objectives

- Calculate the price elasticity of demand
- Calculate the price elasticity of supply

Both the demand and supply curve show the relationship between price and the number of units demanded or supplied. **Price elasticity** is the ratio between the percentage change in the quantity demanded (Qd) or supplied (Qs) and the corresponding percent change in price. The price elasticity of demand is the percentage change in the quantity *demanded* of a good or service divided by the percentage change in the price. The price elasticity of supply is the percentage change in quantity *supplied* divided by the percentage change in price.

We can usefully divide elasticities into three broad categories: elastic, inelastic, and unitary. Because price and quantity demanded move in opposite directions, price elasticity of demand is always a negative number. Therefore, price elasticity of demand is usually reported as its absolute value, without a negative sign. The summary in <u>Table 5.3a</u> is assuming absolute values for price elasticity of demand. An elastic demand or elastic supply is one in which the elasticity is greater than one, indicating a high responsiveness to changes in price. Elasticities that are less than one indicate low responsiveness to price changes and correspond to inelastic demand or supply, as <u>Table 5.3a</u> summarizes.

If	Then	And It Is Called
%change in quantity > $%$ change in price	${rac{\% { m change in quantity}}{\% { m change in price}}} > 1$	Elastic
%change in quantity = $%$ change in price	$rac{\% { m change in quantity}}{\% { m change in price}} = 1$	Unitary
%change in quantity < $%$ change in price	${rac{\% { m change in quantity}}{\% { m change in price}}} < 1$	Inelastic

Table 5.3a Elastic, Inelastic, and Unitary: Three Cases of Elasticity

Link It Up

Before we delve into the details of elasticity, enjoy the article <u>Super Bowl XLVIII Pricing: A Lesson In</u> Demand Elasticity[New Tab] (https://www.forbes.com/sites/prishe/2013/09/19/super-bowl-xlviiipricing-a-lesson-in-demand-elasticity/?sh=7e73438c796f) to learn about elasticity and ticket prices at the Super Bowl.

To calculate elasticity along a demand or supply curve economists use the average percent change in both quantity and price. This is called the Midpoint Method for Elasticity, and is represented in the following equations:

 $\% \ change \ in \ quantity \quad rac{Q_2-Q_1}{(Q_2+Q_1)/2} imes 100$

$$\%\ change\ in\ price$$
 $rac{P_2-P_1}{(P_2+P_1)/2} imes 100$

The advantage of the Midpoint Method is that one obtains the same elasticity between two price points whether there is a price increase or decrease. This is because the formula uses the same base (average quantity and average price) for both cases.

Calculating Price Elasticity of Demand

Let's calculate the elasticity between points A and B and between points G and H as Figure 5.3a shows.



Figure 5.3a Calculating the Price Elasticity of Demand. <u>Figure</u> by Steven A. Greenlaw & David Shapiro (OpenStax), licensed under <u>CC BY 4.0</u>.

Figure 5.3a Calculating the Price Elasticity of Demand (Text Version)

The graph shows a downward sloping line that represents the price elasticity of demand. The vertical axis is Price (\$) and the horizontal axis is Quantity (Q). Data for Figure 5.3a is detailed in the table Table 5.3b Calculating the Price Elasticity of Demand.

Points	Location on the graph (Quantity, Price)
А	(3000, 60)
В	(2800, 70)
С	(2600, 80)
D	(2400, 90)
Е	(2200, 100)
F	(2000, 110)
G	(1800, 120)
Н	(1600, 130)

Figure 5.3a Calculating the Price Elasticity of Demand We calculate the price elasticity of demand as the

percentage change in quantity divided by the percentage change in price.

First, apply the formula to calculate the elasticity as price decreases from \$70 at point B to \$60 at point A:

$$\%\ change\ in\ quantity=\ {3,000-2,800\over (3,000+2,800)/2} imes 100$$

$$=$$
 $\frac{200}{2,900} \times 100$

= 6.9

$$\% \ change \ in \ price = \ \ rac{60-70}{(60+70)/2} imes 100 \ = \ \ rac{-10}{65} imes 100 \ = \ \ -15.4$$

Price Elasticity of Demand = $\frac{6.9\%}{-15.4\%}$

= 0.45

Therefore, the elasticity of demand between these two points is 6.9%–15.4% 6.9%–15.4% which is 0.45, an amount smaller than one, showing that the demand is inelastic in this interval. Price elasticities of demand are *always* negative since price and quantity demanded always move in opposite directions (on the demand curve). By convention, we always talk about elasticities as positive numbers. Mathematically, we take the absolute value of the result. We will ignore this detail from now on, while remembering to interpret elasticities as positive numbers.

This means that, along the demand curve between point B and A, if the price changes by 1%, the quantity demanded will change by 0.45%. A change in the price will result in a smaller percentage change in the quantity demanded. For example, a 10% *increase* in the price will result in only a 4.5% *decrease* in quantity demanded. A 10% *decrease* in the price will result in only a 4.5% *increase* in the quantity demanded. Price elasticities of demand are negative numbers indicating that the demand curve is downward sloping, but we read them as absolute values. The following Work It Out feature will walk you through calculating the price elasticity of demand.

Work It Out

Finding the Price Elasticity of Demand

Calculate the price elasticity of demand using the data in <u>Figure 5.3a</u> for an increase in price from G to H. Has the elasticity increased or decreased?

Step 1. We know that:

 $\label{eq:PriceElasticity} \text{PriceElasticity of Demand} = \frac{\% \text{ change in quantity}}{\% \text{ change in price}}$

Step 2. From the Midpoint Formula we know that:

$$\% \ change \ in \ quantity = -rac{Q_2-Q_1}{(Q_2+Q_1)/2} imes 100$$

$$\% change in price \quad \frac{P_2 - P_1}{(P_2 + P_1)/2} \times 100$$
Step 3. So we can use the values provided in the figure in each equation:

$$\% change in quantity = \quad \frac{1,600 - 1,800}{(1,600 + 1,800)/2} \times 100$$

$$= \quad -2001,700 \times 100$$

$$= \quad 11.76$$

$$\% change in price = \quad \frac{130 - 120}{(130 + 120)/2} \times 100$$

$$= \quad \frac{10}{125} \times 100$$

$$= \quad 8.0$$

Step 4. Then, we can use those values to determine the price elasticity of demand:

Price Elasticity of Demand=
$$\frac{\% \text{ change in quantity}}{\% \text{ change in price}}$$

= $\frac{-11.76}{8}$
= 1.47

Therefore, the elasticity of demand from G to is H 1.47. The magnitude of the elasticity has increased (in absolute value) as we moved up along the demand curve from points A to B. Recall that the elasticity between these two points was 0.45. Demand was inelastic between points A and B and elastic between points G and H. This shows us that price elasticity of demand changes at different points along a straight-line demand curve.

Calculating the Price Elasticity of Supply

Assume that an apartment rents for \$650 per month and at that price the landlord rents 10,000 units are rented as <u>Figure 5.3b</u> shows. When the price increases to \$700 per month, the landlord supplies 13,000 units into the market. By what percentage does apartment supply increase? What is the price sensitivity?





Figure 5.3b Price Elasticity of Supply (Text Version)

The graph shows an upward sloping line that represents the supply of apartment rentals. The vertical axis is Price (\$/month) and the horizontal axis is Quantity (1,000s of rental units). The supply curve (\$) has a concave upward slope running from left to right. Point A (10, 000 rental units, \$650) and Point B (11, 500 rental units, \$700) occur along the line.

Using Figure 5.3b Price Elasticity of Supply we calculate the price elasticity of supply as the percentage

change in quantity divided by the percentage change in price. Using the midpoint method:

$$\% \ change \ in \ quantity = rac{13,000-10,00}{(13,000-10,00)/2} imes 100 \ = rac{3,000}{11,500} imes 100 \ = 26.1 \ \% \ change \ in \ price = rac{700-650}{(700+650)/2} imes 100 \ = rac{50}{675} imes 100 \ = 7.4 \ Price \ Elasticity \ of \ Demand = rac{26.1\%}{7.4\%} \ = 3.53$$

Again, as with the elasticity of demand, the elasticity of supply is not followed by any units. Elasticity is a ratio of one percentage change to another percentage change—nothing more—and we read it as an absolute value. In this case, a 1% rise in price causes an increase in quantity supplied of 3.5%. The greater than one elasticity of supply means that the percentage change in quantity supplied will be greater than a one percent price change. If you're starting to wonder if the concept of slope fits into this calculation, read the following Clear It Up box.

Clear It Up

Is the elasticity the slope?

It is a common mistake to confuse the slope of either the supply or demand curve with its elasticity. The slope is the rate of change in units along the curve, or the rise/run (change in y over the change in x). For example, in <u>Figure 5.3a</u>, at each point shown on the demand curve, price drops by \$10 and the number of units demanded increases by 200 compared to the point to its left. The slope is –10/200 along the entire demand curve and does not change. The price elasticity, however, changes along the

curve. Elasticity between points A and B was 0.45 and increased to 1.47 between points G and H. Elasticity is the *percentage* change, which is a different calculation from the slope and has a different meaning.

When we are at the upper end of a demand curve, where price is high and the quantity demanded is low, a small change in the quantity demanded, even in, say, one unit, is pretty big in percentage terms. A change in price of, say, a dollar, is going to be much less important in percentage terms than it would have been at the bottom of the demand curve. Likewise, at the bottom of the demand curve, that one unit change when the quantity demanded is high will be small as a percentage.

Thus, at one end of the demand curve, where we have a large percentage change in quantity demanded over a small percentage change in price, the elasticity value would be high, or demand would be relatively elastic. Even with the same change in the price and the same change in the quantity demanded, at the other end of the demand curve the quantity is much higher, and the price is much lower, so the percentage change in quantity demanded is smaller and the percentage change in price is much higher. That means at the bottom of the curve we'd have a small numerator over a large denominator, so the elasticity measure would be much lower, or inelastic.

As we move along the demand curve, the values for quantity and price go up or down, depending on which way we are moving, so the percentages for, say, a \$1 difference in price or a one unit difference in quantity, will change as well, which means the ratios of those percentages and hence the elasticity will change.

Key Concepts and Summary

Price elasticity measures the responsiveness of the quantity demanded or supplied of a good to a change in its price. We compute it as the percentage change in quantity demanded (or supplied) divided by the percentage change in price. We can describe elasticity as elastic (or very responsive), unit elastic, or inelastic (not very responsive). Elastic demand or supply curves indicate that quantity demanded or supplied respond to price changes in a greater than proportional manner. An inelastic demand or supply curve is one where a given percentage change in price will cause a smaller percentage change in quantity demanded or supplied. A unitary elasticity means that a

given percentage change in price leads to an equal percentage change in quantity demanded or supplied.

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5.4 - POLAR CASES OF ELASTICITY AND CONSTANT ELASTICITY

Learning Objectives

- Differentiate between infinite and zero elasticity
- Analyze graphs in order to classify elasticity as constant unitary, infinite, or zero

There are two extreme cases of elasticity: when elasticity equals zero and when it is infinite. A third case is that of **constant unitary elasticity**. We will describe each case.

Infinite elasticity or **perfect elasticity** refers to the extreme case where either the quantity demanded (Qd) or supplied (Qs) changes by an infinite amount in response to any change in price at all. In both cases, the supply and the demand curve are horizontal as Figure 5.4a shows. While perfectly **elastic supply** curves are for the most part unrealistic, goods with readily available inputs and whose production can easily expand will feature highly elastic supply curves. Examples include pizza, bread, books, and pencils. Similarly, perfectly **elastic demand** is an extreme example. However, luxury goods, items that take a large share of individuals' income, and goods with many substitutes are likely to have highly elastic demand curves. Examples of such goods are Caribbean cruises and sports vehicles.



Figure 5.4a Infinite Elasticity. <u>Figure</u> by Steven A. Greenlaw & David Shapiro (OpenStax), licensed under <u>CC BY 4.0</u>.

In Figure 5.4a Infinite Elasticity the horizontal lines show that an infinite quantity will be demanded or supplied at a specific price. This illustrates the cases of a perfectly (or infinitely) elastic demand curve and supply curve. The quantity supplied or demanded is extremely responsive to price changes, moving from zero for prices close to P to infinite when prices reach P.

Zero elasticity or perfect inelasticity, as <u>Figure 5.4b</u> depicts, refers to the extreme case in which a percentage change in price, no matter how large, results in zero change in quantity. While a perfectly **inelastic supply** is an extreme example, goods with limited supply of inputs are likely to feature highly inelastic supply curves. Examples include diamond rings or housing in prime locations such as apartments facing Central Park in New York City. Similarly, while perfectly **inelastic demand** is an extreme case, necessities with no close substitutes are likely to have highly inelastic demand curves. This is the case of life-saving drugs and gasoline.



Figure 5.4b Zero Elasticity. Figure by Steven A. Greenlaw & David Shapiro (OpenStax), licensed under <u>CC BY 4.0</u>.

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In Figure 5.4b Zero Elasticity the vertical supply curve and vertical demand curve show that there will be zero percentage change in quantity (a) demanded or (b) supplied, regardless of the price.

Constant unitary elasticity, in either a supply or demand curve, occurs when a price change of one percent results in a quantity change of one percent. Figure 5.4c shows a demand curve with constant unit elasticity. Using the midpoint method, you can calculate that between points A and B on the demand curve, the price changes by 66.7% and quantity demanded also changes by 66.7%. Hence, the elasticity equals 1. Between points B and C, price again changes by 66.7% as does quantity, while between points C and D the corresponding percentage changes are again 66.7% for both price and quantity. In each case, then, the percentage change in price equals the percentage change in quantity, and consequently elasticity equals 1. Notice that in absolute value, the declines in price, as you step down the demand curve, are not identical. Instead, the price falls by \$8.00 from A to B, by a smaller amount of \$4.00 from B to C, and by a still smaller amount of \$2.00 from C to D. As a result, a demand curve with constant unitary elasticity moves from a steeper slope on the left and a flatter slope on the right—and a curved shape overall.



Figure 5.4c. A Constant Unitary Elasticity Demand Curve. <u>Figure</u> by Steven A. Greenlaw & David Shapiro (OpenStax), licensed under <u>CC BY 4.0</u>.

Figure 5.4c. A Constant Unitary Elasticity Demand Curve (Text Version)

The vertical axis is Price (P) in dollars and the horizontal axis Quantity (Q). The demand curve sloped concave curve downward from left to right and Points A, B, C and D occur along it. The price and quantity demanded change by an identical percentage amount (66.7%) between each pair of points on the demand curve.

Point	Point location (Quantity, Price)
А	20 quantity, 16 dollars
В	40 quantity, 8 dollars
С	80 quantity, 4 dollars
D	160 quantity, 2 dollars

Table 5.4a. A Constant Unitary Elasticity Demand Curve

Figure 5.4c A Constant Unitary Elasticity Demand Curve. A demand curve with constant unitary elasticity will be a curved line. Notice how price and quantity demanded change by an identical percentage amount between each pair of points on the demand curve.

Unlike the demand curve with **unitary elasticity**, the supply curve with unitary elasticity is represented by a straight line, and that line goes through the origin. In each pair of points on the supply curve there is an equal difference in quantity of 30. However, in percentage value, using the midpoint method, the steps are decreasing as one moves from left to right, from 28.6% to 22.2% to 18.2%, because the quantity points in each percentage calculation are getting increasingly larger, which expands the denominator in the elasticity calculation of the percentage change in quantity.

Consider the price changes moving up the supply curve in <u>Figure 5.4d</u>. From points D to E to F and to G on the supply curve, each step of \$1.50 is the same in absolute value. However, if we measure the price changes in percentage change terms, using the midpoint method, they are also decreasing, from 28.6% to 22.2% to 18.2%, because the original price points in each percentage calculation are getting increasingly larger in value, increasing the denominator in the calculation of the percentage change in price. Along the constant unitary elasticity supply curve, the percentage quantity increases on the horizontal axis exactly match the percentage price increases on the vertical axis—so this supply curve has a constant unitary elasticity at all points.



Figure 5.4d A Constant Unitary Elasticity Supply Curve. <u>Figure</u> by Steven A. Greenlaw & David Shapiro (OpenStax), licensed under <u>CC BY 4.0.</u>

Figure 5.4d. A Constant Unitary Elasticity Supply Curve (Text Version)

A constant unitary elasticity supply curve is a straight line reaching up from the origin. Between each pair of points, the percentage increase in quantity supplied is the same as the percentage increase in price. The vertical axis is Price (P) and the horizontal axis is Quantity (Q). The supply curve (S) slopes upward from left to right. Points D, E, F, and G occur along the supply line is detailed in the table below.

Point	Point location (Quantity, Price)
D	90 quantity, 4.50 dollars
E	120 quantity, 6 dollars
F	150 quantity, 7.50 dollars
G	180 quantity, 9 dollars

Table 5.4b. A Constant Unitary Elasticity Supply Curve

The percentage value increases in steps between points:

- 1. Point D to E increases by 33.3%
- 2. Point E to F increases 25%
- 3. Point F to G increases 16.7%

Key Concepts and Summary

Infinite or perfect elasticity refers to the extreme case where either the quantity demanded or supplied changes by an infinite amount in response to any change in price at all. Zero elasticity refers to the extreme case in which a percentage change in price, no matter how large, results in zero change in quantity. Constant unitary elasticity in either a supply or demand curve refers to a situation where a price change of one percent results in a quantity change of one percent.

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5.5 - ELASTICITY AND PRICING

Learning Objectives

- Analyze how price elasticities impact revenue
- Evaluate how elasticity can cause shifts in demand and supply
- Predict how the long-run and short-run impacts of elasticity affect equilibrium
- Explain how the elasticity of demand and supply determine the incidence of a tax on buyers and sellers

Studying elasticities is useful for a number of reasons, pricing being most important. Let's explore how elasticity relates to revenue and pricing, both in the long and short run. First, let's look at the elasticities of some common goods and services.

<u>Table 5.5a</u> shows a selection of demand elasticities for different goods and services drawn from a variety of different studies by economists, listed in order of increasing elasticity.

Goods and Services	Elasticity of Price
Housing	0.12
Transatlantic air travel (economy class)	0.12
Rail transit (rush hour)	0.15
Electricity	0.20
Taxi cabs	0.22
Gasoline	0.35
Transatlantic air travel (first class)	0.40
Wine	0.55
Beef	0.59
Transatlantic air travel (business class)	0.62
Kitchen and household appliances	0.63
Cable TV (basic rural)	0.69
Chicken	0.64
Soft drinks	0.70
Beer	0.80
New vehicle	0.87
Rail transit (off-peak)	1.00
Computer	1.44
Cable TV (basic urban)	1.51
Cable TV (premium)	1.77
Restaurant meals	2.27

Table 5.5a Some Selected Elasticities of Demand

Note that demand for necessities such as housing and electricity is inelastic, while items that are not necessities such as restaurant meals are more price-sensitive. If the price of a restaurant meal increases by 10%, the quantity demanded will decrease by 22.7%. A 10% increase in the price of housing will cause only a slight decrease of 1.2% in the quantity of housing demanded.

Link It Up

Read the article Movie Ticket Prices Hit All-Time High in 2012 [New Tab] (https://business.time.com/ 2013/02/19/movie-ticket-prices-hit-all-time-high-in-2012-why-thats-probably-good-for-moviegoers/) for an example of price elasticity that may have affected you.

Does Raising Price Bring in More Revenue?

Imagine that a band on tour is playing in an indoor arena with 15,000 seats. To keep this example simple, assume that the band keeps all the money from ticket sales. Assume further that the band pays the costs for its appearance, but that these costs, like travel, and setting up the stage, are the same regardless of how many people are in the audience. Finally, assume that all the tickets have the same price. (The same insights apply if ticket prices are more expensive for some seats than for others, but the calculations become more complicated.) The band knows that it faces a downward-sloping demand curve; that is, if the band raises the ticket price and, it will sell fewer seats. How should the band set the ticket price to generate the most total revenue, which in this example, because costs are fixed, will also mean the highest profits for the band? Should the band sell more tickets at a lower price or fewer tickets at a higher price?

The key concept in thinking about collecting the most revenue is the price elasticity of demand. Total revenue is price times the quantity of tickets sold. Imagine that the band starts off thinking about a certain price, which will result in the sale of a certain quantity of tickets. The three possibilities are in <u>Table 5.5b</u>. If demand is elastic at that price level, then the band should cut the price, because the percentage drop in price will result in an even larger percentage increase in the quantity sold—thus raising total revenue. However, if demand is inelastic at that original quantity level, then the band should raise the ticket price, because a certain percentage increase in price will result in a smaller percentage decrease in the quantity sold—and total revenue will rise. If demand has a unitary elasticity at that quantity, then an equal percentage change in quantity will offset a moderate percentage change in the price—so the band will earn the same revenue whether it (moderately) increases or decreases the ticket price.

If Demand Is	Then	Therefore
Elastic	$\%$ change in $\rm Q_d > \%$ change in P	A given % rise in P will be more than offset by a larger % fall in Q so that total revenue(P \times Q) falls.
Unitary	$\%$ change in $\mathrm{Q}_{\mathrm{d}}=\%$ change in P	A given % rise in P will be exactly offset by an equal % fall in Q so that total revenue $(P \times Q)$ is unchanged.
Inelastic	$\%$ change in $\rm Q_d < \%$ change in P	A given % rise in P will cause a smaller % fall in Q so that total revenue $(P \times Q)$ rises.

Table 5.5b Will the Band Earn More Revenue by Changing Ticket Prices?

What if the band keeps cutting price, because demand is elastic, until it reaches a level where it sells all 15,000 seats in the available arena? If demand remains elastic at that quantity, the band might try to move to a bigger arena, so that it could slash ticket prices further and see a larger percentage increase in the quantity of tickets sold. However, if the 15,000-seat arena is all that is available or if a larger arena would add substantially to costs, then this option may not work.

Conversely, a few bands are so famous, or have such fanatical followings, that demand for tickets may be inelastic right up to the point where the arena is full. These bands can, if they wish, keep raising the ticket price. Ironically, some of the most popular bands could make more revenue by setting prices so high that the arena is not full—but those who buy the tickets would have to pay very high prices. However, bands sometimes choose to sell tickets for less than the absolute maximum they might be able to charge, often in the hope that fans will feel happier and spend more on recordings, T-shirts, and other paraphernalia.

Can Businesses Pass Costs on to Consumers?

Most businesses face a day-to-day struggle to figure out ways to produce at a lower cost, as one pathway to their goal of earning higher profits. However, in some cases, the price of a key input over which the firm has no control may rise. For example, many chemical companies use petroleum as a key input, but they have no control over the world market price for crude oil. Coffee shops use coffee as a key input, but they have no control over the world market price of coffee. If the cost of a key input rises, can the firm pass those higher costs along to consumers in the form of higher prices? Conversely, if new and less expensive ways of producing are invented, can the firm keep the benefits in the form of higher profits, or will the market pressure them to pass the gains along to consumers in the form of lower prices? The price elasticity of demand plays a key role in answering these questions.

Imagine that as a consumer of legal pharmaceutical products, you read a newspaper story that a technological

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breakthrough in the production of aspirin has occurred, so that every aspirin factory can now produce aspirin more cheaply. What does this discovery mean to you? Figure 5.5a illustrates two possibilities. In Figure 5.5a (a), the demand curve is highly inelastic. In this case, a technological breakthrough that shifts supply to the right, from S₀ to S₁, so that the equilibrium shifts from E₀ to E₁, creates a substantially lower price for the product with relatively little impact on the quantity sold. In Figure 5.5a (b), the demand curve is highly elastic. In this case, the technological breakthrough leads to a much greater quantity sold in the market at very close to the original price. Consumers benefit more, in general, when the demand curve is more inelastic because the shift in the supply results in a much lower price for consumers.



(a) Cost-saving with inelastic demand



(b) Cost-saving with elastic demand

Figure 5.5a Passing along Cost Savings to Consumers. Cost-saving gains cause supply to shift out to the right from S0 to S1; that is, at any given price, firms will be willing to supply a greater quantity. If demand is inelastic, as in (a), the result of this cost-saving technological improvement will be substantially lower prices. If demand is elastic, as in (b), the result will be only slightly lower prices. Consumers benefit in either case, from a greater quantity at a lower price, but the benefit is greater when demand is inelastic, as in (a). Eigure by Steven A. Greenlaw & David Shapiro (OpenStax), licensed under <u>CC BY 4.0</u>.

Figure 5.5a Passing along Cost Savings to Consumers (Text Version)

Depicts two graphs and both have the vertical axis Price (P) and the horizontal axis Quantity (Q). **Graph A** – **Cost-Saving with inelastic demand:** The demand curve (D) is highly inelastic, sloping sharply downward from left to right. The original supply curve (S₀) intersects the demand curve (D) at the equilibrium E₀ at point P₀ and Q₀. S₀ shifts to the right to the new supply curve S₁. S₁ now intersects D at the new equilibrium E_1 at point P_1 and Q_1 . P_1 is noticeably lower then P0 and Q_1 is only slightly to further the right then Q_0 .

Graph B – **Cost-Saving with elastic demand:** The demand curve (D) is highly elastic, sloping downward from left to right. The original supply curve (S₀) intersects the demand curve (D) at the equilibrium E₀ at point Pv and Q₀. S₀ shifts to the right to S₁. S₁ now intersects D at the new equilibrium E₁ at point P₁ Q₁. Q₁ is noticeably further to the right and P1 is only slightly down then P₀.

Aspirin producers may find themselves in a nasty bind here. The situation in <u>Figure 5.5a</u>, with extremely inelastic demand, means that a new invention may cause the price to drop dramatically while quantity changes little. As a result, the new production technology can lead to a drop in the revenue that firms earn from aspirin sales. However, if strong competition exists between aspirin producers, each producer may have little choice but to search for and implement any breakthrough that allows it to reduce production costs. After all, if one firm decides not to implement such a cost-saving technology, other firms that do can drive them out of business.

Since demand for food is generally inelastic, farmers may often face the situation in <u>Figure 5.5a</u> (a). That is, a surge in production leads to a severe drop in price that can actually decrease the total revenue that farmers receive. Conversely, poor weather or other conditions that cause a terrible year for farm production can sharply raise prices so that the total revenue that the farmer receives increases. The Clear It Up box discusses how these issues relate to coffee.

Clear It Up

How do coffee prices fluctuate?

Coffee is an international crop. The top five coffee-exporting nations are Brazil, Vietnam, Colombia, Indonesia, and Ethiopia. In these nations and others, 20 million families depend on selling coffee beans as their main source of income. These families are exposed to enormous risk, because the world price of coffee bounces up and down. For example, in 1993, the world price of coffee was about 50 cents per pound. In 1995 it was four times as high, at \$2 per pound. By 1997 it had fallen by half to \$1.00 per pound. In 1998 it leaped back up to \$2 per pound. By 2001 it had fallen back to 46 cents a pound. By early 2011 it rose to about \$2.31 per pound. By the end of 2012, the price had fallen back to about \$1.31 per pound.

The reason for these price fluctuations lies in a combination of inelastic demand and shifts in supply. The elasticity of coffee demand is only about 0.3; that is, a 10% rise in the price of coffee leads to a decline of about 3% in the quantity of coffee consumed. When a major frost hit the Brazilian coffee

crop in 1994, coffee supply shifted to the left with an inelastic demand curve, leading to much higher prices. Conversely, when Vietnam entered the world coffee market as a major producer in the late 1990s, the supply curve shifted out to the right. With a highly inelastic demand curve, coffee prices fell dramatically. <u>Figure 5.5a</u> (a) illustrates this situation.

Elasticity also reveals whether firms can pass higher costs that they incur on to consumers. Addictive substances, for which demand is inelastic, are products for which producers can pass higher costs on to consumers. For example, the demand for cigarettes is relatively inelastic among regular smokers who are somewhat addicted. Economic research suggests that increasing cigarette prices by 10% leads to about a 3% reduction in the quantity of cigarettes that adults smoke, so the elasticity of demand for cigarettes is 0.3. If society increases taxes on companies that produce cigarettes, the result will be, as in Figure 5.5b (a), that the supply curve shifts from S_0 to S_1 . However, as the equilibrium moves from E_0 to E_1 , governments mainly pass along these taxes to consumers in the form of higher prices. These higher taxes on cigarettes will raise tax revenue for the government, but they will not much affect the quantity of smoking.

If the goal is to reduce the quantity of cigarettes demanded, we must achieve it by shifting this inelastic demand back to the left, perhaps with public programs to discourage cigarette use or to help people to quit. For example, anti-smoking advertising campaigns have shown some ability to reduce smoking. However, if cigarette demand were more elastic, as in Figure 5.5b (b), then an increase in taxes that shifts supply from S_0 to S_1 and equilibrium from E_0 to E_1 would reduce the quantity of cigarettes smoked substantially. Youth smoking seems to be more elastic than adult smoking—that is, the quantity of youth smoking will fall by a greater percentage than the quantity of adult smoking in response to a given percentage increase in price.



Figure 5.5b Passing along Higher Costs to Consumers. Higher costs, like a higher tax on cigarette companies for the example we gave in the text, lead supply to shift to the left. This shift is identical in (a) and (b). However, in (a), where demand is inelastic, companies largely can pass the cost increase along to consumers in the form of higher prices, without much of a decline in equilibrium quantity. In (b), demand is elastic, so the shift in supply results primarily in a lower equilibrium quantity. Consumers suffer in either case, but in (a), they suffer from paying a higher price for the same quantity, while in (b), they suffer from buying a lower quantity (and presumably needing to shift their consumption elsewhere). Figure by Steven A. Greenlaw & David Shapiro (OpenStax), licensed under <u>CC BY 4.0</u>.

Figure 5.5b Passing along Higher Costs to Consumers

Depicts two graphs. Both graphs have the vertical axis Price (P) and the horizontal axis Quantity (Q). **Graph A – higher costs with inelastic demand:** The demand curve (D) is highly inelastic, sloping sharply downward from left to right. The original supply curve (S0) intersects the demand curve (D) at the equilibrium E_0 at point P0 and Q0. S0 shifts to the left to the new supply curve S_1 . $S1_1$ now intersects D at the new equilibrium E_1 at point P1 and Q1. P1 has noticeably higher then P0 and Q0 shifts only slightly to the left to Q1.

Graph B – **higher costs with elastic demand:** The demand curve (D) is highly elastic, sloping downward from left to right. The original supply curve (S₀) intersects the demand curve (D) at the equilibrium E_0 at point P_0 and Q_0 . S0 shifts to the left to S_1 . S_1 now intersects D at the new equilibrium E1 at point P_1 and Q_1 . Q_1 is noticeably further to the left and P_0 has only slightly increased to Q_1 .

Elasticity and Tax Incidence

The example of cigarette taxes demonstrated that because demand is inelastic, taxes are not effective at

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reducing the equilibrium quantity of smoking, and they mainly pass along to consumers in the form of higher prices. The analysis, or manner, of how a tax burden is divided between consumers and producers is called tax incidence. Typically, the tax incidence, or burden, falls both on the consumers and producers of the taxed good. However, if one wants to predict which group will bear most of the burden, all one needs to do is examine the elasticity of demand and supply. In the tobacco example, the tax burden falls on the most inelastic side of the market.

If demand is more inelastic than supply, consumers bear most of the tax burden, and if supply is more inelastic than demand, sellers bear most of the tax burden.

The intuition for this is simple. When the demand is inelastic, consumers are not very responsive to price changes, and the quantity demanded reduces only modestly when the tax is introduced. In the case of smoking, the demand is inelastic because consumers are addicted to the product. The government can then pass the tax burden along to consumers in the form of higher prices, without much of a decline in the equilibrium quantity.

Similarly, when a government introduces a tax in a market with an inelastic supply, such as, for example, beachfront hotels, and sellers have no alternative than to accept lower prices for their business, taxes do not greatly affect the equilibrium quantity. The tax burden now passes on to the sellers. If the supply was elastic and sellers had the possibility of reorganizing their businesses to avoid supplying the taxed good, the tax burden on the sellers would be much smaller. The tax would result in a much lower quantity sold instead of lower prices received. Figure 5.5c illustrates this relationship between the tax incidence and elasticity of demand and supply.



Figure 5.5c Elasticity and Tax Incidence. An excise tax introduces a wedge between the price paid by consumers (Pc) and the price received by producers (Pp). The vertical distance between Pc and Pp is the amount of the tax per unit. Pe is the equilibrium price prior to introduction of the tax. (a) When the demand is more elastic than supply, the tax incidence on consumers Pc – Pe is lower than the tax incidence on producers Pe – Pp. (b) When the supply is more elastic than demand, the tax incidence on consumers Pc – Pe is larger than the tax incidence on producers Pe – Pp. The more elastic the demand and supply curves, the lower the tax revenue. Eigure by Steven A. Greenlaw & David Shapiro (OpenStax), licensed under <u>CC BY 4.0</u>.

Figure 5.5c Elasticity and Tax Incidence (Text Version)

Depicts two graphs with a vertical axis of Price (P) and the horizontal axis Quantity (Q). An excise tax introduces a wedge between the price paid by consumers (Pc) and the price received by producers (Pp). The vertical distance between Pc and Pp is the amount of the tax per unit.

Graph A- Elastic demand and inelastic supply: The supply curve (S) slopes sharply upward from left to right and the demand curve (D) slopes downward from left to right. Pe is the equilibrium price prior to introduction of the tax, occurring where S and D interact, Point E at Qe and Pe.

In the lower lefthand corner in the space between where the supply curve and demand curve intersect is the exercise tax.

Pc (price paid by consumers) is the highest point, slightly above Pe, and runs to Qt where it intersects with the demand curve (D) at point Qt.

Pp (price received by producers) is the lowest point, significantly below Pe, and runs to Qt where it intersects with the supply curve (S) at point Qt.

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When the demand is more elastic than supply, the tax incidence on consumers Pc – Pe is lower than the tax incidence on producers Pe – Pp.

Graph B- Elastic supply and inelastic demand: The supply curve (S) slopes upward from left to right and the demand curve (D) slopes sharply downward from left to right. Pe is the equilibrium price prior to introduction of the tax, occurring where S and D interact, Point E at Qe and Pe.

In the upper lefthand corner in the space between where the supply curve and demand curve intersect is the exercise tax.

Pc (price paid by consumers) is the highest point, significantly above Pe, and runs to Qt where it intersects with the demand curve (D) at point Qt.

Pp (price received by producers) is the lowest point, slightly below Pe, and runs to Qt where it intersects with the supply curve (S) at point Qt.

When the demand is more elastic than supply, the tax incidence on consumers Pc – Pe is lower than the tax incidence on producers Pe – Pp. The more elastic the demand and supply curves, the lower the tax revenue.

In <u>Figure 5.5c</u> (a), the supply is inelastic and the demand is elastic, such as in the example of beachfront hotels. While consumers may have other vacation choices, sellers can't easily move their businesses. By introducing a tax, the government essentially creates a wedge between the price paid by consumers Pc and the price received by producers Pp. In other words, of the total price paid by consumers, part is retained by the sellers and part is paid to the government in the form of a tax. The distance between Pc and Pp is the tax rate. The new market price is Pc, but sellers receive only Pp per unit sold, as they pay Pc-Pp to the government. Since we can view a tax as raising the costs of production, this could also be represented by a leftward shift of the supply curve, where the new supply curve would intercept the demand at the new quantity Qt. For simplicity, Figure 5.5c omits the shift in the supply curve.

The tax revenue is given by the shaded area, which we obtain by multiplying the tax per unit by the total quantity sold Qt. The tax incidence on the consumers is given by the difference between the price paid Pc and the initial equilibrium price Pe. The tax incidence on the sellers is given by the difference between the initial equilibrium price Pe and the price they receive after the tax is introduced Pp. In Figure 5.5c (a), the tax burden falls disproportionately on the sellers, and a larger proportion of the tax revenue (the shaded area) is due to the resulting lower price received by the sellers than by the resulting higher prices paid by the buyers. Figure 5.5c (b) describes the example of the tobacco excise tax where the supply is more elastic than demand. The tax incidence now falls disproportionately on consumers, as shown by the large difference between the price they pay, Pc, and the initial equilibrium price, Pe. Sellers receive a lower price than before the tax, but this difference is much smaller than the change in consumers' price. From this analysis one can also predict

whether a tax is likely to create a large revenue or not. The more elastic the demand curve, the more likely that consumers will reduce quantity instead of paying higher prices. The more elastic the supply curve, the more likely that sellers will reduce the quantity sold, instead of taking lower prices. In a market where both the demand and supply are very elastic, the imposition of an excise tax generates low revenue.

Some believe that excise taxes hurt mainly the specific industries they target. For example, the medical device excise tax, in effect since 2013, has been controversial for it can delay industry profitability and therefore hamper start-ups and medical innovation. However, whether the tax burden falls mostly on the medical device industry or on the patients depends simply on the elasticity of demand and supply.

Long-Run vs. Short-Run Impact

Elasticities are often lower in the short run than in the long run. On the demand side of the market, it can sometimes be difficult to change Qd in the short run, but easier in the long run. Consumption of energy is a clear example. In the short run, it is not easy for a person to make substantial changes in energy consumption. Maybe you can carpool to work sometimes or adjust your home thermostat by a few degrees if the cost of energy rises, but that is about all. However, in the long run you can purchase a car that gets more miles to the gallon, choose a job that is closer to where you live, buy more energy-efficient home appliances, or install more insulation in your home. As a result, the elasticity of demand for energy is somewhat inelastic in the short run, but much more elastic in the long run.

<u>Figure 5.5d</u> is an example, based roughly on historical experience, for the responsiveness of Qd to price changes. In 1973, the price of crude oil was \$12 per barrel and total consumption in the U.S. economy was 17 million barrels per day. That year, the nations who were members of the Organization of Petroleum Exporting Countries (OPEC) cut off oil exports to the United States for six months because the Arab members of OPEC disagreed with the U.S. support for Israel. OPEC did not bring exports back to their earlier levels until 1975—a policy that we can interpret as a shift of the supply curve to the left in the U.S. petroleum market. <u>Figure 5.5d</u> (a) and <u>Figure 5.5d</u> (b) show the same original equilibrium point and the same identical shift of a supply curve to the left from S₀ to S₁.



Figure 5.5d How a Shift in Supply Can Affect Price or Quantity. The intersection (E₀) between demand curve D and supply curve S₀ is the same in both (a) and (b). The shift of supply to the left from S₀ to S₁ is identical in both (a) and (b). The new equilibrium (E₁) has a higher price and a lower quantity than the original equilibrium (E₀) in both (a) and (b). However, the shape of the demand curve D is different in (a) and (b), being more elastic in (b) than in (a). As a result, the shift in supply can result either in a new equilibrium with a much higher price and an only slightly smaller quantity, as in (a), with more inelastic demand, or in a new equilibrium with only a small increase in price and a relatively larger reduction in quantity, as in (b), with more elastic demand. Figure by Steven A. Greenlaw & David Shapiro (OpenStax), licensed under <u>CC BY 4.0</u>.

Figure 5.5d How a Shift in Supply Can Affect Price or Quantity (text Version)

Depicts two graphs with the same vertical axis Price (US\$ per barrel) and the horizontal axis Quantity (million barrels per day).

The original supply curve (S_0) slopes upward from left to right for both graphs.

In image (a), the shape of the demand curve (D) slopes steeply downward from left to right, whereas in image (b) the demand curve (D) slope is more gradual. The demand curve (D) is more elastic in (b) than in (a).

The original intersection (E_0), occurring between demand curve D and supply curve S_0 , is the same in both graphs (a) and (b), occurring at \$17 per barrel and 12 million barrels per day.

The shift of supply to the left from S_0 to S_1 is identical in both (a) and (b). The new equilibrium (E₁), occurring at the intersection between D_0 and S_1 , has a higher price and a lower quantity than the original equilibrium (E₀) in both image (a) and (b).

The new equilibrium (E1) for image (a) is \$16 per barrel and 25 million barrels per day. The new equilibrium (E1) for image (b) is \$163 per barrel and 14 million barrels per day.

Figure 5.5d (a) shows inelastic demand for oil in the short run similar to that which existed for the United States in 1973. In Figure 5.5d (a), the new equilibrium (E₁) occurs at a price of \$25 per barrel, roughly double the price before the OPEC shock, and an equilibrium quantity of 16 million barrels per day. Figure 5.5d (b) shows what the outcome would have been if the U.S. demand for oil had been more elastic, a result more likely over the long term. This alternative equilibrium (E₁) would have resulted in a smaller price increase to \$14 per barrel and larger reduction in equilibrium quantity to 13 million barrels per day. In 1983, for example, U.S. petroleum consumption was 15.3 million barrels a day, which was lower than in 1973 or 1975. U.S. petroleum consumption was down even though the U.S. economy was about one-fourth larger in 1983 than it had been in 1973. The primary reason for the lower quantity was that higher energy prices spurred conservation efforts, and after a decade of home insulation, more fuel-efficient cars, more efficient appliances and machinery, and other fuel-conserving choices, the demand curve for energy had become more elastic.

On the supply side of markets, producers of goods and services typically find it easier to expand production in the long term of several years rather than in the short run of a few months. After all, in the short run it can be costly or difficult to build a new factory, hire many new workers, or open new stores. However, over a few years, all of these are possible.

In most markets for goods and services, prices bounce up and down more than quantities in the short run, but quantities often move more than prices in the long run. The underlying reason for this pattern is that supply and demand are often inelastic in the short run, so that shifts in either demand or supply can cause a relatively greater change in prices. However, since supply and demand are more elastic in the long run, the long-run movements in prices are more muted, while quantity adjusts more easily in the long run.

Key Concepts and Summary

In the market for goods and services, quantity supplied and quantity demanded are often relatively slow to react to changes in price in the short run, but react more substantially in the long run. As a result, demand and supply often (but not always) tend to be relatively inelastic in the short run and relatively elastic in the long run. A tax incidence depends on the relative price elasticity of supply

and demand. When supply is more elastic than demand, buyers bear most of the tax burden, and when demand is more elastic than supply, producers bear most of the cost of the tax. Tax revenue is larger the more inelastic the demand and supply are.

Attribution

Except where otherwise noted, this chapter is adapted from "<u>Elasticity and Pricing (https://openstax.org/</u> <u>books/principles-microeconomics-2e/pages/5-3-elasticity-and-pricing</u>)" and "<u>Key Concepts and Summary</u>" In <u>Principles of Microeconomics 2e (https://openstax.org/books/principles-microeconomics-2e/pages/</u> <u>1-introduction</u>) (OpenStx) by Steven A. Greenlaw & David Shapiro, licensed under <u>CC BY 4.0</u>./Adaptations include addition of chapter key concepts and summary. Access for free at <u>https://openstax.org/books/principles-microeconomics-2e/pages/1-introduction</u>

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