Supply and Demand

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1. One assumption of the supply and demand model is that all goods bought and sold are identical. Why do you suppose economists commonly make this assumption? Does the supply and demand model lose its usefulness if goods are not identical?

1. Economists make this assumption, along with many others, in order to capture the meaningful relationships of the real world in simplified models. The models then can predict how variables within these relationships change in response to economic factors. If goods are not identical, many predictions of the model will still prove to be correct. However, we would be less confident in the predictions resting most heavily on that assumption.

2. List the assumptions of the supply and demand model. Then, for each assumption, give one example of a market in which the assumption is satisfied, and one example of a market in which that assumption is not satisfied. Is it reason• able to use the supply and demand model when assumptions are violated?

2. *Assumption 1.* We focus on supply and demand in a single market. This assumption is satisfied if we look at the market for hotel rooms in Lincoln, Nebraska, which is likely to be independent of the market for hotel rooms in other cities. This assumption is not satisfied if we look at the market for gold in Lincoln, Nebraska, which would be dependent on gold's global supply and demand.

Assumption 2. All goods sold in the market are identical. This assumption is satisfied if we look at the market for a commodity such as crude oil. If we look at shoes, the fact that there are countless distinctions between different types and styles of shoes means that the assumption is not satisfied.

Assumption 3. All goods sold in the market sell for the same price, and everyone has the same information. This assumption is satisfied in a market such as retail gasoline stations. Although gas prices differ by a few cents per gallon between retailers, they match one another within a fairly close range. And prices are visible to anyone in the vicinity of the gas station. An example of a market where this assumption is not satisfied would be home furnishings. A furniture item such as a desk, for example, could have a significant price range, with the price of the most expensive desk being multiple times higher than that of an inexpensive one.

Assumption 4. There are many buyers and sellers in the market. This assumption is satisfied in the market for fresh fruit, where there are many small orchards supplying produce and many consumers shopping for peaches, apples, oranges, and pears. In contrast, the market for intercity passenger rail transportation in the United States has only one seller: Amtrak. Such a market would not satisfy the assumption.

The supply and demand model can still be useful even when these four assumptions are not met, because the basic economic relationships captured in the model apply even outside the boundaries of such assumptions.

*3. The demand for organic carrots is given by the following equation:

$$Q_o = 75 - 5P_o + P_c + 2I$$

where P_o is the price of organic carrots, P_c is the price of conventional carrots, and I is the average consumer income. Notice how this isn't a standard demand curve that just relates the quantity of organic carrots demanded to the price of organic carrots. This demand function also describes how other factors affect demand—namely, the price of another good (conventional carrots) and income.

a. Graph the inverse demand curve for organic carrots when $P_c = 5$ and $I = 10$. What is the choke price?

b. Using the demand curve drawn in (a), what is the quantity demanded of organic carrots when $P_o = 5$? When $P_o = 10$?

c. Suppose P_c increases to 15, while I remains at 10. Calculate the quantity demanded of organic carrots. Show the effects of this change on your graph and indicate the choke price. Has there been a change in the demand for organic carrots, or a change in the quantity demanded of organic carrots?

d. What happens to the demand for organic carrots when the price of conventional carrots increases? Are organic and conventional carrots complements or substitutes? How do you know?

e. What happens to the demand for organic carrots when the average consumer's income increases? Are carrots a normal or an inferior good?

3. a. We begin with the demand equation and substitute the given values for P_c and I:

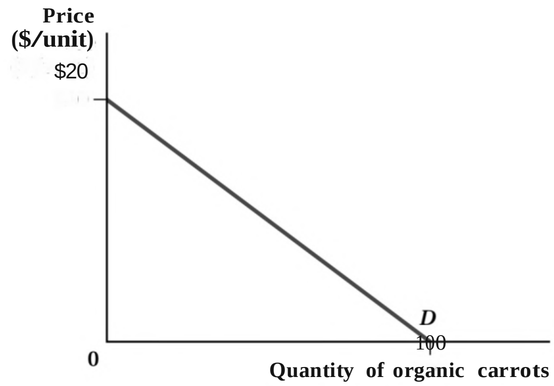
$$Q^d_o = 75 - 5P_o + P_c + 2I$$
$$Q^d_o = 75 - 5P_o + 5 + (2 \times 10)$$

This simplifies to

$$Q^d_o = 100 - 5P_o$$

To find the inverse demand curve, we want to rearrange terms to express P as a function of Q:

$$5P_o = 100 - Q^d_o$$
$$P_o = 20 - 0.2Q^d_o$$



The choke price can be found by solving for the price that corresponds to a quantity demanded of zero:

$$P_o = 20 - (0.2 \times 0) = 20$$

b. Substitute 5 for P_o in the demand function to find Q^d_o:

$$Q^d_o = 100 - 5P_o = 100 - 5(5) = 75$$

Substitute 10 for P_o in the inverse demand function to find Q^d_o:

$$P_o = 20 - 0.2Q^d_o$$
$$10 = 20 - 0.2Q^d_o$$
$$10 = 0.2Q^d_o$$
$$50 = Q^d_o$$

c. We begin with the demand equation and substitute the given values for P_c and I:

$$Q^d_o = 75 - 5P_o + P_c + 2I$$
$$Q^d_o = 75 - 5P_o + 15 + (2 \times 10)$$

This simplifies to

$$Q^d_o = 110 - 5P_o$$

To find the inverse demand curve, we want to rearrange terms to express P as a function of Q:

$$5P_o = 110 - Q^d_o$$
$$P_o = 22 - 0.2Q^d_o$$

We can substitute 10 for the price of organic carrots to find the quantity demanded:

$$10 = 22 - 0.2Q^d_o$$
$$0.2Q^d_o = 12$$
$$Q^d_o = 60$$

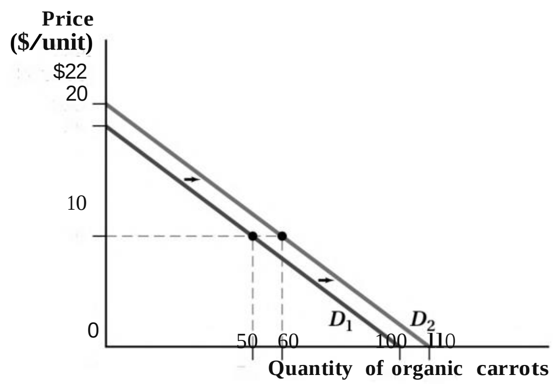
We find the choke price by finding the price that would make quantity demanded equal to zero:

$$P_o = 22 - 0.2Q^d_o$$
$$P_o = 22 - (0.2 \times 0) = 22$$

The demand for organic carrots has changed because the entire curve has shifted to the right.

d. The demand for organic carrots has increased, shifting the demand curve to the right. This shows that the two goods are substitutes for one another, because an increase in the price of conventional carrots has led to a higher quantity of organic carrots demanded at any given price.

e. There is a positive coefficient (+2) on the variable for income. This means that an increase in income will shift the demand for organic carrots to the right. As a consequence, we know that organic carrots are a normal good.



*4. Out of the following events, which are likely to cause the demand for coffee to increase? Explain your answers.

a. An increase in the price of tea
b. An increase in the price of doughnuts
c. A decrease in the price of coffee
d. The Surgeon General's announcement that drinking coffee lowers the risk of heart disease
e. Heavy rains causing a record-low coffee harvest in Colombia

4. a. Since tea and coffee are the classic examples of substitutes, as the price of tea increases, the demand for coffee is likely to increase.
b. An increase in the price of doughnuts decreases the quantity demanded of doughnuts. Because doughnuts and coffee are complements, this will likely decrease the demand for coffee.
c. A decrease in the price of coffee will decrease the quantity demanded of coffee via a movement along the demand curve.
d. The Surgeon General's announcement will likely increase the number of people who are interested in drinking coffee and, thus, increase the demand for coffee.
e. Heavy rain will decrease the supply of coffee. This can be shown as an inward shift of the supply curve. As a result, the equilibrium price increases and the equilibrium quantity decreases. **This** adjustment is accomplished via a movement along the demand curve.

5. How is each of the following events likely to shift the supply curve or the demand curve for fast-food hamburgers in the United States? Make sure you indicate which curve (curves) is affected and if it shifts out or in.

a. The price of beef triples.
b. The price of chicken falls by half.
c. The number of teenagers in the economy falls due to population aging.
d. Mad cow disease, a rare but fatal medical condition caused by eating tainted beef, becomes common in the United States.
e. The Food and Drug Administration publishes a report stating that a certain weight-loss diet, which encourages the intake of large amounts of meat, is dangerous to one's health.
f. An inexpensive new grill for home use that makes delicious hamburgers is heavily advertised on television.
g. The minimum wage rises.

5. a. An increase in the price of beef represents an increase in the cost of an input. This will cause the supply curve to shift in as the production becomes more expensive.
b. Demand for fast-food hamburgers in the United States will likely shift in since many consumers see chicken and beef as substitutes. As chicken becomes less expensive, more people will consume chicken and reduce their consumption of hamburgers, resulting in a decrease in the demand for fast-food hamburgers.
c. The demand curve shifts in.
d. Consumers' awareness of the mad cow disease shifts the demand for fast-food hamburgers in.
e. Fewer people will follow this diet, causing the demand curve to shift in.
f. As consumers purchase the advertised inexpensive new grill, they are more likely to prepare hamburgers at home. Given that at-home hamburgers and fast-food hamburgers are likely to be substitutes in the minds of consumers, the demand for fast-food hamburgers can be expected to shift in.
g. An increase in the minimum wage increases the supplier's cost of production, which leads to a decrease in supply. This is shown as a shifting in of the supply curve.

6. The supply of wheat is given by the following equation:

$$Q^S_W = 6 + 4P_W - 2P_C - P_F$$

where Q^S_W is the quantity of wheat supplied, in millions of bushels; P_W is the price of wheat per bushel; P_C is the price of corn per bushel; and P_F is the price of tractor fuel per gallon.

a. Graph the inverse supply curve when corn sells for $4 a bushel and fuel sells for $2 a gallon. What is the supply choke price?

b. How much wheat will be supplied at a price of $4? $8?

c. What will happen to the supply of wheat if the price of corn increases to $6 per bushel? Explain intuitively; then graph the new inverse supply carefully and indicate the new choke price.

d. Suppose instead that the price of corn remains $4, but the price of fuel decreases to $1. What will happen to the supply of wheat as a result? Explain intuitively; then graph the new inverse supply. Be sure to indicate the new choke price.

6. a. We begin with the supply equation and substitute values for the price of corn and the price of tractor fuel:

$$Q^S_W = 6 + 4P_W - 2P_C - P_F$$

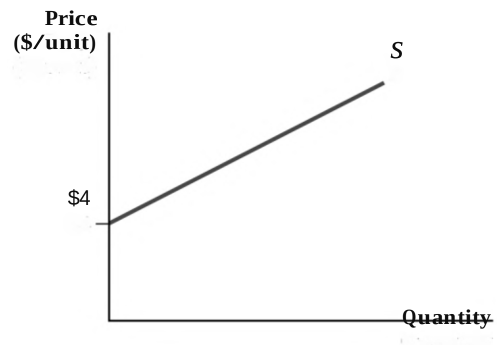
$$Q^S_W = 6 + 4P_W - (2 \times 4) - 2$$

$$Q^S_W = 16 + 4P_W$$

Now we rearrange terms to express price as a function of quantity supplied:

$$4P_W = 16 + Q$$

$$P_W = 4 + 0.25Q^S_W$$



To find the price that would make quantity supplied equal to zero, substitute a zero for Q:

$$P_W = 4 + (0.25 \times 0) = 4$$

The supply choke price is 4.

b. Using the supply equation, when $P_W = 4$:

$$Q^S_W = 16 + (4 \times 4) = 16 + 16 = 0$$

When $P_W = 8$:

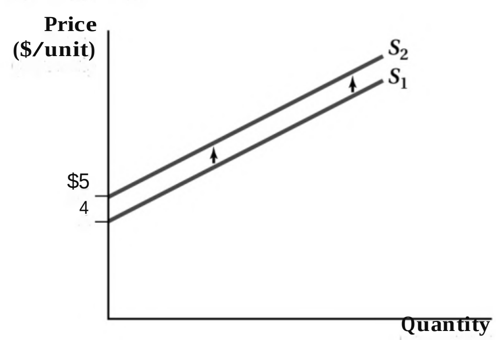
$$Q^S_W = 16 + (4 \times 8) = 16 + 32 = 16$$

c. Wheat and corn are substitutes in production, so an increase in the selling price of corn that causes farmers to grow more corn will decrease the supply of wheat. Start with the supply equation again, substituting the value of 6 for the price of corn and 2 for the price of fuel:

$$Q^S_W = 6 + 4P_W - 2P_C - P_F$$

$$Q^S_W = 6 + 4P_W - (2 \times 6) - 2$$

$$Q^S_W = 20 + 4P_W$$



Convert this to an inverse supply function by expressing price as a function of quantity:

$$Q^S_W = 20 + 4P_W$$

$$4P_W = 20 + Q^S_W$$

$$P_W = 5 + 0.25Q^S_W$$

The price that would make Q equal to zero is 5. This is the supply choke price.

d. Start with the supply equation again, substituting the value of 4 for the price of corn and the value of 1 for the price of fuel:

0} =6+4P,−2P,−P,

Q} =6+4P%−(2x4)−1

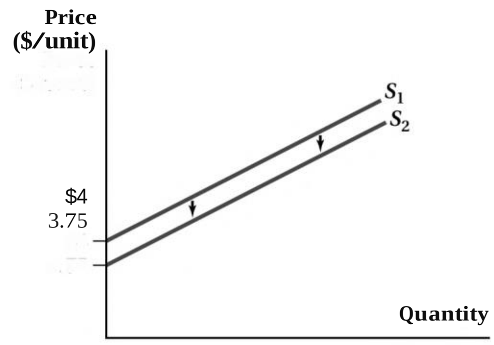
0} =15 +4P%

Convert this to an inverse supply function by expressing price as a function of quantity:

4P, =15 +O}

4P, =15 +O}

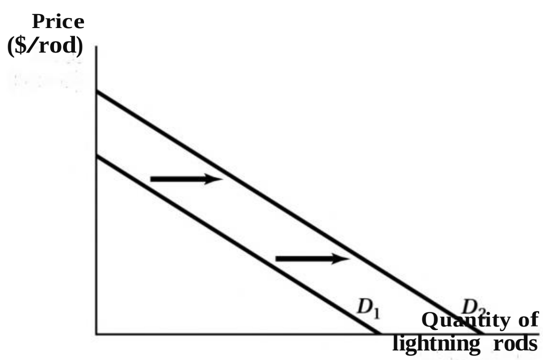
P%=3.75 +0.25O}



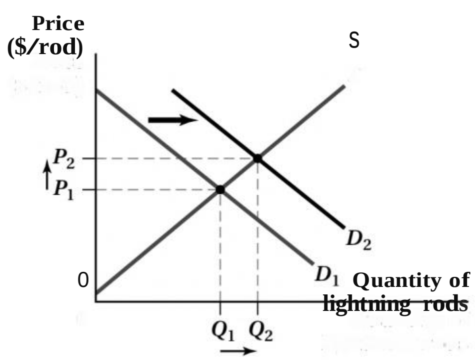
Ata price of 3.75, quantity supplied would be zero. This is the supply choke price.

7. Collectors of vintage lightning rods formerly had to drift from antique store to antique store hoping to find a lightning rod for sale. The invention of the Internet reduced the cost of finding lighting rods available for sale.
   a. Draw a diagram showing how the invention and popularization of the Internet have caused the demand curve for lightning rods to shift.
   b. Suppose that the only change in the market for lightning rods is the change you described in (a). How would that change affect the equilibrium price of lightning rods and the equilibrium quantity of lightning rods sold?

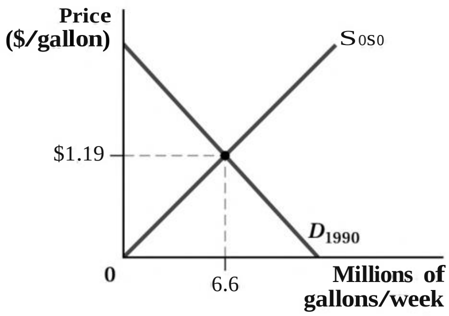
7. a. The invention and popularization of the Internet have caused an increase in the demand for lightning rods.



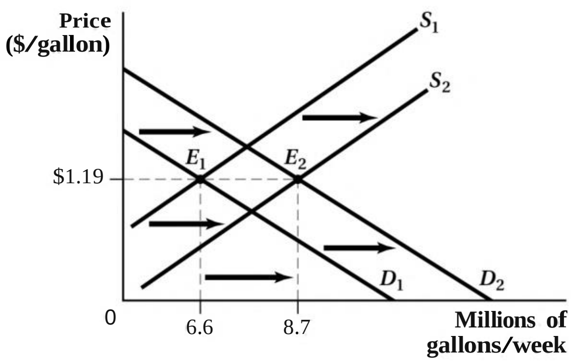
b. Assuming the supply curve is fixed and not a special case in terms of elasticity (as depicted below), then the equilibrium price of lightning rods and the equilibrium quantity will increase.



8. In March 2002 the retail price of gasoline was \$1.19 per gallon—exactly the same as it was in August 1990. Yet, total gasoline production and consumption rose from 6.6 million gallons per week in 1990 to 8.7 million gallons per week in 2002. Using the graph below, draw the appropriate shifts in the demand and supply curves to explain these two phenomena.



8. As stated in the problem, the total consumption as well as the production of gasoline increased. So both supply and demand increase. Shifts are such that the equilibrium price remains constant, but the equilibrium quantity increases from 6.6 million to 8.7 million, that is, the horizontal price line \$1.19 goes through the old and new equilibrium points.



9. When the demand for toilet paper increases, the equilibrium quantity sold increases. Consumers are buying more, and producers are producing more.
   a. How do producers receive the signal that they need to increase production to meet the new demand?
   b. Based on the facts given above, can you say that an increase in the demand for toilet paper causes an increase in the supply of toilet paper? Carefully explain why or why not.

9. a. Producers react to the signal of a higher price that has resulted from an increase in demand. Along a given supply curve, they expand the quantity supplied.
   b. No, the increase in demand does not cause an increase in supply. It causes only an increase in quantity supplied along a stationary supply curve.

10. Suppose the demand for towels is given by $Q^D = 100 - 5P$, and the supply of towels is given by $Q = 10P$.
   a. Derive and graph the inverse supply and inverse demand curves.
   b. Solve for the equilibrium price and quantity.
   c. Suppose that supply changes so that at each price, 20 fewer towels are offered for sale. Derive and graph the new inverse supply curve.
   d. Solve for the new equilibrium price and quantity. How does the decrease in supply affect the equilibrium price and quantity sold?
   e. Suppose instead that supply does not change, but demand decreases so that at each price 25 fewer towels are desired by consumers. Solve for the new equilibrium price and quantity. How does the decrease in demand affect the equilibrium price and quantity sold? How do those changes compare to your response in (d)?

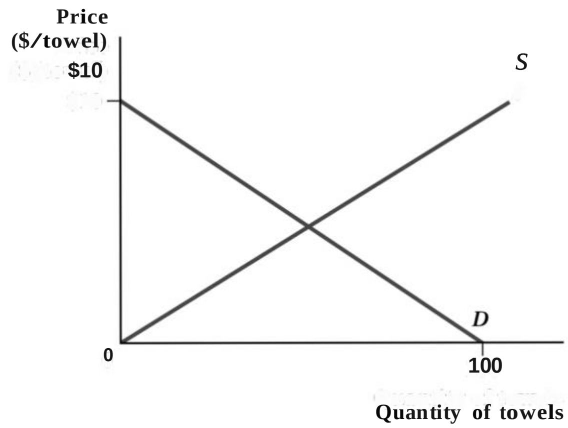
10. a. The inverse supply is

$$P = \frac{Q^S}{10}$$

whereas the inverse demand is

$$P = 20 - \frac{Q^D}{5}$$

The graph is shown at the right.



b. Define Q_E and P_E as equilibrium quantity and price, respectively. In equilibrium, price is such that quantity demanded is equal to quantity supplied. Therefore in equilibrium,

$$\frac{Q_E}{10} = 20 - \frac{Q_E}{5}$$

$$Q_E = 200 - 2Q_E$$

$$3Q_E = 200$$

$$Q_E = \frac{200}{3}$$

The equilibrium price is then

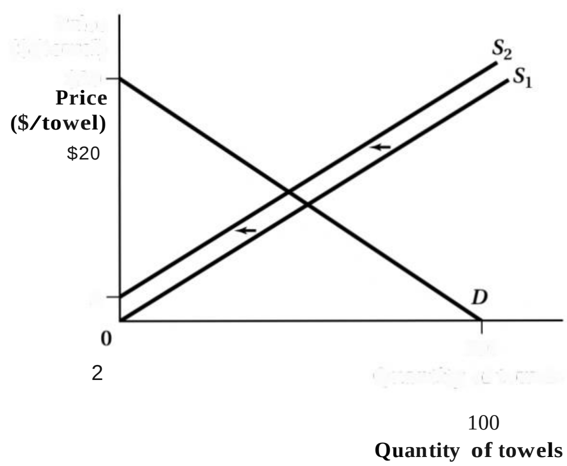
$$P_E = \frac{200/3}{10} = \frac{20}{3}$$

c. The new supply function is

$$Q^S = 10P - 20$$

Hence, the new inverse supply function is

$$P = \frac{Q^S}{10} + 2$$



d. Solving for the new equilibrium price and quantity, we get

$$\frac{Q_E}{10} + 2 = 20 - \frac{Q_E}{5}$$

$$Q_E + 20 = 200 - 2Q_E$$

$$3Q_E = 180$$

$$Q_E = 60$$

The equilibrium price is now

$$P_E = \frac{Q_E}{10} + 2 = \frac{60}{10} + 2 = 8$$

The decrease in supply has lowered the equilibrium quantity to 60 and raised the equilibrium price to 8.

e. If the quantity of towels demanded at any given price is 25 less than before, this means that the demand equation becomes $Q' = 75 - 5P$ and the inverse demand is $P = 15 - 0.2Q$.

Therefore, in equilibrium,

$$\frac{Q'}{10} = 15 - \frac{Q'}{5}$$
$$\frac{Q'}{10} = 15 - \frac{Q'}{5}$$
$$Q = 150 - 2Q$$
$$3Q = 150$$
$$Q = 50$$

The equilibrium price is now $P = \frac{Q}{5} = \frac{50}{10} = 5$.

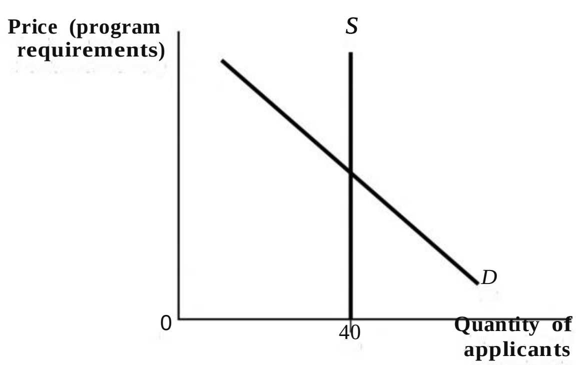
The decrease in demand has lowered both the equilibrium price and quantity. This is in contrast to the decrease in supply that lowered the equilibrium quantity and raised the equilibrium price.

11. Your university has an honors program that accepts exactly 40 freshmen each year. Every year before soliciting applications, students are informed of the standards for program participation. The admissions staff observed that whenever the difficulty of the program requirements increased (decreased), they received fewer (more) applicants than in the previous year and have since begun to adjust requirements for each incoming group of students in an attempt to equate the number of applicants with the number of spots in the program. Though the system is not perfect, the administrators are able to estimate their applicant pool with relative accuracy.

a. In this situation, what is the "price" that determines how many students will apply to the honors program? Also, assume that the people who run the honors program do not plan to expand or contract it. Depict the demand and supply curves that represent this situation.

b. How does the way "price" is determined in this situation differ from the way we normally think about the determination of equilibrium price?

11. a. The program requirements can be treated as the price. The supply curve is vertical and intersects the quantity of freshmen at 40. On the other hand, the demand curve is downward-sloping; that is, an increase in the "price" attracts fewer applicants.



b. The equilibrium "price" in this particular case is determined by the university.

12. Consider the market for van Gogh paintings and assume no forgeries are possible.

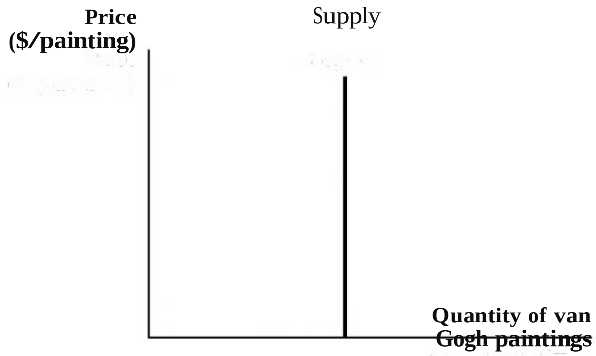
a. Is the supply of van Gogh paintings somewhat elastic, somewhat inelastic, perfectly elastic, or perfectly inelastic? Why?

b. Draw the supply curve for van Gogh paintings.

c. Suppose there are only 10 van Gogh paintings in the world, and the demand curve is $Q = 50 - 0.5P$. What is the equilibrium price?

d. A tragic fire destroys five of the paintings. What is the new equilibrium price?

12. a. Due to the limited number of van Gogh paintings, the supply is perfectly inelastic.



b. The supply curve is simply a vertical line.

c. $Q^s = 10$ and $Q^d = 50 - 0.5P$. In equilibrium, $Q^s = Q^d$ so that

$$Q^s = 10 = 50 - 0.5P = Q^d$$

$$10 = 50 - 0.5P$$

$$P_E = 80$$

Therefore, the equilibrium price is 80.

d. The quantity supplied becomes $Q^s = 5$ and the demand equation remains unchanged, so that

$$5 = 50 - 0.5P$$

$$P_E = 90$$

The new equilibrium price is 90.

13. Suppose the demand for down pillows is given by $Q^d = 100 - P$, and that the supply of down pillows is given by $Q^s = 20 + 2P$.

a. Solve for the equilibrium price.
b. Plug the equilibrium price back into the demand equation and solve for the equilibrium quantity.
c. Double-check your work by plugging the equilibrium price back into the supply equation and solving for the equilibrium quantity. Does your answer agree with what you got in (b)?
d. Solve for the elasticities of demand and supply at the equilibrium point. Which is more elastic, demand or supply?
e. Invert the demand and supply functions (in other words, solve each for P) and graph them. Do the equilibrium point and relative elasticities shown in the graph appear to coincide with your answers?

13. a. In equilibrium, $Q^s = Q^d$ so that

$$Q^d = 100 - P = 20 + 2P = Q^s$$

$$100 - P = 20 + 2P$$

$$P_E = 40$$

The equilibrium price for pillows is 40.

b. The equilibrium quantity is

$$Q_d = 100 - P_E = 60$$

c. The equilibrium quantity using the supply equation is

$$Q^s = 20 + 2P_E = 60 = Q_E$$

Hence, $Q^s = Q^d = Q_E$ just like what was obtained in (b).

d. The elasticity of supply or demand can be calculated using the expression

$$E = \frac{1}{\text{slope of the inverse demand curve}} \frac{P}{Q}$$

Note that $P = 40$ and $Q = 60$ at the equilibrium point. The slope of the demand curve is –1, so that

$$E_D = \frac{1}{-1} \times \frac{40}{60} = -\frac{2}{3}$$

whereas the slope of our supply curve is 0.5, so

$$E_S = \frac{1}{0.5} \times \frac{40}{60} = \frac{4}{3}$$

The elasticity of demand lies within the interval $-1 < E_D < 0$. Hence, the demand is inelastic. The coefficient of elasticity of supply indicates that supply is elastic. Out of the two, the supply is more elastic.

e. Inverting the demand function, we get

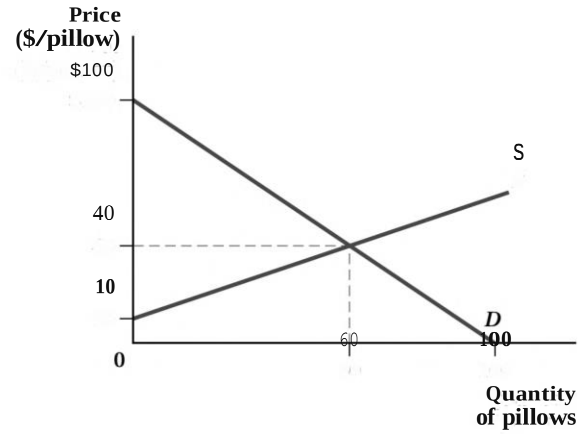
$$Q^d = 100 - P$$
$$P = 100 - Q^d$$

Inverting the supply function yields

$$Q^s = -20 + 2P$$
$$P = 0.5Q + 10$$

At the equilibrium, we get

$$100 - Q = \frac{Q}{2} + 10$$
$$100 - Q_e = \frac{1}{2}Q_e + 10$$
$$\frac{3}{2}Q_e = 90$$
$$Q_e = 60$$
$$P_e = 100 - Q_e = 40$$



Therefore, the equilibrium point coincides with our previous answer. Since the equilibrium point is the same and since the slopes of both curves are also unchanged, the elasticities will correspond to the previously derived coefficients in part (d).

14. Determine the effects of the following events on the price and quantity of beer sold. Assume that beer is a normal good.
   a. The price of wine, a substitute for beer, decreases.
   b. The price of pizza, a complement to beer, increases.
   c. The price of barley, an ingredient used to make beer, increases.
   d. Brewers discover they can make more money producing wine than they can producing beer.
   e. Consumers' incomes increase as the economy emerges from a recession

14. a. When the price of wine decreases, consumers will increase their consumption of wine and this, in turn, will cause a leftward shift in the demand for beer. Both the equilibrium price and equilibrium quantity of beer will decrease.
   b. When the price of pizza increases, consumers will decrease their consumption of pizza and this, in turn, will decrease the demand for beer. A lower equilibrium price and quantity will result.
   c. The higher price of barley increases costs for suppliers of beer. This causes the supply of beer to shift to the left, resulting in a higher equilibrium price and lower equilibrium quantity.
   d. Firms will leave the beer industry to enter the winemaking industry. This causes a decrease in the supply of beer, which leads to a higher equilibrium price and lower equilibrium quantity.
   e. Assuming that beer is a normal good, the increase in incomes will cause a rightward shift in demand. Both the equilibrium price and quantity will increase.

15. Suppose that budding economist Buck measures the inverse demand curve for toffee as $P = \$100 - Q^D$, and the inverse supply curve as $P = Q^S$. Buck's economist friend Penny likes to measure everything in cents. She measures the inverse demand for toffee as $P = 10{,}000 - 100Q^D$, and the inverse supply curve as $P = 100Q^S$.
   a. Find the slope of the inverse demand curve, and compute the price elasticity of demand at the market equilibrium using Buck's measurements.
   b. Find the slope of the inverse demand curve, and compute the price elasticity of demand at the market equilibrium using Penny's measurements. Is the slope the same as Buck calculated? How about the price elasticity of demand?

15. a. We first find the market equilibrium quantity

$$P = 100 - Q = Q = P$$
$$Q_e = 50$$

The equilibrium price is

$$P_* = 50$$

The slope of the inverse demand curve is -1; hence, the price elasticity of demand is

$$E_D \quad \frac{1}{1} \quad \frac{850}{50} \quad 1$$

The demand at the equilibrium is unit-elastic.

b. The market equilibrium quantity is

$$P = \$10{,}000 - 100Q'' = 100Q = P$$

$$Q_* = 50$$

The equilibrium price is

$$P_* = 5{,}000 \text{ cents}$$

The slope of the inverse demand function is -100. The price elasticity of demand is

$$E_D = \frac{1}{-100} \times \frac{5{,}000}{50} = -1$$

The slope is 100 times greater compared to Buck's calculations. However, the price elasticity of demand is unchanged because the price elasticity of supply and that of demand are not affected by the unit of measurement used.

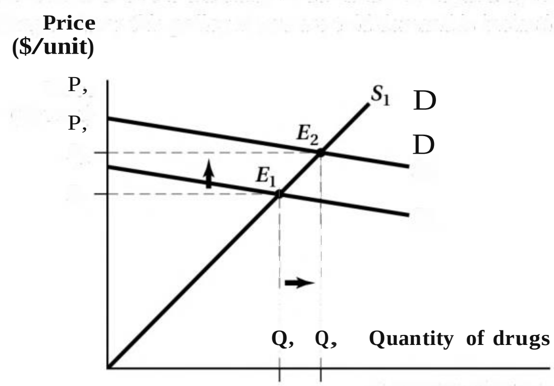
16. Some policy makers have claimed that the U.S. government should purchase illegal drugs, such as cocaine, to increase the price that drug users will face and therefore reduce their consumption. Does this idea have any merit? Illustrate this logic in a simple supply and demand framework. How does the elasticity of demand for illegal drugs relate to the efficacy of this policy? Are you more or less willing to favor this policy if you are told demand is inelastic?

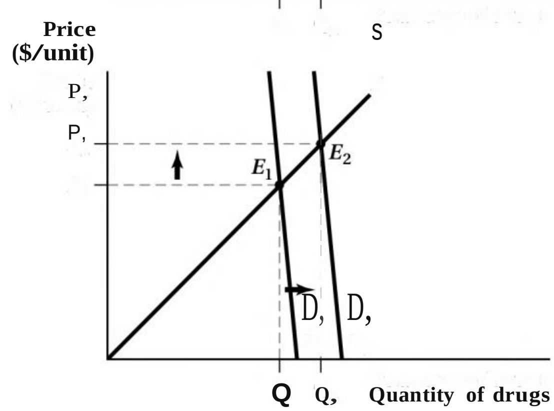
16. It does have merit. The demand curve will shift out when government becomes an added purchaser and the price the drug users will face will increase. I would not support such a policy because drug usage is an addiction; that is, the demand for drugs is quite inelastic.

Assuming the demand for illegal drugs is elastic, the price and quantity demanded increase as a result of the movement along the supply curve.

Assuming the demand curve for illegal drugs is inelastic, due to the intervention, both price and quantity increase.

However, the amount consumed by drug users will decrease in both cases once one subtracts the amounts sold to the government. The more inelastic the demand is, the smaller is the quantity response by illegal drug users. Therefore, such would not be an optimal policy in this situation. Increasing the (legal/penal) cost of supplying and demanding illegal drugs would be far more effective since it would shift the actual supply and demand curves in, reducing the quantity used by drug addicts.

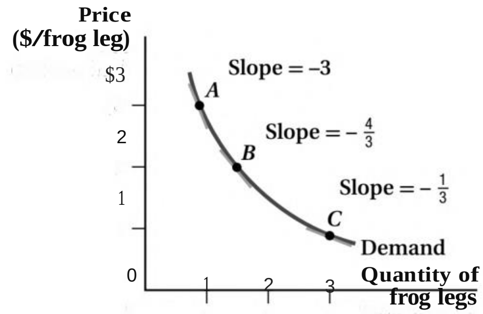




*17. Suppose that a typical consumer has an inverse demand for frog's legs given by the following:

$P = \frac{3}{Q}$. A graph of that inverse demand curve is given in the figure to the right.

Show that the demand curve is unit-elastic.



17. Consider increasing frog's legs from 1 to 3; that is, by 200%. On the other hand, the price decreases from $3 to $1; that is, by 200%. Hence, the price elasticity of demand is

$$E = \frac{\%\Delta Q}{\%\Delta P} = \frac{200\%}{-200\%} = -1$$

The demand curve is unit-elastic.

18. The cross-price elasticity of demand measures the percentage change in the quantity of a good demanded when the price of a different good changes by 1%. The income elasticity of demand measures the percentage change in the quantity of a good demanded when the income of buyers changes by 1%.

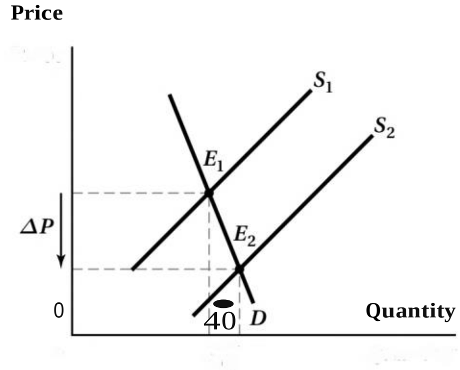
a. What sign might you expect the cross-price elasticity to have if the two goods are shampoo and conditioner? Why?
b. What sign might you expect the cross-price elasticity to have if the two goods are gasoline and ethanol? Why?
c. What sign might you expect the cross-price elasticity to have if the two goods are coffee and shoes? Why?
d. What sign might you expect the income elasticity to have if the good in question is hot stone massages?
e. What sign might you expect the income elasticity to have if the good in question is Ramen noodles?
f. What sign might you expect the income elasticity to have if the good in question is table salt?

18. a. Cross-price elasticity would likely be negative, because an increase in the price of shampoo would likely cause people to use less conditioner. The higher price of shampoo would decrease the quantity of shampoo demanded, so people would buy less conditioner, which is a complement good.
b. Gasoline and ethanol are viewed as substitutes. An increase in the price of gasoline would cause an increase in the demand for ethanol. This gives us a positive number for cross-price elasticity.
c. There is not an obvious connection between these two goods. Most likely, cross-price elasticity would be zero. A change in the price of one does not have a predictable effect on the quantity of the other.
d. A hot stone massage is considered a luxury good, so demand would increase as incomes increase. The income elasticity would be positive.
e. We can expect a negative number for income elasticity. Ramen noodles are viewed as a low-cost meal. People will buy more Ramen noodles when incomes decrease.
f. Table salt is a necessity, and the amount purchased is largely independent of income. Zero would be the most likely number for income elasticity.

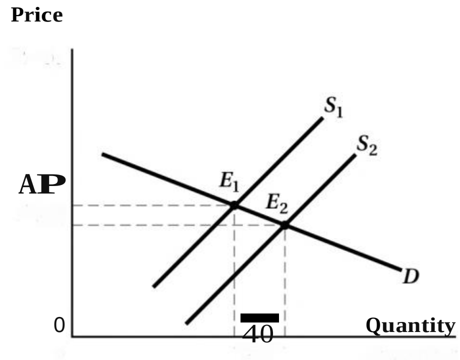
19. Which of the following cases will result in the largest decrease in equilibrium price? The largest change in equilibrium quantity? Verify your answers by drawing graphs.

a. Demand is highly inelastic; there is a relatively large increase in supply.
b. Demand is highly elastic; there is a relatively small increase in supply.
c. Supply is highly inelastic; there is a relatively small decrease in demand.
d. Supply is highly elastic and demand is very inelastic; there is a relatively large increase in supply.

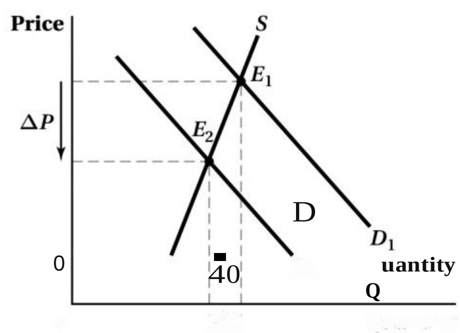
19. a. Because demand is inelastic, the rightward shift of supply will cause a fairly significant decrease in price.



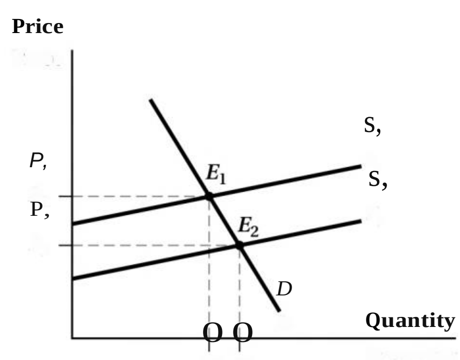
b. If the demand curve is flat and the shift in supply is relatively small, then price decreases only slightly.



c. The price will fall due to the decrease in demand. Equilibrium quantity decreases only slightly because the supply curve is steep.



d. This scenario will result in the largest decrease in price because the demand curve is steep and the supply curve is flat.



The Calculus of Equilibrium and Elasticities

2

Online Appendix

1. Suppose that the supply of specialty workstation laptops is represented by Q = 1,000 + P, where price is measured in dollars and quantity is measured in units.
   a. Now suppose that the demand for the laptops is Q'' = 9,000 – P – $0.05I$, where I is income. What are the current equilibrium price and quantity if income is $100,000?
   b. Suppose that income falls to $80,000. What is the new equation for the demand?
   c. What will be the new equilibrium price and quantity after the income increase?
   d. Is the laptop workstation a normal or an inferior good? Answer the question using a partial derivative.

Solution

1. a. If income is $100,000, demand is Q'' = 9,000 -- P – 0.05(100,000) = 4,000 -- P. The equilibrium condi• tion then is 1,000 + P = 4,000 – P or P = 1,500. At this price, Q'' = 4,000 – 1,500 = 2,500 (or to double-check, $Q?$ = 1,000 + 1,500 = 2,500). Price therefore is $1,500 per workstation laptop and 2,500 of these specialty computers are sold.
   b. If income is $80,000, demand is Q'' = 9,000 -- P – 0.05(80,000) = 5,000 -- P.
   c. At the new income level, the equilibrium condition is 1,000 + P = 5,000 -- P or P = 2,000. At this price, Q'' = 5,000 – 2,000 = 3,000 (or alternatively, $Q?$ = 1,000 + 2,000 = 3,000). Price therefore is now $2,000 per workstation laptop and 3,000 specialty computers are sold (or alternatively, Q = 1,000 + 2,000 = 3,000).
   d. The workstation is an inferior good since $\frac{Q''}{\sim}$ = –0.05 < 0.

2. Suppose that the supply of a flat panel TV stand is represented by $Q?$ = $8P$ – $20P$, – 200, where P is the price of the stand and P, is the price of the hardware needed to hold the stand together. All prices are in dollars and quantity is in units. Assume that the current hardware price is $5.
   a. Suppose that the demand for the TV stand is Q'' = 4,700 – $2P$ + $0.5I$, where P is the price and I is a representative household's income. What are the current equilibrium price and quantity if income is $1,000?
   b. Suppose that income falls to $800. What is the new equation for the demand for TV stands as a function of price P? Does this correspond to an increase or decrease in the demand for the TV stands? Does the demand curve shift to the left or right?
   c. Suppose that the price of the hardware increases to $6. What is the new equation for the supply of TV stands as a function of price P? Does this correspond to an increase or decrease in supply? Does the supply curve shift to the left or right?
   d. What will be the new equilibrium price and quantity of the TV stand after the changes in supply and de• mand [after all changes in parts (b) and (c)]?

Solution

2. a. At these values, supply is Q = $8P$ – 20(5) – 200 = $8P$ – 300 and demand for the TV stand is Q'' = 4,700 – $2P$ + 0.5(1,000) = 5,200 – $2P$. Equilibrium price is $8P$ – 300 = 5,200 – $2P$, or P = 550. Equi• librim quantity is Q'' = 5,200 – 2(550) = 4,100 (or, alternately, Q = 8(550) – 300 = 4,100). At the equilibrium price of $550, 4,100 stands are sold.
   b. After the increase in income, the new demand equation is Q'' = 4,700 – $2P$ 4 0.5(800) = 5,100 -- $2P$, which tells us that a decrease in income leads to a decrease in the demand for the TV stands, and a shift in the demand curve to the left.
   c. After the increase in the price of the hardware, the new supply equation is Q^8 = SP – 20(6) – 200 = $8P$ – 320. Supply decreases, and the supply curve shifts to the left.
   d. The new equilibrium price is 5,100 – $2P$ = $8P$ – 320 or P = 542, and the new equilibrium quantity is Q'' = 5,100 – 2(542) = 4,016 (or, alternately, $Q?$ = 8(542) – 320 = 4,016). The price therefore is now $542, and 4,016 stands are sold.

3. From the original setup in Problem 2, suppose that the quantity supplied of flat panel TV stands is represented by $Q^S = 8P - 20P_h - 200$, where P is the price of the stand and P_h is the price of hardware inputs, and that quantity demanded is $Q^D = 4{,}700 - 2P + 0.5I$, where I is income. Assume that at the equilibrium, income is \$1,000 and the hardware price is \$5.
   a. Calculate the income elasticity of demand using calculus.
   b. Calculate an input elasticity of supply using calculus. (*Hint*: Think about cross-price elasticities on the demand side as being analogous to input elasticities on the supply side.)

Solution

3. a. The income elasticity of demand is $E_I^D = \frac{\partial Q^D}{\partial I}\frac{I}{Q^D} = 0.5\frac{1{,}000}{4{,}100} \approx 0.122$.
   b. The input elasticity of supply is $E_{P_h}^S = \frac{\partial Q^S}{\partial P_h}\frac{P_h}{Q^S} = -20\frac{5}{4{,}100} = -0.024$.

4. Suppose that the inverse demand curve for a dinner-for-two special at a small local restaurant can be expressed as $P = 4{,}900 - 3Q^2$, where price is expressed in dollars and quantity in number of specials. What is the price elasticity of demand when 40 specials are purchased?

Solution

4. When quantity is 40,

$$P = 4{,}900 - 3(40)^2 = \$100$$

Using the demand equation, $\frac{\partial P}{\partial Q} = -3(2)Q = -6Q$. At $Q = 40$, this value is $-6(40) = -240$. The price elasticity of demand is $E^D = \frac{1}{\frac{\partial P}{\partial Q}}\frac{P}{Q} = \frac{1}{-240}\frac{100}{40} \approx -0.01$. Demand for this particular dinner special, therefore, is very inelastic.

Supply and Demand 2

teaching tip

While much of this material will be review for most students, many may not have used supply and demand equations before. If you take your time explaining these equations and how to solve for equilibrium, students will master this skill quickly.

2.1 Markets and Models

A. What Is a Market?

1. A market can be defined by many things.
   a. Type of product sold
   b. Particular location
   c. A point in time

B. Key Assumptions of the Supply and Demand Model

1. We restrict our focus to supply and demand in a single market.
   Definition: **Supply** is the combined amount of a good that all producers in a market are willing to sell.
   Definition: **Demand** is the combined amount of a good that all consumers in a market are willing to buy.
2. All goods bought and sold in the market are identical.
   Definition: **Commodities** are products traded in markets in which consumers view different varieties of the good as essentially interchangeable.
3. All goods sold in the market sell for the same price and everyone has the same information about prices, the quality of the goods being sold, and so on.
4. There are many buyers and sellers in the market.

2.2 Demand

A. Factors That Influence Demand

1. Price
2. The Number of Consumers
3. Consumer Income or Wealth

teaching tip

You may want to introduce the concepts of normal and inferior goods here, although they are not formally defined until Chapter 5. Students generally have heard these terms before in Principles courses and understand what they are and how income affects the demand for each differently.

4. Consumer Tastes
5. Prices of Other Goods
   Definition: **A substitute** is a good that can be used in place of another good.
   Definition: **A complement** is a good that is purchased in combination with another good.

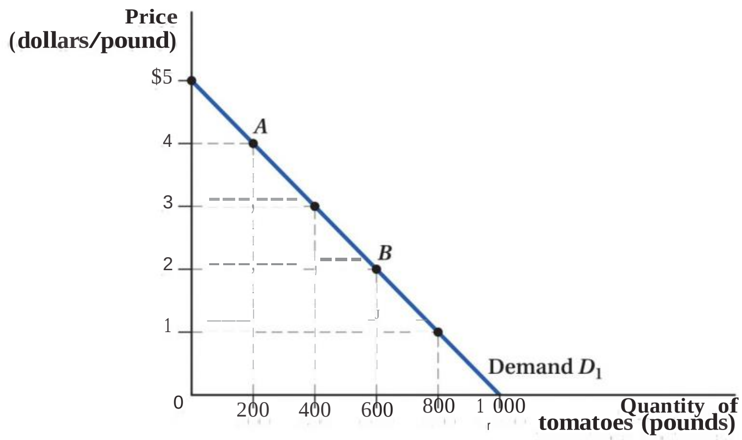
B. Demand Curves

1. Graphical Representation of the Demand Curve
   Definition: **A demand curve** is the relationship between the quantity of a good that consumers demand and the good's price, holding all other factors constant.
   a. Demand curves generally slope downward. As price falls, quantity demanded rises.

teaching tip

Stress the fact that ***everything*** except price and quantity demanded is held constant on • demand curve.

Figure 2.1 Demand for Tomatoes



2. Mathematical Representation of the Demand Curve
   a. Any demand curve can be represented by an equation.
   b. The demand curve in Figure 2.1 can be represented by $Q = 1{,}000 - 200P$.

   Definition: **Demand choke price** is the price at which no consumer is willing to buy a good and quantity demanded is zero; it is the vertical intercept of the inverse demand curve.

   Definition: **Inverse demand curve** is a demand curve written in the form of price as a func• tion of quantity demanded.

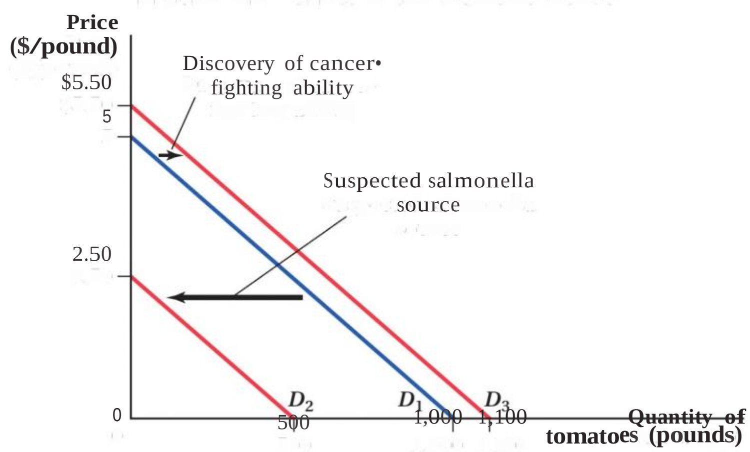
teaching tip

Explain to students that there will be times when it is easier to work with the demand curve equation and times when it is easier to work with inverse demand. But this should not be a problem because students can move from one form to the other using basic algebra.

   c. The inverse demand curve can be represented as $P = 5 - 0.005Q$.

C. Shifts in Demand Curves

Figure 2.2 Shifts in the Demand Curve



Definition: **Change in quantity demanded** is a movement along the demand curve that occurs as a result of a change in the good's price.
Definition: **Change in demand** is a shift of the entire demand curve caused by a change in a determinant of demand other than the good's own price.

teaching tip

Make sure you get students thinking of an increase in demand as a shift out (or to the right) rather than up. Likewise, a decrease in demand is a shift in or left (rather than down). This becomes very important when students think about changes in supply.

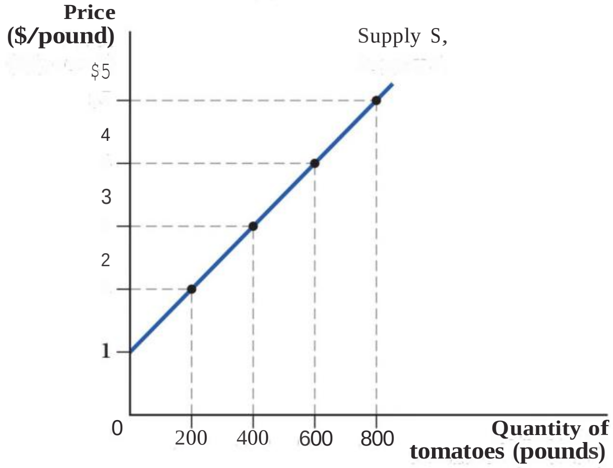
D. Why Is Price Treated Differently from the Other Factors That Affect Demand?
1. There are three reasons economists focus on the effect of a good's price:
a. Price is typically one of the most important factors that influence demand.
b. Prices can be changed frequently and easily.
c. Price is the only factor that also exerts a large, direct influence on the supply side of the market.

2.3 Supply

A. Factors That Influence Supply
1. Price
2. Suppliers' Costs of Production
Definition: **Production technology** is the processes used to make, distribute, and sell a good.
3. The Number of Sellers
4. Sellers' Outside Options

B. Supply Curves

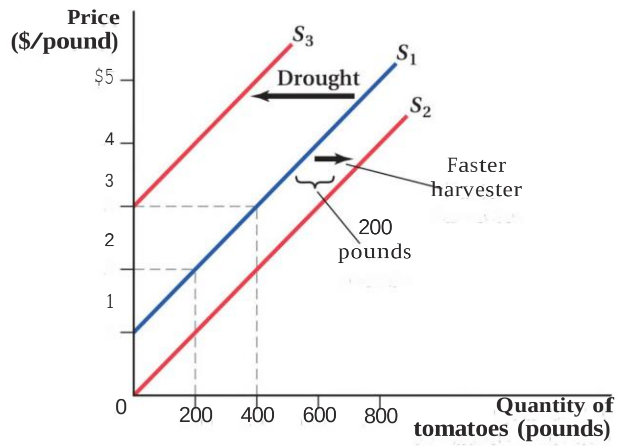
Figure 2.3 Supply of Tomatoes



1. Graphical Representation of the Supply Curve
Definition: **Supply curve** is the relationship between the quantity supplied of a good and the good's price, holding all other factors constant.
• Supply curves generally slope upward. As price rises, quantity supplied rises.
2. Mathematical Representation of the Supply Curve
a. The supply curve in Figure 2.3 can be expressed as $Q = 200P - 200$.
Definition: **Supply choke price** is the price at which no firm is willing to produce a good and quantity supplied is zero; it is the vertical intercept of the inverse supply curve.
Definition: **Inverse supply curve** is a supply curve written in the form of price as a function of quantity supplied.
b. The inverse supply curve from Figure 2.3 can be expressed as $P = 0.005Q + 1$.

C. Shifts in the Supply Curve

Figure 2.4 Shifts in the Supply Curve



Definition: **Change in quantity supplied** is a movement along the supply curve that occurs as a result of a change in the good's price.

Definition: **Change in supply** is a shift of the entire supply curve caused by a change in a determinant of supply other than the good's own price.

D. Why Is Price Also Treated Differently for Supply?

1. Price is the only factor that influences both supply and demand.

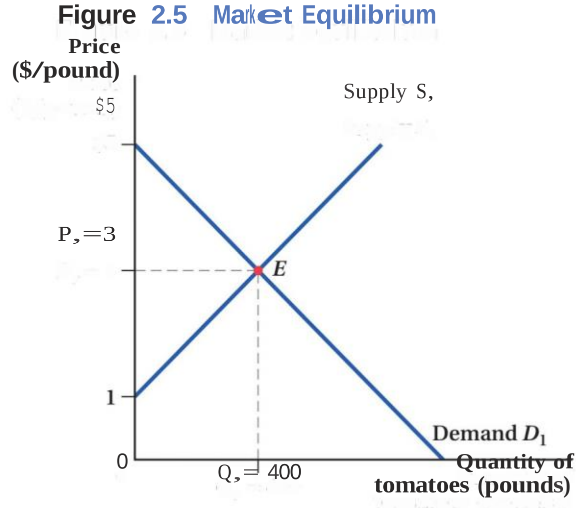
2.4 Market Equilibrium

Definition: **Market equilibrium** is the point at which the quantity demanded by consumers exactly equals the quantity supplied by producers.

- The point at which the demand and supply curves intersect

Definition: **Equilibrium price** is the only price at which quantity supplied equals quantity demanded.

Figure 2.5 Market Equilibrium



A. The Mathematics of Equilibrium

1. To solve for the equilibrium price, we equate quantity supplied with quantity demanded.

$$Q^D = Q^S$$

$$1{,}000 - 200P_e = 200P_e - 200$$

$$P_e = \$3$$

2. To solve for equilibrium quantity, we plug the equilibrium price into either the supply or demand equation.

$$Q'' = 1{,}000 - 200P, = 1{,}000 - 200(3) = 1{,}000 - 600 = 400$$

$$Q = 200P, - 200 = 200(3) - 200 = 600 - 200 = 400.$$

teaching tip

[illegible] tion they use.

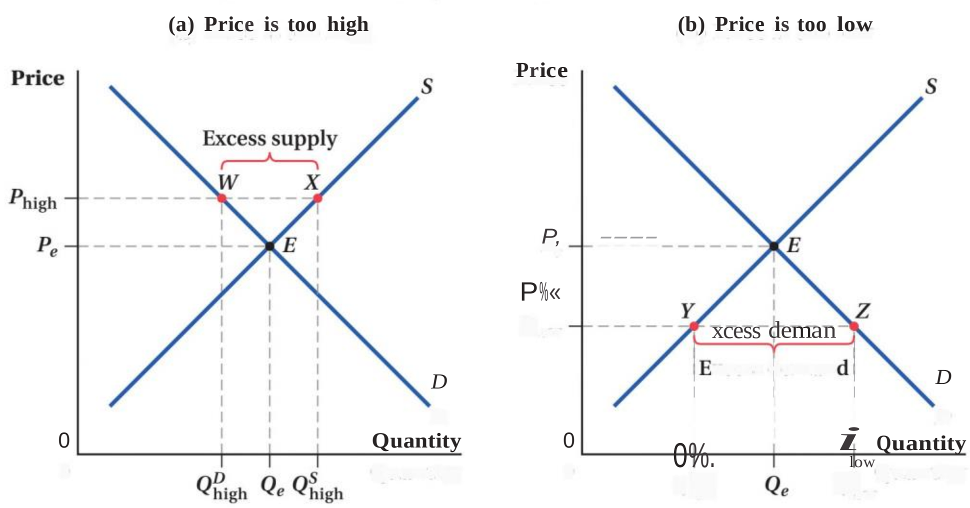
B. Why Markets Move toward Equilibrium

teaching tip

It is very important to stress this concept in your course. The true economics lies in the story of how markets adjust to equilibrium, not in the calculation of the equilibrium price and quantity. Make sure students understand that price adjusts when there is an imbalance between quantity demanded and quantity supplied.

1. Excess Supply
   a. When a surplus exists, price falls, quantity demanded rises, and quantity supplied falls until equilibrium is reached.

Figure 2.6 Why P_e Is the Equilibrium Price



2. Excess Demand
   a. When a shortage occurs, the price rises, quantity demanded falls, and quantity supplied rises.
3. Adjusting to Equilibrium
   a. Real-world markets rely on the "invisible hand" to move to equilibrium.
   b. Producers and consumers act independently, so sometimes markets are not in equilibrium.

2.1 additional figure it out

The supply and demand for monthly gym memberships are given as $Q = 10P - 300$ and $Q! = 600 - 10P$, where P is the monthly price of a membership.

1. If the current price for memberships is \$50 per month, is the market in equilibrium?
2. Would you expect the price to rise or fall?
3. If so, by how much?

Solution:

There are two ways to solve the problem:

1. Compute quantity demanded and quantity supplied at a price of \$50.

2. Solve for the market equilibrium price and quantity.

$$10P - 300 = 10 \times 50 - 300 = 200$$

$$Q'' = 600 - 10P = 600 \quad 10 \times 50 = 100$$

Therefore, since $Q'' \quad Q$, the market is not in equilibrium. There is a surplus, so we can expect the price to fall.

3. Solving for equilibrium, we get:

$$0^{\circ} = O?$$

$$lOP - 300 = 600 - 10P$$

$$P = \$45,\ Q = 150$$

Therefore, price must fall by \$5, and 50 more memberships are sold.

C. The Effects of Demand Shifts

Example: Suppose a news story reports that tomatoes are suspected of being the source of a salmonella outbreak.

- At every price, the quantity of tomatoes buyers who want tomatoes will fall.
- This shifts the demand curve to the left.
- The new demand curve is $Q = 500 - 200P$.
- Setting $Q'' = Q_9$ we get:

$$500 - 200P, = 200P, - 200$$

$$400P, = 700$$

$$P, = \$1.75$$

- The equilibrium quantity is:

$$Q! = 500 - 200P = 500 - 200(1.75) = 500 - 350 = 150.$$

$$Q^5 = 200P - 200 = 200(1.75) - 200 = 350 - 200 = 150.$$

- Therefore, the equilibrium price and quantity both fall.

2.2 additional figure it out

Draw a supply and demand diagram of the market for generators in Tampa, Florida.

1. Suppose a hurricane watch is issued, and some residents expect to lose power. Using the supply and demand diagram, show what will happen to the equilibrium price and quantity in the market for generators in Tampa.
2. Does this change reflect a change in demand or a change in the quantity demanded?

Solution:

1. The initial equilibrium occurs at a price of P, and quantity Q. When the hurricane watch is issued, demand shifts to the right. The new price is *P,* and the new quantity is *Q*. Thus, price and quantity exchanged have both increased.
2. This represents a change (or shift) in demand.

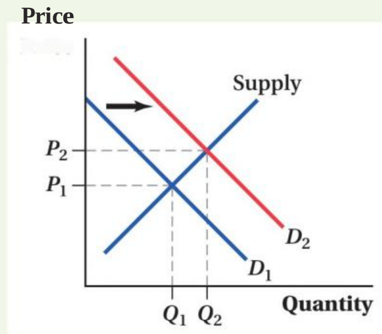
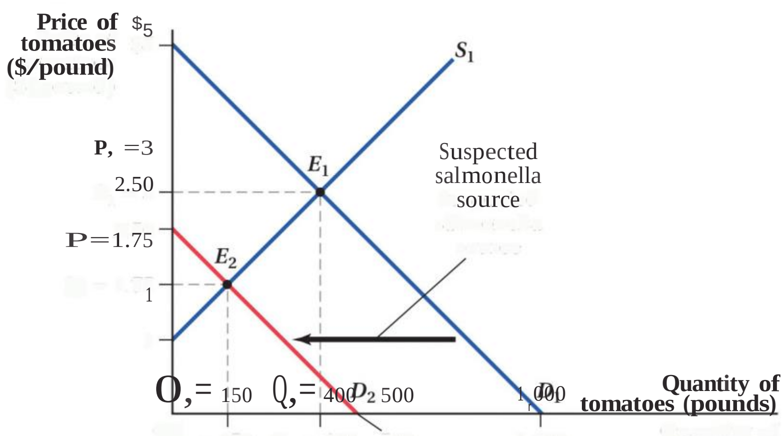


Figure 2.7 Effects of a Fall in the Demand for Tomatoes



2. Shifts in Curves versus Movement along a Curve
   a. Anything that changes the quantity of a good that consumers wish to buy at every price causes a *shift* in the demand curve.
   b. The shift in the demand curve causes the equilibrium price to change, which leads to a *change in quantity supplied* (demonstrated by the movement along the supply curve).

D. The Effects of Supply Shifts

Example: Suppose the price of fertilizer falls, reducing farmers' costs.

- Farmers will be more willing to supply tomatoes at every price.
- The new supply curve becomes $Q = 200P, + 200$.
- The supply curve will shift to the right.
- We can solve for the new equilibrium by setting $Q' = Q$:

$$1{,}000 - 200P, = 200P, + 200$$

$$400P, = 800$$

$$P, = \$2$$

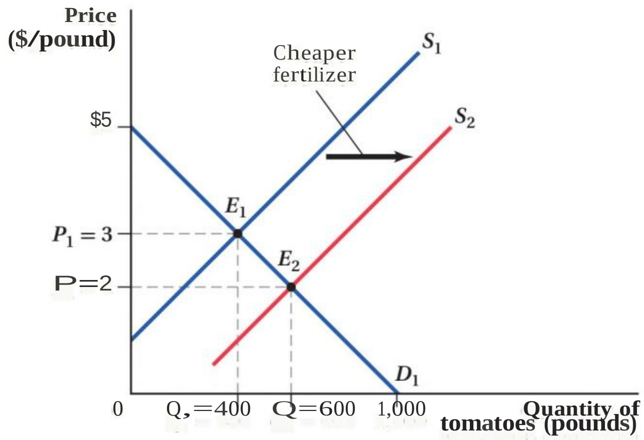
- The equilibrium quantity is:

$$Q! = 1{,}000 \quad 200(2) = 1{,}000 - 400 = 600.$$

$$Q = 200(2) + 200 = 400 + 200 = 600.$$

- The equilibrium price will fall and the equilibrium quantity will rise.

Figure 2.8 Effects of an Increase in the Supply of Tomatoes



freakonomics: What Do President Obama and Taylor Swift Have in Common?

- A large amount of public interest in both the Obama family and Taylor Swift leads to high prices for photos of them, providing incentives for the paparazzi to take photos whenever possible.
- To mitigate this, the White House provided photos to media outlets for free, lowering the demand for the paparazzi's photos.
- Taylor Swift, meanwhile, lowered the demand for paparazzi photos of her belly button by taking her own photo and posting it on Instagram.
- In both cases, the lower prices also reduced the paparazzi's incentives to take the photos.

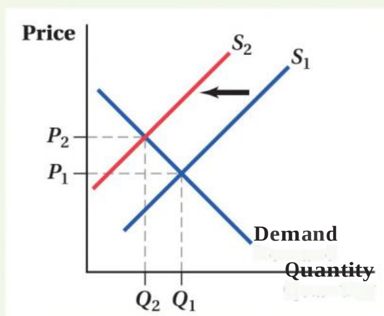
2.3 additional figure it out

This summer you noticed the price of lobster in your supermarket rising but at the same time much less lob• ster was sold. Using a supply and demand diagram, what can you infer about this market?

Solution:

The only shift that leads to a higher equilibrium price and a lower quantity sold is a decrease in supply. Therefore, the supply curve for lobster shifted in. The new price is P, and the new quantity is Q.

This represents a **change (or shift) in supply** and a **change in the quantity demanded.**



E. Summary of Effects
1. Table 2.2 summarizes the changes in equilibrium price and quantity for any shift in supply and demand.

Table 2.2 Effect of Shifts in Demand and Supply Curves in Isolation

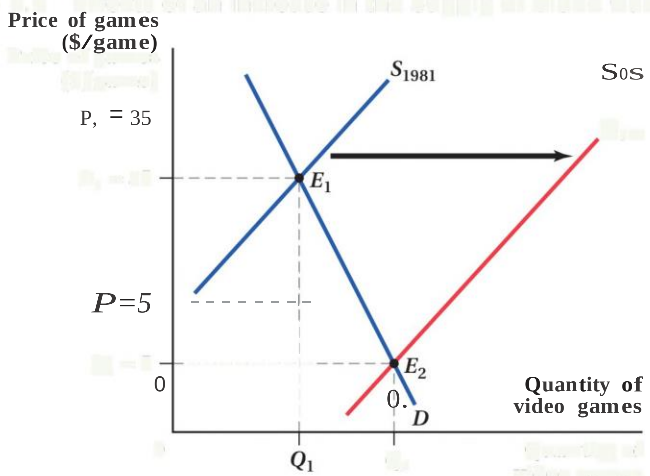
Curve that Shifts	Direction of Shift	Impact on Equilibrium Price	Impact on Equilibrium Quantity
Demand Curve	Out (increase in D)	t	↑
	In (decrease in D)	↓	↓
Supply Curve	Out (increase in S)	↓	↑
	In (decrease in S)	t	↓

·l, **application**

Supply Shifts and the Video Game Crash of 1983

- A large shift in the supply of video games occurred between 1981 and 1983.
- This led to a sharp decline in the price of video games.

Figure 2.9 Effects of an Increase in the Supply of Video Games



2.4 additional figure it out

Return to the example of gym memberships in ad• ditional figure it out 2.1, where $Q? = 10P - 300$ and $Q'' = 600 - 10P$.

Now suppose the town opens a new community center with a pool and a weight room. As a result, consumers demand 200 fewer gym memberships at every price.

1. Write down the new demand equation.
2. What do you expect to happen to the equilibrium price and quantity? (Remember, previously $P^* = \$45, Q = 150$.)
3. Compute the new equilibrium price and quantity.

Solution:

1. Q'' has fallen by 200. Therefore, $Q = 600$ $10P - 200 = 400$ $10P$.
2. Because demand has fallen, we should see a reduction in both the equilibrium price and quantity.
3. $O = O?$

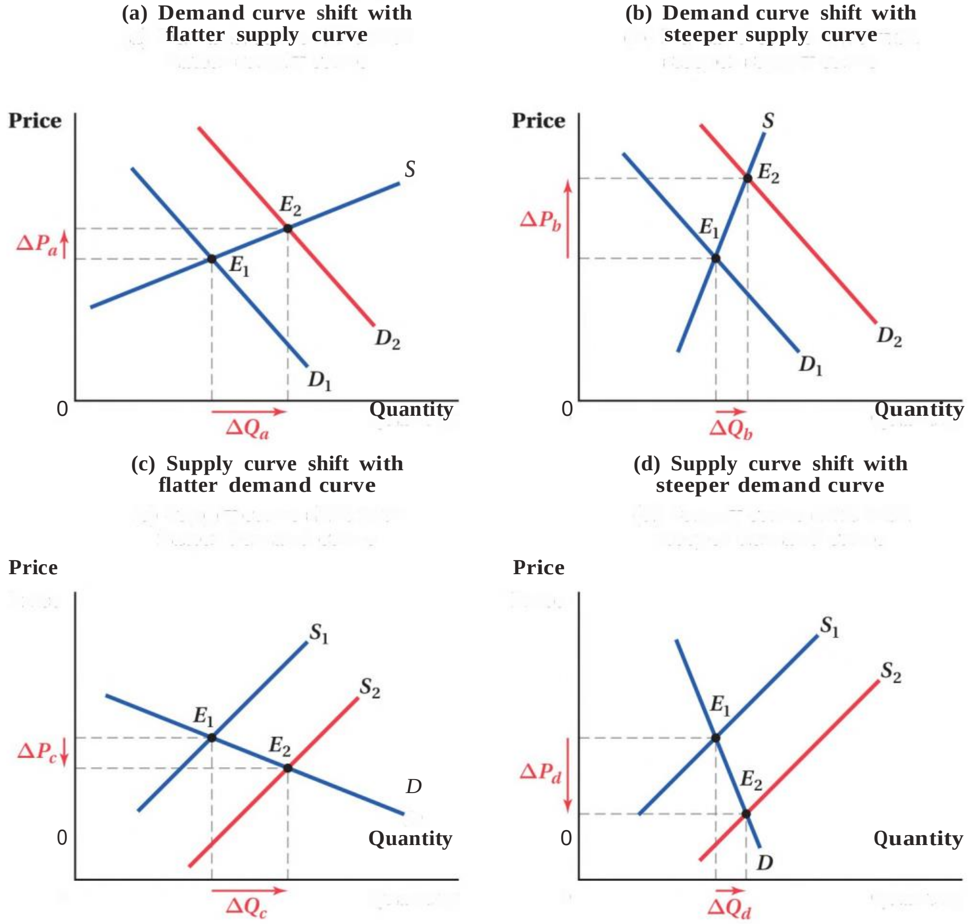
$$10P - 300 = 400 - 10P$$

$$P = \$35, Q = 50$$

As expected, price has fallen (by \$10), and the quantity of memberships sold has fallen as well (by 100).

F. What Determines the Size of Price and Quantity Changes?
   1. Size of the Shift
   2. Slopes of the Curves
      a. Demand shifts
         i. Relatively flat supply: small change in equilibrium price and a large change in equilibrium quantity.
         ii. Relatively steep supply: large change in equilibrium price and a small change in equilibrium quantity.
      b. Supply shifts
         i. Relatively flat demand: small change in equilibrium price and a large change in equilibrium quantity.
         ii. Relatively steep demand: large change in equilibrium price and a small change in equilibrium quantity.

Figure 2.10 Size of Equilibrium Price and Quantity Changes, and the Slopes of the Demand and Supply Curves



application

The Supply Curve of Housing and Housing Prices: A Tale of Two Cities

- The relative slope of the supply curve determines the size of the effect of an increase in demand.
- New York has a relatively steep supply of housing, while Houston has a relatively flat supply of housing.
- Between 1977 and 2009, the population of New York grew by about 15%, while Houston's population more than doubled.
- But because the supply of housing is flatter for Houston than for New York, housing prices did not rise as much in Houston as they did in New York.

Figure 2.11 Population Indices for New York and Houston, 1977–2013

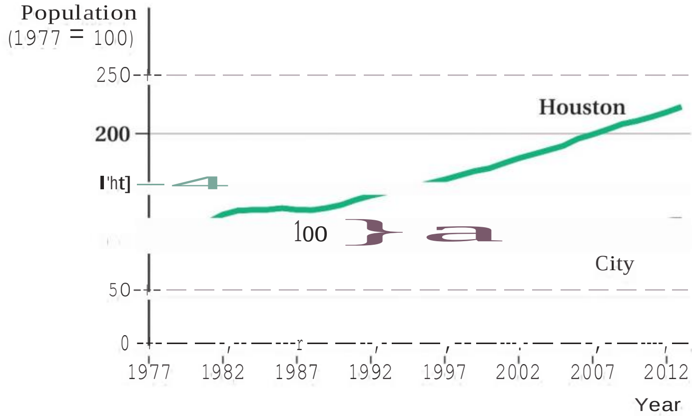
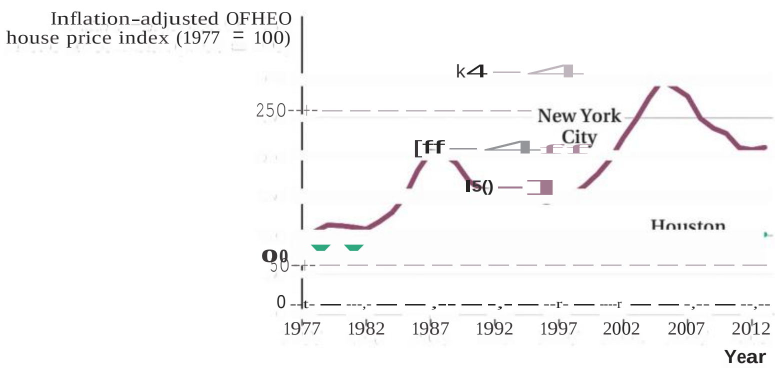


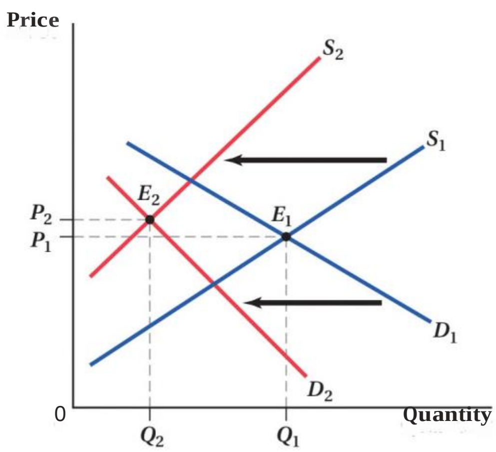
Figure 2.12 Housing Price Indices for New York and Houston, 1977–2013



G. Changes in Market Equilibrium When Both Curves Shift

1. As a rule, when both curves shift at the same time, we will know with certainty the direction of the change of either the equilibrium price or the equilibrium quantity but not both.

Figure 2.13 Example of a Simultaneous Shift in Demand and Supply

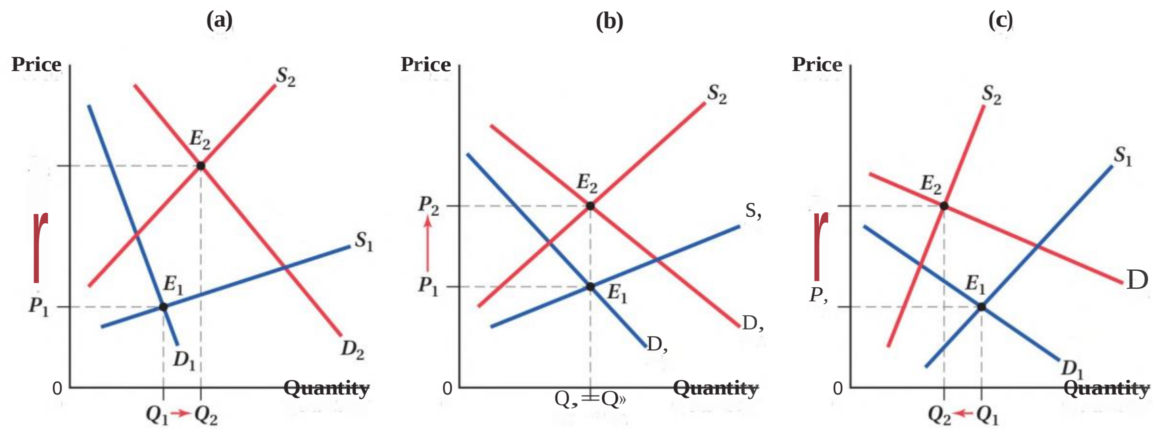


2. Each separate shift in supply and demand leads to a unique result. That is why two simultaneous shifts will not move equilibrium price and quantity in the same ways.

teaching tip

An easy way to prove this is to divide your class into thirds. Have the first third draw a large increase in demand accompanied by a small increase in supply. Have the second third do the opposite—draw a diagram showing a small increase in demand accompanied by a large increase in supply. The last third should draw their graphs assuming the supply and demand both increase by the same amount. Then ask your class to describe their results. They will all show an increase in the equilibrium quantity; but they will differ with the effects on equilibrium price. Emphasize to them that it is always best to draw simultaneous shifts on separate graphs, because once they draw the shifts, they are making assumptions about the relative sizes of the shifts.

Figure 2.14 When Both Curves Shift, the Direction of Either Price or Quantity Will Be Ambiguous



2.5 Elasticity

Definition: Elasticity is the ratio of the percentage change in one value to a percentage change in another.

Definition: Price elasticity of demand is the percentage change in quantity demanded resulting from a given percentage change in price.

A. Slope and Elasticity Are Not the Same
   1. The slope relates the change in one level to a change in another level.
      a. Slopes depend on units of measure.
      b. You cannot compare slopes across two different products.
   2. Elasticities are measured using relative percentage changes.

B. The Price Elasticities of Demand and Supply
   1. E' = percent change in quantity demanded divided by percent change in price.
      a. Because demand curves slope down, $E'' < 0$.
      b. Because E' is a ratio, it can be thought of as the percent change in Q'' for a 1% change in price.
   2. E = percent change in quantity supplied divided by percent change in price.
      a. Because supply curves slope up, $E > 0$.
      b. Because E is a ratio, it can be thought of as the percent change in Q? for a 1% change in price.

teaching tip

While many Principles of Economics texts teach students to ignore the negative sign on the price elasticity of demand, it is best to keep the sign with the elasticity and then focus on the absolute value when talking about its magnitude. Students may need to use an elasticity to calculate a percentage change in a variable, and dropping the sign can lead to incorrect understanding. Also, signs are important for the income elasticity and cross-price elasticity, so keeping the sign here will lead to consistency there.

C. Price Elasticities and Price Responsiveness

1. When demand (supply) is very price-sensitive, a small change in price will lead to large changes in quantities demanded (supplied).
2. This means that the numerator of the elasticity expression, the percentage change in quantity, will be very large compared to the percentage change in price in the denominator.
3. The availability of substitutes is a factor that can lead to price elasticities of demand with larger magnitudes.
4. The ability of producers to adjust their production is an important factor that influences the magnitude of the price elasticity of supply.

application

Demand Elasticities and the Availability of Substitutes

- The availability of substitutes results in a greater responsiveness on the part of the consumer to changes in prices.
- As a result, the demand for broad groupings of goods (e.g., juice) is less elastic than is the demand for more narrowly defined, more easily substitutable goods (e.g., Shredded Wheat brand breakfast cereal).
- An extreme example of the effect of substitution possibilities is the finding that the price elasticity of demand for easily substitutable CPUs and memory chips on a price search engine Web site is on the order of −25.

5. Elasticities and Time Horizons
   a. In the short run, consumers and producers are often limited in their ability to change their behaviors. Therefore, demand and supply will often be less elastic in the short run.
   b. Larger-magnitude elasticities imply flatter demand and supply curves. As a result, long-run demand and supply curves tend to be flatter than their short-run versions.
6. Classifying Elasticities by Magnitude

   Definition: **Elastic** means having a price elasticity with an absolute value greater than 1: $|E| > 1$.

   Definition: **Inelastic** means having a price elasticity with an absolute value less than 1: $|E| < 1$.

   Definition: **Unit elastic** means having a price elasticity with an absolute value equal to 1: $|E| = 1$.

   Definition: **Perfectly inelastic** means having a price elasticity that is equal to zero; there is no change in quantity demanded or supplied for any change in price: $|E| = 0$.

   Definition: **Perfectly elastic** means having a price elasticity that is infinite; any change in price leads to an infinite change in quantity demanded or supplied: $|E| = \infty$

D. Elasticities and Linear Demand and Supply Curves

1. Elasticity of a Linear Demand Curve

$$E = \frac{\%\Delta Q}{\%\Delta P} = \frac{\Delta Q/Q}{\Delta P/P} = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q} = \frac{1}{\text{slope}} \times \frac{P}{Q}$$

Figure 2.15 Elasticity of a Linear Demand Curve

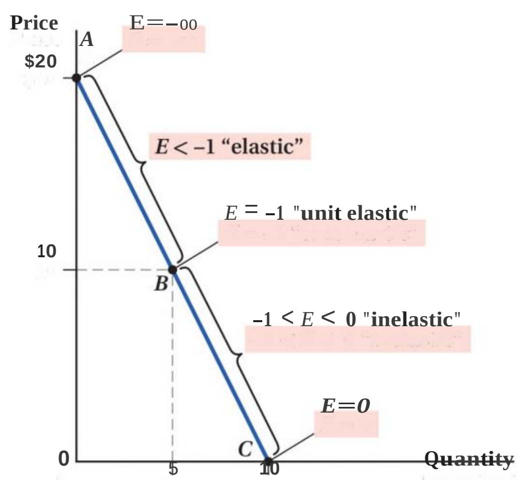
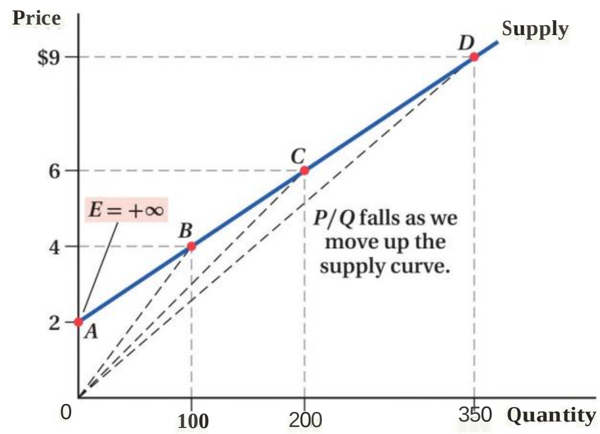


Figure 2.16 Elasticity of a Linear Supply Curve



2.5 additional figure it out

The demand for movie tickets in a small town is given as $Q'' = 1000 - 50P$.

1. Calculate the price elasticity of demand when the price of tickets is $5.

2. Calculate the price elasticity of demand when the price of tickets is $12.

3. At what price is the price elasticity of demand unit elastic?

4. What happens to the price elasticity of demand as you move down a linear demand curve?

Solution:

The price elasticity of demand is given as $E!$ $\frac{AQ}{AP} \times \frac{P}{Q}$. For this demand curve, $\frac{6.P}{AO}$ is constant and equal to –50.

1. When P = $5, Q'' = 750. Therefore, $E?$ wit –0.3333. Demand is inelastic.

2. When P = $12, Q'' = 400. Therefore, $E?$ = –50 x .}$\frac{2}{00}$ = –1.5. Demand is elastic.

3. Demand is unit elastic when E'' = 1. Therefore, we substitute 1 for E' and then solve for P:

$$-1 = -50 \times \frac{P}{1{,}000 - 50P}$$

$$-(1{,}000 - 50P) = -50P$$

$$1{,}000 - 50P = 50P$$

$$100P = 1{,}000$$

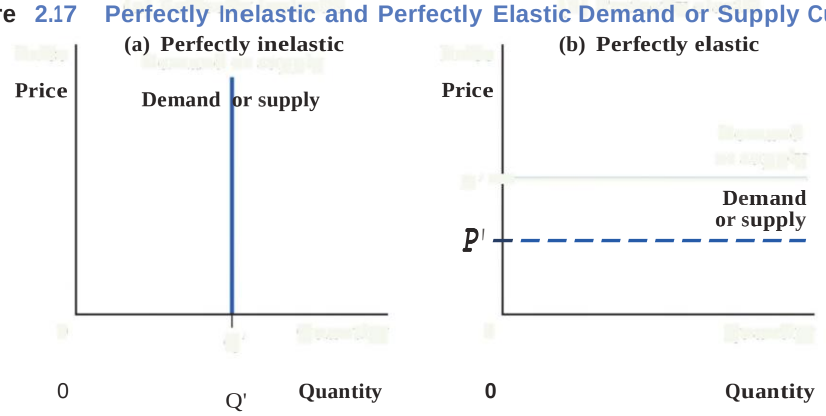
$$P = \$10$$

Demand will be unit elastic at a price of $10.

4. As you move down a linear demand curve, demand becomes less elastic (more inelastic).

E. Perfectly Inelastic and Perfectly Elastic Demand and Supply
   1. Perfectly Inelastic
      a. Any change in price leads to no change in quantity demanded (supplied).
      b. The demand (supply) curve will be vertical.

Figure 2.17 Perfectly Inelastic and Perfectly Elastic Demand or Supply Curves



2. Perfectly Elastic
   a. Any change in price leads to an infinite change in quantity demanded (supplied).
   b. The demand (supply) curve is a horizontal line.

teaching tip

Take your time and go through this step by step. Encourage students to learn how to solve for these changes rather than relying on memorization.

F. Income Elasticity of Demand

$$E_I^D = \frac{\%\Delta Q^D}{\%\Delta I} = \frac{\Delta Q^D}{\Delta I} \times \frac{I}{Q^D}$$

Definition: **Income elasticity of demand** measures the percentage change in quantity demanded associated with a 1% change in consumer income.

1. The sign of this elasticity indicates whether the good is normal (positive) or inferior (negative).

Definition: An **inferior good** is a good for which quantity demanded decreases when income rises.

Definition: A **normal good** is a good for which quantity demanded rises when income rises.

Definition: A **luxury good** is a good with an income elasticity greater than 1.

G. Cross-Price Elasticity of Demand

$$E_{XY}^D = \frac{\%\Delta Q_X^D}{\%\Delta P_Y} = \frac{\Delta Q_X^D}{\Delta P_Y} \times \frac{P_Y}{Q_X^D}$$

Definition: **Cross-price elasticity of demand** is the percentage change in the quantity demanded of one good associated with a 1% change in the price of another good.

1. The sign of this elasticity indicates whether the two goods are substitutes (positive) or complements (negative).

Chapter 2 Online Appendix: The Calculus of Equilibrium and Elasticities

This text provides a number of math supplements—from the chapter Figure It Out features to the in-text calculus appendices and math review appendix. Why add another appendix? These online appendices give us an opportunity to illustrate additional—and often more advanced—mathematical techniques that can be applied to the economics you learn throughout the course. Some online appendices will build on concepts explored in the chapters themselves, whereas others will provide richer detail on the mathematics in the in-text calculus appendices. As with the other math supplements, the online appendices provide information and techniques that may further your understanding of economics, but are not intended as substitutes for what you would learn in your college mathematics courses.

In this first online appendix, we use calculus to describe the effect of changes in variables other than the good's own price on equilibrium outcomes. We also calculate and apply a variety of supply and demand elasticities using calculus, enabling us to calculate elasticities in a wider variety of circumstances than those shown in the text.

Demand

A **demand curve** is a representation of a relationship between the quantity of a good that consumers demand and that good's price, holding all other factors constant. Let's consider the hypothetical linear demand curve for tomatoes from the text: $Q^D = 1{,}000 - 200P$, where Q^D is the quantity demanded of tomatoes in pounds and P is the price in dollars per pound. Note that this demand equation is written so that quantity is a function of price only.

The definition of a demand curve, however, is more general. Particularly, it specifies that demand may also depend on "other factors" (which we then hold constant for our calculations of demand curves). In the chapter we learned that when other factors change (such as changes in income, the prices of related goods, or tastes), the demand curve shifts. It is therefore useful to think about an "expanded" demand function for which quantity demanded is a function not only of the good's own price but also of some of these other factors.

As a relatively simple example, consider adding the prices of related goods and income to the linear demand curve: $Q^D = 900 - 200P + 100P_s - 600P_c + 0.01I$, where P_s and P_c are the prices of a substitute good and of a complementary good respectively and I is income. Why might we include the prices of substitute and complementary goods in the demand curve for tomatoes? As we saw in the text, a change in the price of a substitute for a good (a good that can be used in place of another good) affects demand for the original good. Similarly, a change in the price of a good that is used in combination with another (a complement) also affects the good's demand.

Let's use the demand for tomatoes to explore these relationships more fully. Suppose peppers are a substitute for tomatoes with price P_s, and the people enjoy eating lettuce with tomatoes, so it is a complementary good with price P_c.

Assume lettuce and peppers each cost $1 per unit, and that the average consumer income is $60,000. Note that at these values $Q^D = 900 - 200P + 100(1) - 600(1) + 0.01(60{,}000)$. Simplifying this, we see that the demand curve written only as a function of price is $Q^D = 1{,}000 - 200P$—the same relationship as in the text!

What happens if the price of peppers—the substitute—increases to $2? An increase in the price of a substitute product increases the quantity demanded of the original good at all prices, all else equal, thereby shifting the original demand curve to the right. We can see this by plugging the new price of peppers into the original demand curve: $Q^D = 900 - 200P + 100(2) - 600(1) + 0.01(60{,}000) = 1{,}100 - 200P$. The slope[1] of the demand curve is the same: $-1/200$. Because the intercept[2] has increased from 5 to 5.5, the price increase has resulted in a parallel shift up and to the right of the demand curve.

Now let's add another layer of changes to the demand curve. Suppose that the price of lettuce increases to $2. The quantity demanded of tomatoes becomes $Q^D = 900 - 200P + 100(2) - 600(2) + 0.01(60{,}000) = 500 - 200P$. In this example, the price increases of peppers and lettuce are equivalent—both the substitute and complement experienced price increases from $1 to $2. You might then expect that these two price increases would cause demand shifts of equivalent magnitudes. Instead, given this particular demand function, the effect (shift of the demand curve down and to the left) of the increase in the price of lettuce (a complement to tomatoes) more than offsets the magnitude of the rightward shift due to the increased price of peppers (the substitute good). As a result, the new demand curve lies to the left of the original demand curve. We can use partial derivatives to show differences in the magnitudes of the two effects and to draw further conclusions.

Because the demand curve is now multivariable (quantity demanded depends not just on own price, but many other variables as well), it is useful to consider what the partial derivatives reviewed in the book's math review appendix tell us in this context. As a starting point, consider the partial derivative of the demand curve with respect to its own price $\frac{\partial Q^D}{\partial P}$. This partial derivative isolates the effect of own price P on quantity demanded Q^D. It can be interpreted similarly to $\frac{\Delta Q^D}{\Delta P}$ studied in the text. The partial derivative holds all the other factors in our multivariable setting constant.

Next, consider the partial derivative of the demand curve with respect to the price of the substitute good $\frac{\partial Q^D}{\partial P_s}$. This partial derivative isolates the effect of the substitute's price P_s on quantity demanded Q^D, holding everything else constant. Likewise, the partial derivative of the demand curve with respect to the complement good's price $\frac{\partial Q^D}{\partial P_c}$ isolates the effect of P_c on Q^D, holding everything else constant. Finally, $\frac{\partial Q^D}{\partial I}$ isolates the effect of income on quantity demanded, holding everything else constant.

We can use the partial derivatives of quantity demanded with respect to each variable to demonstrate a series of economic concepts from Chapter 2. Going back to our example, $Q^D = 900 - 200P + 100P_s - 600P_c + 0.01I$, note that

$$\frac{\partial Q^D}{\partial P} = 200 < 0 \quad (1)$$

$$\frac{\partial Q^D}{\partial P_s} = [illegible] > 0 \quad (2)$$

$$\frac{\partial Q^D}{\partial P_c} = -600 < 0 \quad (3)$$

$$\frac{\partial Q^D}{\partial I} = 0.01 > 0 \quad (4)$$

[1] Recall that since quantity is on the x-axis and price is on the y-axis, the slope of the line is $1/(\Delta Q/\Delta P)$.

[2] The intercept is from the inverse form of the demand curve with price expressed as a funtion of quantity demanded.

What do these partial derivatives tell us about the demand for this product (tomatoes)? First, most demand curves are downward-sloping by the law of demand, which states that as price increases, quantity demanded decreases, all else equal. This is precisely what the negative relationship in (1) tells us.

Partial derivatives with respect to the prices of other goods can tell us whether a good is a substitute (2) or a complement (3). Recall that a substitute is a good for which a price increase translates into a quantity increase in the market for the original good and a complement is a good for which there is a negative relationship between the price in one market and the quantity demanded in another. Expressed mathematically in terms of calculus, this means that $\frac{\partial Q^D}{\partial P_s} > 0$ and $\frac{\partial Q^D}{\partial P_c} < 0$, exactly as shown in (2) and (3).

The partial derivative with respect to income (4) can reveal whether we are dealing with a normal or an inferior good. Recall that a normal good is a good for which quantity demanded rises when income rises and an inferior good is a good for which quantity demanded decreases when income rises. In terms of calculus, this means that $\frac{\partial Q^D}{\partial I} > 0$ for a normal good and $\frac{\partial Q^D}{\partial I} < 0$ for an inferior good.[3] Because we find a positive relationship between income and quantity demanded for our tomato example in (4), we know that tomatoes are normal goods in this particular case.

Supply

A **supply curve** illustrates the relationship between the quantity supplied of a good and its price, holding all other factors constant. The supply curve we examine for tomatoes is $Q^S = 200P - 200$. As in the demand case, this equation is written with quantity as a function of price alone, although changes in other factors can cause the supply curve to shift. Here, consider an "expanded" supply function where quantity supplied is a function not only of a good's own price but also of suppliers' costs of production. As an example, let's consider the case of tomato seeds and fertilizer, two inputs to the production of tomatoes. Now, quantity supplied can be written $Q^S = 200P - 100P_1 - 5P_2 - 50$, where P_1 is the price of input 1 and P_2 is the price of input 2. In particular, let's set P_1 to be the price of tomato seeds at **$1** per pound, and P_2 as the price of fertilizer at $10 per bag. Substituting into the supply relationship, we see that $Q^S = 200P - 100(1) - 5(10) - 50 = 200P - 200$. Note that this yields the same function for the supply curve as in the chapter.

We can analyze the effects of changes in input prices in a way that is similar to how we analyzed the effects on demand of changes in the prices of other goods and in income. Particularly, suppose that the price of fertilizer decreases to $5. Now, $Q^S = 200P - 100(1) - 5(5) - 50 = 200P - 175$. When the price of an input falls, production becomes cheaper. The quantity supplied increases at every price, and the supply curve shifts out to the right. Note that in this example (like in the examples for demand shifts in the previous section), the change described is the result of a supply curve *shift*, as opposed to a movement along a given supply curve. When the price of fertilizer decreases, therefore, $Q^S = 200P - 175$ instead of $Q^S = 200P - 200$. The supply curve has shifted because suppliers are now willing to produce more at every price.

Just as they are for demand, partial derivatives are a useful tool for further examining the effects of price changes on the supply of a good. Consider the partial derivative

[3] In Chapter 5, you will see a special (and very rare) case of inferior goods called **Giffen goods,** which have the characteristic that own price and quantity demanded are positively related. In the language of partial derivatives, this means that for Giffen goods $\frac{\partial Q^D}{\partial P} > 0$ while $\frac{\partial Q^D}{\partial I} < 0$ (because Giffen goods are a type of inferior goods).

of the supply curve with respect to a good's own price $\frac{\partial Q^s}{\partial P}$. This partial derivative now isolates the effect of own price P on quantity supplied Q^s and can be interpreted as the change in quantity supplied for a given change in price, holding all other factors in this multivariable setting constant. In our example, $\frac{\partial Q^s}{\partial P} = 200 > 0$. The fact that this partial derivative is positive is consistent with the law of supply, which indicates that as price increases, quantity supplied increases so that supply curves generally have a positive slope.

In addition to the partial derivative of the quantity supplied with respect to own price, consider the partial derivatives of the supply curve with respect to the prices of the inputs $\frac{\partial Q^s}{\partial P}$ and $\frac{\partial Q^s}{\partial P}$. These partial derivatives isolate the effects of the input prices on quantity supplied Q^s. We expect that quantity supplied will decrease if input prices rise (and will increase if input prices fall), all else equal. Therefore, our expectation is that $\frac{\partial Q^s}{\partial P} < 0$ and $\frac{\partial Q^s}{\partial P} < 0$. For our example, we find that this is true:

$$\frac{\partial Q^s}{\partial P} = -100 < 0 \text{ and } \frac{\partial Q^s}{\partial P} = -5 < 0.$$

Comparative Statics

By extending our supply and demand framework to one of many variables, we can now model the effects on equilibrium price and quantity of a change in variables other than a good's own price. This type of before and after modeling of an equilibrium is often called *comparative statics*. As a starting point, consider the equilibrium condition (quantity demanded equals quantity supplied) with variables in addition to the good's own price included. We can then solve for a new equilibrium after a change in the value of an additional variable, and solve for the new equilibrium using the algebraic methods in Chapter 2. An example is provided in the following Figure It Out.

2OA.1 figure it out

Let's continue the example from Figure It Out 2.3 in the textbook. As in the text, suppose that the supply of lemonade is represented by $Q^s = 40P$, where quantity is measured in pints and price is measured in cents per pint.

a. Now suppose that the demand for lemonade is $Q^d = 7{,}000 - 10P - 0.02I$, where I is income. What are the current equilibrium price and quantity if income is $100,000?

b. Suppose that income increases to $125,000. What is the new equation for the demand of lemonade?

c. What will be the new equilibrium price and quantity of lemonade after the income increase?

d. Is lemonade a normal or an inferior good? Answer the question using a partial derivative and its interpretation.

Solution:

a. The original equilibrium price and quantity are found by substituting income into the demand relationship and then setting this equal to the supply side:

$$\begin{aligned} Q'' &= 7{,}000 - 10P - 0.02(100{,}000) \\ &= 7{,}000 - 10P - 2{,}000 \\ &= 5{,}000 - 10P \end{aligned}$$

Note that the demand side is equivalent to the demand curve, as given in the problem in the text.

Setting quantity demanded equal to quantity supplied, we get

$$0? = O$$

$$5{,}000 - 10P = 40P$$

$$50P = 5{,}000$$

$$P = 100$$

This corresponds to $1 since price is in cents.

To obtain the quantity, we can substitute into the supply or demand equations (or both to check):

$$Q'' = 5{,}000 - 10(100) = 4{,}000 \text{ or } Q? = 40(100) = 4{,}000$$

This corresponds to 4,000 pints.

b. Now, $Q'' = 7{,}000 - 10P - 0.02(125{,}000) = 4{,}500 - 10P$. Note that the increase in income decreases quantity demanded at each price and results in a parallel shift of the demand curve downward and to the left.

c. Setting quantity demanded equal to quantity supplied yields

$$0'' = O$$

$$4{,}500 - 10P = 40P$$

$$50P = 4{,}500$$

$$P = 90$$

To get quantity, we can substitute P into the supply or demand equation (or both to check):

$$Q'' = 4{,}500 - 10(90) = 3{,}600 \text{ or } Q = 40(90) = 3{,}600$$

Thus, price is now $0.90 and quantity is 3,600 pints.

Note that as income increases, both quantity and price fall.

d. Lemonade is an inferior good here because ail $= -0.02 < 0$ and therefore quantity demanded decreases with income. This is consistent with the directions of the quantity and price changes identified above.

Figure 2.11 in the text examines how an equal magnitude shift of the demand curve (and supply curve) affects equilibrium price and quantity differently depending on the relative steepness or flatness of the supply curve (and demand curve). Note that for the example in the Figure It Out above, the supply curve is relatively flat. Consider instead a supply curve of $Q^S = 10P + 3{,}000$, which is steeper. Note that despite having a different slope and intercept, this curve has the property of going through the original equilibrium because

$$
\begin{aligned}
Q^D &= Q^S \\
5{,}000 - 10P &= 10P + 3{,}000 \\
20P &= 2{,}000 \\
P &= 100 \\
Q^D &= 5{,}000 - 10(100) = 4{,}000 \\
Q^S &= 10(100) + 3{,}000 = 4{,}000
\end{aligned}
$$

Now consider the effects of an increase in income to $125,000. Setting the new demand curve as in the Figure It Out example equal to this alternate supply, we find that $4{,}500 - 10P = 10P + 3{,}000$ or $P = 75$. To obtain the quantity, we can substitute into the supply or demand equations (or both to check). From demand, $Q^D = 4{,}500 - 10(75) = 3{,}750$. The same income increase therefore leads to a lower equilibrium price and higher equilibrium quantity ($P = 75$, $Q = 3{,}750$) when supply is steeper, and a higher equilibrium price and lower quantity ($P = 90$, $Q = 3{,}600$) when supply is flatter. Thus, the price decrease is greater in the case of steep supply, and the quantity decrease is greater in the case of flat supply. This is the same pattern identified in the discussion around Figure 2.11. (Note, however, that the figure illustrates a rightward shift of demand, as opposed to the leftward one in this problem.) The methods here can be used to extend beyond the case of just one curve shifting, to cases in which both supply and demand simultaneously shift, resulting in an even wider range of possible outcomes.

We can also use calculus to examine comparative statics for marginal changes in variables other than price. As an example, let's look at the case of a change in income. The equilibrium condition expressed as a function of income is $Q^D(P(I),I) = Q^S(P(I))$. We want to know how price and quantity change with income, but we don't want to hold everything else constant in the background (i.e., we want to analyze the effects of an income change on actual equilibrium price and quantity). To start, we can differentiate the equilibrium with respect to income:

$$\frac{\partial Q^D}{\partial P}\frac{\partial P}{\partial I} + \frac{\partial Q^D}{\partial I} = \frac{\partial Q^S}{\partial P}\frac{\partial P}{\partial I}$$

Rearranging this equation, we can see that

$$\frac{\partial Q^D}{\partial I} = \frac{\partial Q^S}{\partial P}\frac{\partial P}{\partial I} - \frac{\partial Q^D}{\partial P}\frac{\partial P}{\partial I}$$

$$= \frac{\partial P}{\partial I}\left[\frac{\partial Q^S}{\partial P} - \frac{\partial Q^D}{\partial P}\right]$$

We can then solve for the derivative of price with respect to income:

$$\frac{dP}{dI} = \frac{\frac{\partial Q^D}{\partial I}}{\frac{\partial Q^S}{\partial P} - \frac{\partial Q^D}{\partial P}}$$

4 This condition uses the chain rule from calculus. This rule states that for the function $f(x) = g(h(x))$, the derivative can be calculated as $\frac{df(x)}{dx} = \frac{dg()}{dh(x)} \times \frac{dh()}{dx}$

To make this more concrete, let's reconsider the case in the previous Figure It Out in which $Q'' = 7{,}000 - 10P - 0.02I$ and $Q = 40P$. For that example,

$$\frac{dP}{dI} = \frac{-0.02}{40-(-10)} = -0.0004$$

This means that the $25,000 increase in income in that example lowers the equilibrium price by $10 (−0.0004 x $25,000). Likewise, the change in quantity is dIS = ~r~~ = 40(--0.0004) = −0.016, so the $25,000 increase in income lowers equilibrium quantity by 400 (−0.016 × $25,000). These are the same changes in the price and quantity of lemonade found in the Figure It Out example.

Elasticities

Note that the effect of an income change on equilibrium quantity is different from the effect of an income change on quantity demanded (or likewise on quantity sup• plied). For the latter, we can use calculus to calculate a partial derivative, as we did in part (d) of the Figure It Out exercise. The partial derivative 0Q'' for example, lets us know that for a very small increase in income—holding all else equal—quantity demanded changes by iJD units. These units, however, are difficult to interpret. As a result, econo• mists turn to another calculation that allows for easier interpretation: elasticities.

In calculus terms, elasticities are partial derivatives. Consider the price elasticity of demand, which can be written as

ev _@' 0P Q?

where Q'' is quantity demanded and P is price.

Note the similarities to the formula at the top of page 47 of the text. The price elasticity of supply can be written as $E_D = \frac{0Q^\circ}{P}$; Q. Similarly, the income elasticity of demand can be written as E}? I Q,,, where I is income, and the cross-price elasticity of demand can be written using subscripts as in the chapter as E{ = 'if' <<here P_r is the price of a related good (e.g. a substitute or a complement) to good X.

Total Expenditure and the Price Elasticity of Demand

We can also use calculus to derive the relationship between (1) total expenditure changes from price changes and (2) the elasticity of demand. Total expenditure, and likewise total revenue, can be expressed as $R(P) = P \times Q''(P)$, where quantity is expressed as a func• tion of price. We can therefore think about maximizing this function with respect to P:

$$\max_P \; P \times Q'(P)$$

We can find the first-order condition by taking the derivative of the total expenditure function with respect to P and then setting this derivative equal to zero. The first-order condition[5] therefore is

$$\frac{dQ^D(P)}{dP}P + Q^D(P) = 0$$

[5] This first-order condition uses the product rule from calculus. This rule states that for the function $f() = g() \times h()$, the derivative can be calculated as $\frac{df()}{dx} = \frac{dh(x)}{dx}g() + \frac{dg()}{dx}h()$.

Rearranging, we can see that

$$\frac{dQ^*(P)}{dP}P = -Q^*(P)$$

$$\frac{dQ^*(P)}{dP}\frac{P}{Q^*(P)} = -1$$

Note that the left side of this equality is simply the price elasticity of demand[6], so $E^D = -1$. This means that expenditure is maximized when demand is unit-elastic.[7] When demand is inelastic (when the price elasticity of demand is less than 1 in absolute value), consumer expenditure increases with a price increase. Expressed with calculus, this means that for inelastic demand, $\frac{dR(P)}{dP} > 0$. This can be shown by examining the case that $\frac{dQ^*(P)}{dP}P + Q^*(P) > 0$. Rearranging this, $\frac{dQ^*(P)}{dP}P > -Q^*(P)$. Dividing both sides by $Q^*(P)$, we see that $E^D > -1$. Because E^D is a negative number for a downward-sloping demand curve, this condition corresponds to inelastic demand.

Similarly, for elastic demand (when the price elasticity of demand is greater than 1 in absolute value), consumer expenditure decreases for a price increase, meaning that $\frac{dR(P)}{dP} < 0$. Therefore, only in the case of unit-elastic demand (when the price elasticity of demand is exactly 1 in absolute value) would consumer expenditure be at a maximum (as it should be given the optimization exercise outlined above)!

2OA.2 figure it out

Suppose that the inverse demand curve for hospital scrubs in bright floral prints can be expressed as $P = 80 - 10Q^{0.5}$, where price is in dollars and quantity is in thousand sets (top and bottom). What is the price elasticity of demand at a quantity of 25,000 sets?

Solution:

Note that this is a nonlinear demand curve since quantity Q is raised to a power other than 1 and therefore the relationship between price and quantity is nonlinear. As a tool, calculus provides a way to calculate the price elasticity of demand for this equation at a given quantity. First, note that when quantity is 25,000 sets, $P = 80 - 10(25)^{0.5} = 80 - 10(5) = 30$, and therefore a set of floral scrubs costs \$30. The price elasticity of demand for this is $E^D = \frac{dQ}{dP}\frac{P}{Q}$. Using the demand curve equation, we can see that $\frac{dP}{dQ} = -10(0.5)Q^{-0.5} = -5Q^{-0.5}$. At a quantity of 25,000 sets, this value is $-5(25)^{-0.5} = -1$. Making the appropriate substitutions, we find that $E^D = -\frac{30}{25} = -1.2$. Sets of floral hospital scrubs therefore are price-elastic, because hospital workers may switch to other patterns when price increases. Notice that this method can be used similarly for income and cross-price elasticities in situations when demand is nonlinear and for supply elasticities when supply is nonlinear.

[6] The price elasticity of demand here is expressed as a standard derivative instead of a partial derivative since we wrote the total expenditure function to be a function of just P.

[7] See Figure 2.19 in the text for a graphical representation. Formal optimization techniques (for finding maxima and minima) and a review of derivatives are presented in the Math Review Appendix in the back of your textbook.

Problems

1. Suppose that the supply of specialty workstation laptops is represented by $Q^8 = 1{,}000 + P$, where price is measured in dollars and quantity is measured in units.
   a. Now suppose that the demand for the laptops is $Q''= 9{,}000 - P - 0.05I$, where I is income. What are the current equilibrium price and quantity if income is $100,000?
   b. Suppose that income falls to $80,000. What is the new equation for the demand?
   c. What will be the new equilibrium price and quantity after the income decrease?
   d. Is the laptop workstation a normal or an inferior good? Answer the question using a partial derivative.
2. Suppose that the supply of a flat panel TV stand is represented by $Q = 8P - 20P, - 200$, where P is the price of the stand and $P,$ is the price of the hardware needed to hold the stand together. All prices are in dollars and quantity is in units. Assume that the current hardware price is $5.
   a. Suppose that the demand for the TV stand is $Q'' = 4{,}700 - 2P + 0.5I$, where P is the price and I is a representative household's income. What are the current equilibrium price and quantity if income is $1,000?
   b. Suppose that income falls to $800. What is the new equation for the demand for TV stands as a function of price P? Does this correspond to an increase or decrease in the demand for the TV stands? Does the demand curve shift to the left or right?
   c. Suppose that the price of the hardware increases to $6. What is the new equation for the supply of TV stands as a function of price P? Does this correspond to an increase or decrease in supply? Does the supply curve shift to the left or right?
   d. What will be the new equilibrium price and quantity of the TV stand after the changes in supply and demand [after all changes in parts (b) and (c)]?
3. From the original setup in Problem 2, suppose that the quantity supplied of flat panel TV stands is represented by $Q? = 8P - 20P, - 200$, where P is the price of the stand and $P,$ is the price of hardware inputs, and that quantity demanded is $Q'' = 4{,}700 - 2P + 0.51$, where I is income. Assume that at the equilibrium, income is $1,000 and the hardware price is $5.
   a. Calculate the income elasticity of demand using calculus.
   b. Calculate the input elasticity of supply using calculus. (*Hint*: Think of cross-price elasticities on the demand side as being analogous to "input" elasticities on the supply side.)
4. Suppose that the inverse demand curve for a dinner-for-two special at a small local restaurant can be expressed as $P = 4{,}900 - 3Q$, where price is expressed in dollars and quantity in number of specials. What is the price elasticity of demand when 40 specials are purchased?

2

Supply and Demand

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Introduction

2

Chapter Outline	
2.1	Markets and Models
2.2	Demand
2.3	Supply
2.4	Market Equilibrium
2.5	Elasticity
2.6	Conclusion

Introduction

In this chapter, we introduce the **supply and demand** model. We will:

- Describe the basics of supply and demand.
- Use equations and graphs to represent supply and demand.
- Analyze markets for goods and services using the supply and demand model.

Markets and Models

2.1

What is a market?

A market is characterized by a specific:

1. Product or service being bought and sold
2. Location
3. Point in time

Markets **facilitate exchange**, including economic resources and final goods and services.

Markets and Models

2.1

What is the **supply** and **demand** for a good?

- **Supply:** The combined amount of a good that all producers in a market are willing to sell.
- **Demand:** The combined amount of a good that all consumers in a market are willing to buy.

Table 2.1 The Four Key Assumptions Underlying the Supply and Demand Model

1.	We focus on supply and demand in a single market.
2.	All goods sold in the market are identical.
3.	All goods sold in the market sell for the same price, and everyone has the same information.
4.	There are many producers and consumers in the market.

Demand

What factors influence the **demand** for a good or service?

1. **Price**
2. **Number of consumers**
3. **Consumer income or wealth**
4. **Consumer tastes**
5. **Prices of other, related goods**
   - Complements and substitutes

Demand

2.2

Many factors influence demand for goods and services. Is there one factor that stands out?

- Focus on how the **price** of a good influences the **quantity demanded** by consumers.
- **Demand curve**: Describes the relationship between quantity of a good that consumers demand and the goad's price, holding all other factors constant.

Demand

2.2

Figure 2.1 Demand for Tomatoes