SOLUTIONS MANUAL

$\mathcal{M}$ICROECONOMICS

SIXTH EDITION
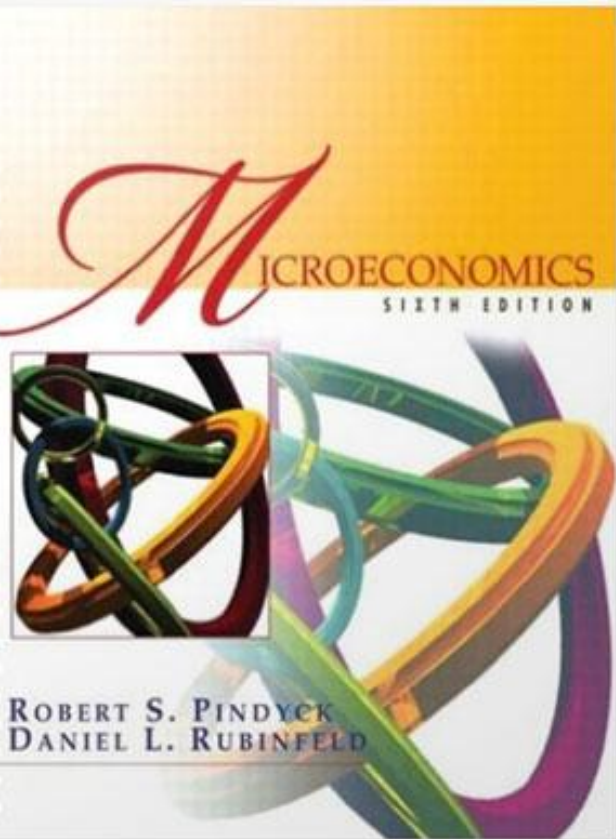
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CHAPTER 2
THE BASICS OF SUPPLY AND DEMAND

TEACHING NOTES

This chapter reviews the basics of supply and demand that students should be familiar with from their introductory economics class. The instructor can choose to spend more or less time on this chapter depending on how much of a review the students require. This chapter departs from the standard treatment of supply and demand basics found in most other intermediate microeconomics textbooks by discussing some of the world's most important markets (wheat, gasoline, and automobiles) and teaching students how to analyze these markets with the tools of supply and demand. The real-world applications of this theory can be enlightening for students.

Some problems plague the understanding of supply and demand analysis. One of the most common sources of confusion is between *movements along the demand curve* and *shifts in demand*. Through a discussion of the *ceteris paribus* assumption, stress that when representing a demand function (either with a graph or an equation), all other variables are held constant. Movements along the demand curve occur *only with changes in price*. As the omitted factors change, the entire demand function shifts. It may also be helpful to present an example of a demand function that depends not only on the price of the good, but also on income and the price of other goods directly. This helps students understand that these other variables are actually in the demand function, and are merely lumped into the intercept term of the simple linear demand function. Example 2.9 includes an example of a demand and supply function which each depend on the price of a substitute good. Students may also find a review of how to solve two equations with two unknowns helpful. In general, it is a good idea at this point to decide on the level of math that you will use in the class. If you plan to use a lot of algebra and calculus it is a good idea to introduce and review it early on.

To stress the quantitative aspects of the demand curve to students, make the distinction between quantity demanded as a function of price, $Q = D(P)$, and the inverse demand function, where price is a function of the quantity demanded, $P = D^{-1}(Q)$. This may clarify the positioning of price on the Y-axis and quantity on the X-axis.

Students may also question how the market adjusts to a new equilibrium. One simple mechanism is the partial-adjustment cobweb model. A discussion of the cobweb model (based on traditional corn-hog cycle or any other example) adds a certain realism to the discussion and is much appreciated by students. If you decide to write down the demand function so that income and other prices are visible variables in the demand function, you can also do some interesting examples, which explore the linkages between markets and how changes in one market affect price and quantity in other markets.

Although this chapter introduces demand, income, and cross-price elasticities, you may find it more appropriate to return to income and cross-price elasticity after demand elasticity is reintroduced in Chapter 4. Students invariably have a difficult time with the concept of elasticity. It is helpful to explain clearly why a firm may be interested in estimating elasticity. Use concrete examples. For example, a Wall Street Journal article back in the spring of 1998 discussed how elasticity could be used by the movie industry so that different movies could have different ticket prices. This example tends to go over well as college students watch a lot of movies. This type of discussion can also be postponed until revenue is discussed.

QUESTIONS FOR REVIEW

1. Suppose that unusually hot weather causes the demand curve for ice cream to shift to the right. Why will the price of ice cream rise to a new market-clearing level?

> Assume the supply curve is fixed. The unusually hot weather will cause a rightward shift in the demand curve, creating short-run excess demand at the current price. Consumers will begin to bid against each other for the ice cream, putting upward pressure on the price. The price of ice cream will rise until the quantity demanded and the quantity supplied are equal.
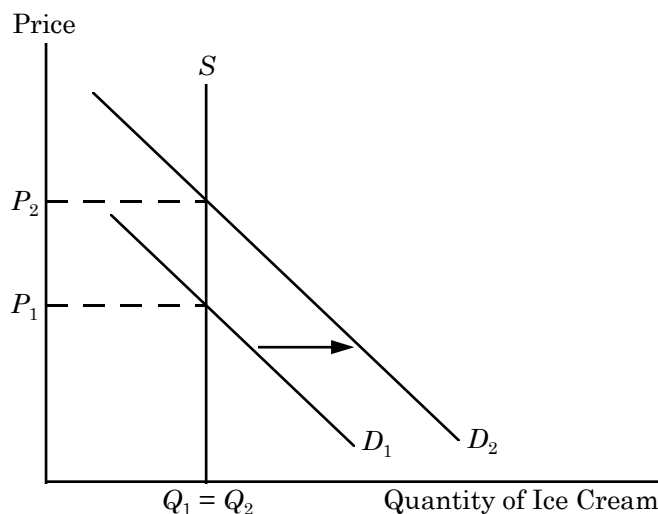
Figure 2.1

2. Use supply and demand curves to illustrate how each of the following events would affect the price of butter and the quantity of butter bought and sold:

a.   An increase in the price of margarine.

> Most people consider butter and margarine to be substitute goods. An increase in the price of margarine will cause people to increase their consumption of butter, thereby shifting the demand curve for butter out from D_1 to D_2 in Figure 2.2.a. This shift in demand will cause the equilibrium price to rise from P_1 to P_2 and the equilibrium quantity to increase from Q_1 to Q_2.

Price

S

P_2

P_1

D_1

D_2

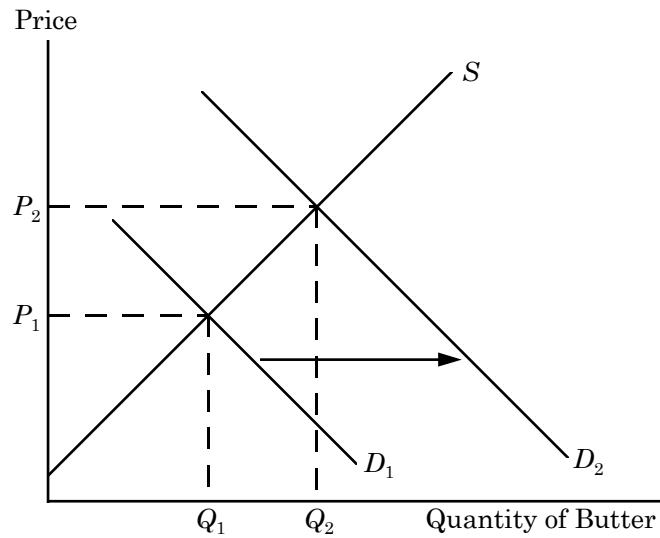Q_1 Q_2 Quantity of Butter

Figure 2.2.a

b.   An increase in the price of milk.

Milk is the main ingredient in butter. An increase in the price of milk will increase the cost of producing butter. The supply curve for butter will shift from S_1 to S_2 in Figure 2.2.b, resulting in a higher equilibrium price, P_2, covering the higher production costs, and a lower equilibrium quantity, Q_2.

Price

S_2

S_1

P_2

P_1

D

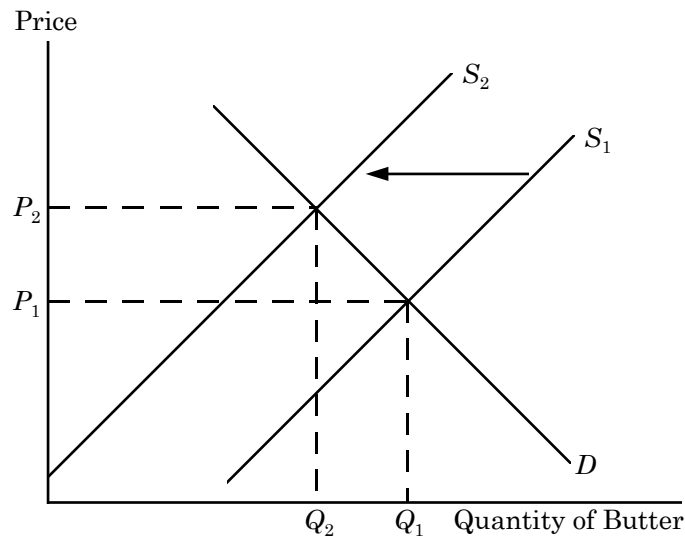Q_2 Q_1 Quantity of Butter

Figure 2.2.b

Note: Given that butter is in fact made from the fat that is skimmed off of the milk, butter and milk are joint products. If you are aware of this relationship, then your answer will change. In this case, as the price of milk increases, so does the quantity supplied. As the quantity supplied of milk increases, there is a larger supply of fat available to make butter. This will shift the supply of butter curve to the right and the price of butter will fall.

c.   A decrease in average income levels.

Assume that butter is a normal good. A decrease in the average income level will cause the demand curve for butter to shift from D_1 to D_2. This will result in a decline in the equilibrium price from P_1 to P_2, and a decline in the equilibrium quantity from Q_1 to Q_2. See Figure 2.2.c.
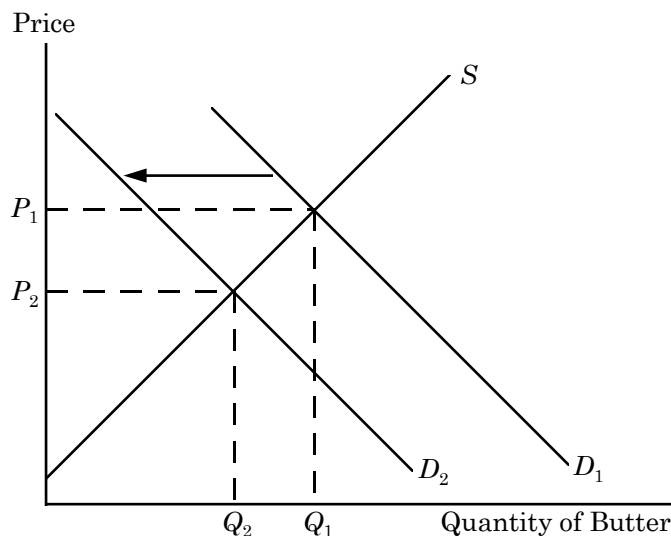

Figure 2.2.c

3.   If a 3-percent increase in the price of corn flakes causes a 6-percent decline in the quantity demanded, what is the elasticity of demand?

The elasticity of demand is the percentage change in the quantity demanded divided by the percentage change in the price. The elasticity of demand for corn flakes is $\dfrac{-6}{+3} = -2$.

This is equivalent to saying that a 1% increase in price leads to a 2% decrease in quantity demanded. This is in the elastic region of the demand curve, where the elasticity of demand exceeds -1.0.

4. Explain the difference between a shift in the supply curve and a movement along the supply curve.

A movement along the supply curve is caused by a change in the price or the quantity of the good, since these are the variables on the axes. A shift of the supply curve is caused by any other relevant variable that causes a change in the quantity supplied at any given price. Some examples are changes in production costs and an increase in the number of firms supplying the product.

5. Explain why for many goods, the long-run price elasticity of supply is larger than the short-run elasticity.

The elasticity of supply is the percentage change in the quantity supplied divided by the percentage change in price. An increase in price induces an increase in the quantity supplied by firms. Some firms in some markets may respond quickly and cheaply to price changes. However, other firms may be constrained by their production capacity in the short run. The firms with short-run capacity constraints will have a short-run supply elasticity that is less elastic. However, in the long run all firms can increase their scale of production and thus have a larger long-run price elasticity.

6. Why do long-run elasticities of demand differ from short-run elasticities? Consider two goods: paper towels and televisions. Which is a durable good? Would you expect the price elasticity of demand for paper towels to be larger in the short-run or in the long-run? Why? What about the price elasticity of demand for televisions?

Long-run and short-run elasticities differ based on how rapidly consumers respond to price changes and how many substitutes are available. If the price of paper towels, a non-durable good, were to increase, consumers might react only minimally in the short run. In the long run, however, demand for paper towels would be more elastic as new substitutes entered the market (such as sponges or kitchen towels). In contrast, the quantity demanded of durable goods, such as televisions, might change dramatically in the short run following a price change. For example, the initial result of a price increase for televisions would cause consumers to delay purchases because durable goods are built to last longer. Eventually consumers must replace their televisions as they wear out or become obsolete, and therefore, we expect the demand for durables to be more inelastic in the long run.

7. Are the following statements true or false? Explain your answer.

a. The elasticity of demand is the same as the slope of the demand curve.

False. Elasticity of demand is the percentage change in quantity demanded for a given percentage change in the price of the product. The slope of the demand curve is the change in price for a given change in quantity demanded, measured in units of output. Though similar in definition, the units for each measure are different.

b. The cross price elasticity will always be positive.

False. The cross price elasticity measures the percentage change in the quantity demanded of one product for a given percentage change in the price of another product. This elasticity will be positive for substitutes (an increase in the price of hot dogs is likely to cause an increase in the quantity demanded of hamburgers) and negative for complements (an increase in the price of hot dogs is likely to cause a decrease in the quantity demanded of hot dog buns).

c. The supply of apartments is more inelastic in the short run than the long run.

True. In the short run it is difficult to change the supply of apartments in response to a change in price. Increasing the supply requires constructing new apartment buildings, which can take a year or more. Since apartments are a durable good, in the long run a change in price will induce suppliers to create more apartments (if price increases) or delay construction (if price decreases).

8. Suppose the government regulates the prices of beef and chicken and sets them below their market-clearing levels. Explain why shortages of these goods will develop and what factors will determine the sizes of the shortages. What will happen to the price of pork? Explain briefly.

If the price of a commodity is set below its market-clearing level, the quantity that firms are willing to supply is less than the quantity that consumers wish to purchase. The extent of the excess demand implied by this response will depend on the relative elasticities of demand and supply. For instance, if both supply and demand are elastic, the shortage is larger than if both are inelastic. Factors such as the willingness of consumers to eat less meat and the ability of farmers to change the size of their herds and hence produce less will determine these elasticities and influence the size of excess demand. Customers whose demands are not met will attempt to purchase substitutes, thus increasing the demand for substitutes and raising their prices. If the prices of beef and chicken are set below market-clearing levels, the price of pork will rise, assuming that pork is a substitute for beef and chicken.

9. The city council of a small college town decides to regulate rents in order to reduce student living expenses. Suppose the average annual market-clearing rent for a two-bedroom apartment had been $700 per month, and rents are expected to increase to $900 within a year. The city council limits rents to their current $700 per month level.

a.   Draw a supply and demand graph to illustrate what will happen to the rental price of an apartment after the imposition of rent controls.

The rental price will stay at the old equilibrium level of $700 per month. The expected increase to $900 per month may have been caused by an increase in demand. Given this is true, the price of $700 will be below the new equilibrium and there will be a shortage of apartments.

b.   Do you think this policy will benefit all students? Why or why not.

It will benefit those students who get an apartment, though these students may also find that the costs of searching for an apartment are higher given the shortage of apartments. Those students who do not get an apartment may face higher costs as a result of having to live outside of the college town. Their rent may be higher and the transportation costs will be higher.

10.   In a discussion of tuition rates, a university official argues that the demand for admission is completely price inelastic. As evidence she notes that while the university has doubled its tuition (in real terms) over the past 15 years, neither the number nor quality of students applying has decreased. Would you accept this argument? Explain briefly. (Hint: The official makes an assertion about the demand for admission, but does she actually observe a demand curve? What else could be going on?)

If demand is fixed, the individual firm (a university) may determine the shape of the demand curve it faces by raising the price and observing the change in quantity sold. The university official is not observing the entire demand curve, but rather only the equilibrium price and quantity over the last 15 years. If demand is shifting upward, as supply shifts upward, demand could have any elasticity. (See Figure 2.7, for example.) Demand could be shifting upward because the value of a college education has increased and students are willing to pay a high price for each opening. More market research would be required to support the conclusion that demand is completely price inelastic.
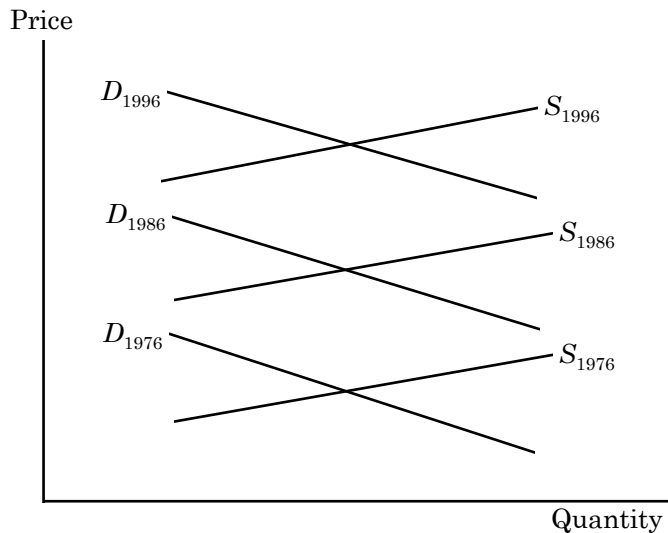

Figure 2.10

11. Suppose the demand curve for a product is given by Q=10-2P+P$_s$, where P is the price of the product and P$_s$ is the price of a substitute good. The price of the substitute good is $2.00.
  a.   Suppose P=$1.00. What is the price elasticity of demand? What is the cross-price elasticity of demand?

First you need to find the quantity demanded at the price of $1.00. Q=10-2(1)+2=10.

Price elasticity of demand $= \dfrac{P}{Q}\dfrac{\Delta Q}{\Delta P} = \dfrac{1}{10}(-2) = -\dfrac{2}{10} = -0.2.$

Cross-price elasticity of demand $= \dfrac{P_s}{Q}\dfrac{\Delta Q}{\Delta P_s} = \dfrac{2}{10}(1) = 0.2.$

b.   Suppose the price of the good, P, goes to $2.00. Now what is the price elasticity of demand? What is the cross-price elasticity of demand?

First you need to find the quantity demanded at the price of $2.00. Q=10-2(2)+2=8.

Price elasticity of demand $= \dfrac{P}{Q}\dfrac{\Delta Q}{\Delta P} = \dfrac{2}{8}(-2) = -\dfrac{4}{8} = -0.5.$

Cross-price elasticity of demand $= \dfrac{P_s}{Q}\dfrac{\Delta Q}{\Delta P_s} = \dfrac{2}{8}(1) = 0.25.$

12. Suppose that rather than the declining demand assumed in Example 2.8, a decrease in the cost of copper production causes the supply curve to shift to the right by 40 percent. How will the price of copper change?

If the supply curve shifts to the right by 40% then the new quantity supplied will be 140 percent of the old quantity supplied at every price. The new supply curve is therefore

Q' = 1.4*(-4.5+16P) = -6.3+22.4P. To find the new equilibrium price of copper, set the new supply equal to demand so that –6.3+22.4P=13.5-8P. Solving for price results in P=65 cents per pound for the new equilibrium price. The price decreased by 10 cents per pound, or 13.3%.

13. Suppose the demand for natural gas is perfectly inelastic. What would be the effect, if any, of natural gas price controls?

If the demand for natural gas is perfectly inelastic, then the demand curve is vertical. Consumers will demand a certain quantity and will pay any price for this quantity. In this case, a price control will have no effect on the quantity demanded.

EXERCISES

1. Suppose the demand curve for a product is given by Q=300-2P+4I, where I is average income measured in thousands of dollars. The supply curve is Q=3P-50.

a.   If I=25, find the market clearing price and quantity for the product.

Given I=25, the demand curve becomes Q=300-2P+4*25, or Q=400-2P. Setting demand equal to supply we can solve for P and then Q:

$$400\text{-}2P=3P\text{-}50$$

$$P=90$$

$$Q=220.$$

b.   If I=50, find the market clearing price and quantity for the product.

Given I=50, the demand curve becomes Q=300-2P+4*50, or Q=500-2P. Setting demand equal to supply we can solve for P and then Q:

$$500\text{-}2P=3P\text{-}50$$

$$P=110$$

$$Q=280.$$

c.   Draw a graph to illustrate your answers.

Equilibrium price and quantity are found at the intersection of the demand and supply curves. When the income level increases in part b, the demand curve will shift up and to the right. The intersection of the new demand curve and the supply curve is the new equilibrium point.

2. Consider a competitive market for which the quantities demanded and supplied (per year) at various prices are given as follows:

Price ($)	Demand (millions)	Supply (millions)
60	22	14
80	20	16
100	18	18
120	16	20

a.   Calculate the price elasticity of demand when the price is $80 and when the price is $100.

We know that the price elasticity of demand may be calculated using equation 2.1 from the text:

$$E_D = \frac{\dfrac{\Delta Q_D}{Q_D}}{\dfrac{\Delta P}{P}} = \frac{P}{Q_D}\frac{\Delta Q_D}{\Delta P}.$$

With each price increase of $20, the quantity demanded decreases by 2. Therefore,

$$\left(\frac{\Delta Q_D}{\Delta P}\right) = \frac{-2}{20} = -0.1.$$

At *P* = 80, quantity demanded equals 20 and

$$E_D = \left(\frac{80}{20}\right)(-0.1) = -0.40.$$

Similarly, at $P = 100$, quantity demanded equals 18 and

$$E_D = \left(\frac{100}{18}\right)(-0.1) = -0.56.$$

b. Calculate the price elasticity of supply when the price is $80 and when the price is $100.

The elasticity of supply is given by:

$$E_S = \frac{\dfrac{\Delta Q_S}{Q_S}}{\dfrac{\Delta P}{P}} = \frac{P}{Q_S}\frac{\Delta Q_S}{\Delta P}.$$

With each price increase of $20, quantity supplied increases by 2. Therefore,

$$\left(\frac{\Delta Q_S}{\Delta P}\right) = \frac{2}{20} = 0.1.$$

At $P = 80$, quantity supplied equals 16 and

$$E_S = \left(\frac{80}{16}\right)(0.1) = 0.5.$$

Similarly, at $P = 100$, quantity supplied equals 18 and

$$E_S = \left(\frac{100}{18}\right)(0.1) = 0.56.$$

c. What are the equilibrium price and quantity?

The equilibrium price and quantity are found where the quantity supplied equals the quantity demanded at the same price. As we see from the table, the equilibrium price is $100 and the equilibrium quantity is 18 million.

d. Suppose the government sets a price ceiling of $80. Will there be a shortage, and if so, how large will it be?

With a price ceiling of $80, consumers would like to buy 20 million, but producers will supply only 16 million. This will result in a shortage of 4 million.

3. Refer to Example 2.5 on the market for wheat. At the end of 1998, both Brazil and Indonesia opened their wheat markets to U.S. farmers. Suppose that these new markets add 200 million bushels to U.S. wheat demand. What will be the free market price of wheat and what quantity will be produced and sold by U.S. farmers in this case?

The following equations describe the market for wheat in 1998:

$$Q_S = 1944 + 207P$$

and

$$Q_D = 3244 - 283P.$$

If Brazil and Indonesia add an additional 200 million bushels of wheat to U.S. wheat demand, the new demand curve would be equal to $Q_D + 200$, or

$$Q_D = (3244 - 283P) + 200 = 3444 - 283P.$$

Equating supply and the new demand, we may determine the new equilibrium price,

$$1944 + 207P = 3444 - 283P, \text{ or}$$

$$490P = 1500, \text{ or } P^* = \$3.06122 \text{ per bushel.}$$

To find the equilibrium quantity, substitute the price into either the supply or demand equation, e.g.,

$$Q_S = 1944 + (207)(3.06122) = 2{,}577.67$$

and

$$Q_D = 3444 - (283)(3.06122) = 2{,}577.67$$

4. A vegetable fiber is traded in a competitive world market, and the world price is $9 per pound. Unlimited quantities are available for import into the United States at this price. The U.S. domestic supply and demand for various price levels are shown below.

Price	U.S. Supply (million lbs.)	U.S. Demand (million lbs.)
3	2	34
6	4	28
9	6	22
12	8	16
15	10	10
18	12	4

a. What is the equation for demand? What is the equation for supply?

The equation for demand is of the form Q=a-bP. First find the slope, which is

$\dfrac{\Delta Q}{\Delta P} = \dfrac{-6}{3} = -2 = -b$. You can figure this out by noticing that every time price increases by 3, quantity demanded falls by 6 million pounds. Demand is now Q=a-2P. To find a, plug in any of the price quantity demanded points from the table: Q=34=a-2*3 so that a=40 and demand is Q=40-2P.

The equation for supply is of the form Q = c + dP. First find the slope, which is

$\dfrac{\Delta Q}{\Delta P} = \dfrac{2}{3} = d$. You can figure this out by noticing that every time price increases by 3, quantity supplied increases by 2 million pounds. Supply is now $Q = c + \dfrac{2}{3}P$. To find c plug in any of the price quantity supplied points from the table: $Q = 2 = c + \dfrac{2}{3}(3)$ so that c=0 and supply is $Q = \dfrac{2}{3}P$.

b. At a price of $9, what is the price elasticity of demand? What is it at price of $12?

Elasticity of demand at P=9 is $\dfrac{P}{Q}\dfrac{\Delta Q}{\Delta P} = \dfrac{9}{22}(-2) = \dfrac{-18}{22} = -0.82.$

Elasticity of demand at P=12 is $\dfrac{P}{Q}\dfrac{\Delta Q}{\Delta P} = \dfrac{12}{16}(-2) = \dfrac{-24}{16} = -1.5.$

c. What is the price elasticity of supply at $9? At $12?

Elasticity of supply at P=9 is $\dfrac{P}{Q}\dfrac{\Delta Q}{\Delta P} = \dfrac{9}{6}\left(\dfrac{2}{3}\right) = \dfrac{18}{18} = 1.0.$

Elasticity of supply at P=12 is $\dfrac{P}{Q}\dfrac{\Delta Q}{\Delta P} = \dfrac{12}{8}\left(\dfrac{2}{3}\right) = \dfrac{24}{24} = 1.0$.

d. In a free market, what will be the U.S. price and level of fiber imports?

> With no restrictions on trade, world price will be the price in the United States, so that P=\$9. At this price, the domestic supply is 6 million lbs., while the domestic demand is 22 million lbs. Imports make up the difference and are 16 million lbs.

5. Much of the demand for U.S. agricultural output has come from other countries. In 1998, the total demand for wheat was $Q = 3244 - 283P$. Of this, domestic demand was $Q_D = 1700 - 107P$. Domestic supply was $Q_S = 1944 + 207P$. Suppose the export demand for wheat falls by 40 percent.

a. U.S. farmers are concerned about this drop in export demand. What happens to the free market price of wheat in the United States? Do the farmers have much reason to worry?

> Given total demand, $Q = 3244 - 283P$, and domestic demand, $Q_d = 1700 - 107P$, we may subtract and determine export demand, $Q_e = 1544 - 176P$.

> The initial market equilibrium price is found by setting total demand equal to supply:

$$3244 - 283P = 1944 + 207P, \text{ or}$$

$$P = \$2.65.$$

> The best way to handle the 40 percent drop in export demand is to assume that the export demand curve pivots down and to the left around the vertical intercept so that at all prices demand decreases by 40 percent, and the reservation price (the maximum price that the foreign country is willing to pay) does not change. If you instead shifted the demand curve down to the left in a parallel fashion the effect on price and quantity will be qualitatively the same, but will differ quantitatively.

> The new export demand is *$0.6Q_e=0.6(1544-176P)=926.4-105.6P$*. Graphically, export demand has pivoted inwards as illustrated in figure 2.5a below.

> Total demand becomes

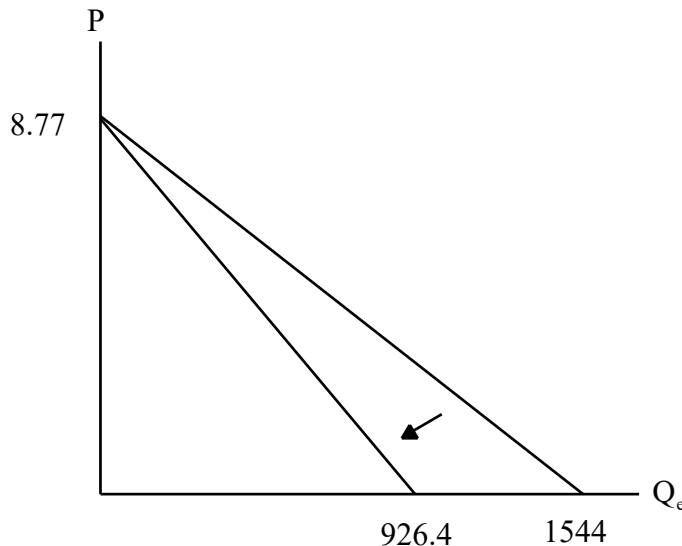$$Q_D = Q_d + 0.6Q_e = 1700 - 107P + 926.4-105.6P = 2626.4 - 212.6P.$$

Figure 2.5a

Equating total supply and total demand,

$$1944 + 207P = 2626.4 - 212.6P, \text{ or}$$

$$P = \$1.63,$$

which is a significant drop from the market-clearing price of $2.65 per bushel. At this price, the market-clearing quantity is 2280.65 million bushels. Total revenue has decreased from $6614.6 million to $3709.0 million. Most farmers would worry.

b.   Now suppose the U.S. government wants to buy enough wheat each year to raise the price to $3.50 per bushel. With this drop in export demand, how much wheat would the government have to buy? How much would this cost the government?

With a price of $3.50, the market is not in equilibrium. Quantity demanded and supplied are

$$Q_D = 2626.4 \text{-} 212.6(3.5) = 1882.3, \text{ and}$$

$$Q_S = 1944 + 207(3.5) = 2668.5.$$

Excess supply is therefore 2668.5-1882.3=786.2 million bushels. The government must purchase this amount to support a price of $3.5, and will spend

$$\$3.5(786.2 \text{ million}) = \$2751.7 \text{ million per year.}$$

6. The rent control agency of New York City has found that aggregate demand is

$Q_D = 160 - 8P$. Quantity is measured in tens of thousands of apartments. Price, the average monthly rental rate, is measured in hundreds of dollars. The agency also noted that the increase in Q at lower P results from more three-person families coming into the city from Long Island and demanding apartments. The city's board of realtors acknowledges that this is a good demand estimate and has shown that supply is $Q_S = 70 + 7P$.

a.   If both the agency and the board are right about demand and supply, what is the free market price? What is the change in city population if the agency sets a maximum average monthly rental of $300, and all those who cannot find an apartment leave the city?

To find the free market price for apartments, set supply equal to demand:

$$160 - 8P = 70 + 7P, \text{ or } P = \$600,$$

since price is measured in hundreds of dollars. Substituting the equilibrium price into either the demand or supply equation to determine the equilibrium quantity:

$$Q_D = 160 - (8)(6) = 112$$

and

$$Q_S = 70 + (7)(6) = 112.$$

We find that at the rental rate of $600, the quantity of apartments rented is 1,120,000. If the rent control agency sets the rental rate at $300, the quantity supplied would then be 910,000 ($Q_S = 70 + (7)(3) = 91$), a decrease of 210,000 apartments from the free market equilibrium. (Assuming three people per family per apartment, this would imply a loss of 630,000 people.) At the $300 rental rate, the demand for apartments is 1,360,000 units, and the resulting shortage is 450,000 units (1,360,000-910,000). However, excess demand (supply shortages) and lower quantity demanded are not the same concepts. The supply shortage means that the market cannot accommodate the new people who would have been willing to move into the city at the new lower price. Therefore, the city population will only fall by 630,000, which is represented by the drop in the number of actual apartments from 1,120,000 (the old equilibrium value) to 910,000, or 210,000 apartments with 3 people each.

b. **Suppose the agency bows to the wishes of the board and sets a rental of $900 per month on all apartments to allow landlords a "fair" rate of return. If 50 percent of any long-run increases in apartment offerings come from new construction, how many apartments are constructed?**

At a rental rate of $900, the supply of apartments would be 70 + 7(9) = 133, or 1,330,000 units, which is an increase of 210,000 units over the free market equilibrium. Therefore, (0.5)(210,000) = 105,000 units would be constructed. Note, however, that since demand is only 880,000 units, 450,000 units would go unrented.

7. In 1998, Americans smoked 470 billion cigarettes, or 23.5 billion packs of cigarettes. The average retail price was $2 per pack. Statistical studies have shown that the price elasticity of demand is -0.4, and the price elasticity of supply is 0.5. Using this information, derive linear demand and supply curves for the cigarette market.

Let the demand curve be of the general form Q=a-bP and the supply curve be of the general form Q=c + dP, where a, b, c, and d are the constants that you have to find from the information given above. To begin, recall the formula for the price elasticity of demand

$$E_P^D = \frac{P}{Q}\frac{\Delta Q}{\Delta P}.$$

You are given information about the value of the elasticity, P, and Q, which means that you can solve for the slope, which is b in the above formula for the demand curve.

$$-0.4 = \frac{2}{23.5}\frac{\Delta Q}{\Delta P}$$

$$\frac{\Delta Q}{\Delta P} = -0.4\left(\frac{23.5}{2}\right) = -4.7 = -b.$$

To find the constant a, substitute for Q, P, and b into the above formula so that 23.5=a-4.7*2 and a=32.9. The equation for demand is therefore Q=32.9-4.7P. To find the supply curve, recall the formula for the elasticity of supply and follow the same method as above:

$$E_P^S = \frac{P}{Q}\frac{\Delta Q}{\Delta P}$$

$$0.5 = \frac{2}{23.5}\frac{\Delta Q}{\Delta P}$$

$$\frac{\Delta Q}{\Delta P} = 0.5\left(\frac{23.5}{2}\right) = 5.875 = d.$$

To find the constant c, substitute for Q, P, and d into the above formula so that 23.5=c+5.875*2 and c=11.75. The equation for supply is therefore Q=11.75+5.875P.

8. In Example 2.8 we examined the effect of a 20 percent decline in copper demand on the price of copper, using the linear supply and demand curves developed in Section 2.4. Suppose the long-run price elasticity of copper demand were -0.4 instead of -0.8.

a. **Assuming, as before, that the equilibrium price and quantity are *P** = 75 cents per pound and *Q** = 7.5 million metric tons per year, derive the linear demand curve consistent with the smaller elasticity.**

Following the method outlined in Section 2.6, we solve for *a* and *b* in the demand equation $Q_D = a - bP$. First, we know that for a linear demand function

$E_D = -b\left(\dfrac{P*}{Q*}\right)$. Here E_D = -0.4 (the long-run price elasticity), $P*$ = 0.75 (the equilibrium price), and $Q* = 7.5$ (the equilibrium quantity). Solving for b,

$$-0.4 = -b\left(\dfrac{0.75}{7.5}\right), \text{ or } b = 4.$$

To find the intercept, we substitute for b, Q_D (= $Q*$), and P (= $P*$) in the demand equation:

$$7.5 = a - (4)(0.75), \text{ or } a = 10.5.$$

The linear demand equation consistent with a long-run price elasticity of -0.4 is therefore

$$Q_D = 10.5 - 4P.$$

b.   **Using this demand curve, recalculate the effect of a 20 percent decline in copper demand on the price of copper.**

The new demand is 20 percent below the original (using our convention that quantity demanded is reduced by 20% at every price):

$$Q'_D = (0.8)(10.5 - 4P) = 8.4 - 3.2P.$$

Equating this to supply,

$$8.4 - 3.2P = -4.5 + 16P, \text{ or}$$

$$P = 0.672.$$

With the 20 percent decline in the demand, the price of copper falls to 67.2 cents per pound.

9. Example 2.9 analyzes the world oil market. Using the data given in that example:

a.   **Show that the short-run demand and competitive supply curves are indeed given by**

$$D = 24.08 - 0.06P$$

$$S_C = 11.74 + 0.07P.$$

First, considering non-OPEC supply:

$$S_c = Q* = 13.$$

With E_S = 0.10 and $P*$ = \$18, $E_S = d(P*/Q*)$ implies $d = 0.07$.

Substituting for d, S_c, and P in the supply equation, $c = 11.74$ and $S_c = 11.74 + 0.07P$.

Similarly, since $Q_D = 23$, $E_D = -b(P*/Q*) = -0.05$, and b = 0.06. Substituting for b, $Q_D = 23$, and P = 18 in the demand equation gives $23 = a - 0.06(18)$, so that $a = 24.08$.

Hence $Q_D = 24.08 - 0.06P$.

b.   **Show that the long-run demand and competitive supply curves are indeed given by**

$$D = 32.18 - 0.51P$$

$$S_C = 7.78 + 0.29P.$$

As above, E_S = 0.4 and E_D = -0.4: $E_S = d(P*/Q*)$ and $E_D = -b(P*/Q*)$, implying $0.4 = d(18/13)$ and $-0.4 = -b(18/23)$. So $d = 0.29$ and $b = 0.51$.

Next solve for c and a:

$S_c = c + dP$ and $Q_D = a - bP$, implying $13 = c + (0.29)(18)$ and $23 = a - (0.51)(18)$.

So $c = 7.78$ and $a = 32.18$.

c. **In 2002, Saudi Arabia accounted for 3 billion barrels per year of OPEC's production. Suppose that war or revolution caused Saudi Arabia to stop producing oil. Use the model above to calculate what would happen to the price of oil in the short run and the long run if OPEC's production were to drop by 3 billion barrels per year.**

With OPEC's supply reduced from 10 bb/yr to 7 bb/yr, add this lower supply of 7 bb/yr to the short-run and long-run supply equations:

$S_c' = 7 + S_c = 11.74 + 7 + 0.07P = 18.74 + 0.07P$ and $S'' = 7 + S_c = 14.78 + 0.29P$.

These are equated with short-run and long-run demand, so that:

$$18.74 + 0.07P = 24.08 - 0.06P,$$

implying that $P = \$41.08$ in the short run; and

$$14.78 + 0.29P = 32.18 - 0.51P,$$

implying that $P = \$21.75$ in the long run.

10. **Refer to Example 2.10, which analyzes the effects of price controls on natural gas.**

a. **Using the data in the example, show that the following supply and demand curves did indeed describe the market in 1975:**

$$\text{Supply: } Q = 14 + 2P_G + 0.25P_O$$

$$\text{Demand: } Q = -5P_G + 3.75P_O$$

where P_G and P_O are the prices of natural gas and oil, respectively. Also, verify that if the price of oil is \$8.00, these curves imply a free market price of \$2.00 for natural gas.

To solve this problem, we apply the analysis of Section 2.6 to the definition of cross-price elasticity of demand given in Section 2.4. For example, the cross-price-elasticity of demand for natural gas with respect to the price of oil is:

$$E_{GO} = \left(\frac{\Delta Q_G}{\Delta P_O}\right)\left(\frac{P_O}{Q_G}\right).$$

$\left(\dfrac{\Delta Q_G}{\Delta P_O}\right)$ is the change in the quantity of natural gas demanded, because of a small

change in the price of oil. For linear demand equations, $\left(\dfrac{\Delta Q_G}{\Delta P_O}\right)$ is constant. If we

represent demand as:

$$Q_G = a - bP_G + eP_O$$

(notice that income is held constant), then $\left(\dfrac{\Delta Q_G}{\Delta P_O}\right) = e$. Substituting this into the cross-

price elasticity, $E_{PO} = e\left(\dfrac{P_O^*}{Q_G^*}\right)$, where P_O^* and Q_G^* are the equilibrium price and quantity.

We know that $P_O^* = \$8$ and $Q_G^* = 20$ trillion cubic feet (Tcf). Solving for e,

$$1.5 = e\left(\frac{8}{20}\right), \text{ or } e = 3.75.$$

Similarly, if the general form of the supply equation is represented as:

$$Q_G = c + dP_G + gP_O,$$

the cross-price elasticity of supply is $g\left(\dfrac{P_O^*}{Q_G^*}\right)$, which we know to be 0.1. Solving for g,

$$0.1 = g\left(\frac{8}{20}\right), \text{ or } g = 0.25.$$

The values for d and b may be found with equations 2.5a and 2.5b in Section 2.6. We know that $E_S = 0.2$, $P^* = 2$, and $Q^* = 20$. Therefore,

$$0.2 = d\left(\frac{2}{20}\right), \text{ or } d = 2.$$

Also, $E_D = -0.5$, so

$$-0.5 = b\left(\frac{2}{20}\right), \text{ or } b = -5.$$

By substituting these values for d, g, b, and e into our linear supply and demand equations, we may solve for c and a:

$$20 = c + (2)(2) + (0.25)(8), \text{ or } c = 14,$$

and

$$20 = a - (5)(2) + (3.75)(8), \text{ or } a = 0.$$

If the price of oil is $8.00, these curves imply a free market price of $2.00 for natural gas. Substitute the price of oil in the supply and demand curves to verify these equations. Then set the curves equal to each other and solve for the price of gas.

$$14 + 2P_G + (0.25)(8) = -5P_G + (3.75)(8)$$

$$7P_G = 14$$

$$P_G = \$2.00.$$

b. **Suppose the regulated price of gas in 1975 had been $1.50 per thousand cubic feet, instead of $1.00. How much excess demand would there have been?**

With a regulated price of $1.50 for natural gas and a price of oil equal to $8.00 per barrel,

$$\text{Demand: } Q_D = (-5)(1.50) + (3.75)(8) = 22.5, \text{ and}$$
$$\text{Supply: } Q_S = 14 + (2)(1.5) + (0.25)(8) = 19.$$

With a supply of 19 Tcf and a demand of 22.5 Tcf, there would be an excess demand of 3.5 Tcf.

c. **Suppose that the market for natural gas had *not* been regulated. If the price of oil had increased from $8 to $16, what would have happened to the free market price of natural gas?**

If the price of natural gas had not been regulated and the price of oil had increased from $8 to $16, then

$$\text{Demand: } Q_D = -5P_G + (3.75)(16) = 60 - 5P_G, \text{ and}$$
$$\text{Supply: } Q_S = 14 + 2P_G + (0.25)(16) = 18 + 2P_G.$$

Equating supply and demand and solving for the equilibrium price,

$$18 + 2P_G = 60 - 5P_G, \text{ or } P_G = \$6.$$

The price of natural gas would have tripled from $2 to $6.

11. The table below shows the retail price and sales for instant coffee and roasted coffee for 1997 and 1998.

Year	Retail Price of Instant Coffee ($/lb)	Sales of Instant Coffee (million lbs)	Retail Price of Roasted Coffee ($/lb)	Sales of Roasted Coffee (million lbs)
1997	10.35	75	4.11	820
1998	10.48	70	3.76	850

a.   Using this data alone, estimate the short-run price elasticity of demand for roasted coffee. Derive a linear demand curve for roasted coffee.

To find elasticity, you must first estimate the slope of the demand curve:

$$\frac{\Delta Q}{\Delta P} = \frac{820 - 850}{4.11 - 3.76} = -\frac{30}{0.35} = -85.7.$$

Given the slope, we can now estimate elasticity using the price and quantity data from the above table. Since the demand curve is assumed to be linear, the elasticity will differ in 1997 and 1998 because price and quantity are different. You can calculate the elasticity at both points and at the average point between the two years:

$$E_p^{97} = \frac{P}{Q}\frac{\Delta Q}{\Delta P} = \frac{4.11}{820}(-85.7) = -0.43$$

$$E_p^{98} = \frac{P}{Q}\frac{\Delta Q}{\Delta P} = \frac{3.76}{850}(-85.7) = -0.38$$

$$E_p^{AVE} = \frac{\dfrac{P_{97} + P_{98}}{2}}{\dfrac{Q_{97} + Q_{98}}{2}}\frac{\Delta Q}{\Delta P} = \frac{3.935}{835}(-85.7) = -0.40.$$

To derive the demand curve for roasted coffee Q=a-bP, note that the slope of the demand curve is -85.7=-b. To find the coefficient a, use either of the data points from the table above so that a=830+85.7*4.11=1172.3 or a=850+85.7*3.76=1172.3. The equation for the demand curve is therefore

Q=1172.3-85.7P.

b.   Now estimate the short-run price elasticity of demand for instant coffee. Derive a linear demand curve for instant coffee.

To find elasticity, you must first estimate the slope of the demand curve:

$$\frac{\Delta Q}{\Delta P} = \frac{75 - 70}{10.35 - 10.48} = -\frac{5}{0.13} = -38.5.$$

Given the slope, we can now estimate elasticity using the price and quantity data from the above table. Since the demand curve Q=a-bP is assumed to be linear, the elasticity will differ in 1997 and 1998 because price and quantity are different. You can calculate the elasticity at both points and at the average point between the two years:

$$E_p^{97} = \frac{P}{Q}\frac{\Delta Q}{\Delta P} = \frac{10.35}{75}(-38.5) = -5.31$$

$$E_p^{98} = \frac{P}{Q}\frac{\Delta Q}{\Delta P} = \frac{10.48}{70}(-38.5) = -5.76$$

$$E_p^{AVE} = \frac{\dfrac{P_{97} + P_{98}}{2}}{\dfrac{Q_{97} + Q_{98}}{2}}\frac{\Delta Q}{\Delta P} = \frac{10.415}{72.5}(-38.5) = -5.53.$$

To derive the demand curve for instant coffee, note that the slope of the demand curve is -38.5=-b. To find the coefficient a, use either of the data points from the table above so that a=75+38.5*10.35=473.5 or a=70+38.5*10.48=473.5. The equation for the demand curve is therefore

Q=473.5-38.5P.

c. **Which coffee has the higher short-run price elasticity of demand? Why do you think this is the case?**

Instant coffee is significantly more elastic than roasted coffee. In fact, the demand for roasted coffee is inelastic and the demand for instant coffee is elastic. Roasted coffee may have an inelastic demand in the short-run as many people think of coffee as a necessary good. Changes in the price of roasted coffee will not drastically affect demand because people must have this good. Many people, on the other hand, may view instant coffee, as a convenient, though imperfect, substitute for roasted coffee. For example, if the price rises a little, the quantity demanded will fall by a large percentage because people would rather drink roasted coffee instead of paying more for a low quality substitute.