Microeconomics Theory and Applications with Calculus 4th edition Perloff Solutions Manual

SKU: 9780134167381-SOLUTIONS

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Chapter 2
Supply and Demand

■ Chapter Outline

Challenge: ***Quantities and Prices of Genetically Modified Foods***

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- The Demand Function
  - A Change in a Product's Price Causes a Movement Along the Demand Curve
  - A Change in Other Prices Causes the Demand Curve to Shift
- Summing Demand Functions
  - **Application:** Aggregating Corn Demand Curves

2.2 Supply
- The Supply Function
  - A Change in a Product's Price Causes a Movement Along the Supply Curve
  - A Change in Another Factor Causes the Supply Curve to Shift
- Summing Supply Functions
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Long Run Versus Short Run
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The Same Equilibrium No Matter Who is Taxed
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2.8 When to Use the Supply-and-Demand Model

■ Teaching Tips

This chapter reviews basic supply-and-demand concepts from the principles level. Your interactions with the class from the first session or two should give you a good indication of how much class time to spend on it. If it has been some time since their principles courses, students may need fairly consistent prompting to recall the basic supply-and-demand model. For example, many will remember that there is a Law of Demand but won't remember the law itself. It is well worth the time spent at this stage to make sure everyone has solid recognition of these basic tools and concepts.

The introduction of demand curves and equations is a good opportunity to review the basic geometric concepts of slope and intercept. This doesn't take much time, as most students can recognize the slope and intercept of a written equation, but there is sometimes a surprising lack of connection between what appears in an equation and the resulting graph. Draw a demand curve and tell the class that the slope of this curve is −2. Then ask the students what will happen in the graph if the slope increases to −4. Although it is likely that several, perhaps most, students will know immediately, some will not. This is also a good time to introduce nonlinear demand functions to illustrate the use of calculus. Assigning some of the quantitative problems at the end of the chapter and collecting them (even if you don't intend to collect homework throughout the term) is another good diagnostic. In addition, students often understand slope in y and x terms and have a surprisingly difficult time extending that to P and Q, especially since the demand function is written with Q (the x-axis variable) on the left-hand side.

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When reviewing demand, be sure students are clear on the difference between movement along the curve and a shift of the entire curve. Two points should be helpful. First, note to them that both in Equation 2.3 and on the graph in Figure 2.1, price is the only independent variable present. Thus only price can cause a movement along the curve. Second, underscore the role of other variables. After compiling a list of the factors that can shift the demand curve (once they get started, the class as a group should be able to provide you with this list), ask what factors are held constant along a single demand curve. Surprisingly, this question is often greeted by a protracted silence. By realizing that it is the same factors that shift the curve when they change, students develop a more solid understanding. The text makes this point well in Equations 2.2 and 2.3. It is here that students should realize the use of partial derivatives to determine the size of the demand shift.

Be sure to review the inverse demand curve and the process of inversion. You can motivate this review by noting that this process will be needed later when formulating a total revenue equation from a demand equation. You can combine this with the discussion of the problem of the reversed axes, and reintroduce the inverse function rule.

Try to keep the discussion of supply parallel to that of demand. For factors that can shift the entire supply curve, note that they can all be lumped together under the broader heading of costs, government rules and regulations, and other variables (as is done in the text). The text notes that there is no "Law of Supply," and most students have learned this in their principles course. Be aware, however, that some principles instructors refer to the upward slope of supply curves in the short run as the "Law of Supply." Adopting a uniform taxonomy and vocabulary reduces confusion. This includes uniformity with the text with respect to symbols and upper- versus lower-case labeling.

When combining supply and demand in the discussion of equilibrium, press the students for a usable definition of the term. You will likely receive the suggestion of "where supply equals demand." Though incorrect, this definition is useful in the introduction of price floors and ceilings where the quantity supplied does not equal quantity demanded at the equilibrium quantity. An important point regarding equilibrium solutions of supply-and-demand problems is that they are typically stable and self-correcting. To illustrate this point, use examples of commonly purchased items such as discounted clothing and older DVDs, where reduced prices reflect excess supply.

When discussing own-price elasticities, students need to understand that several formulas yield an elasticity and the choice of formula is driven mostly by the information that is given. When talking about the formula as simply a ratio of percentage changes, you might try to find a current newspaper piece that has a percentage change in prices and the percentage change in quantity that results.

When discussing elasticities, two points require significant attention. The first is to get the students to make the connection between a verbal description of an elasticity, the slope of the demand curve, the elasticity formulas, and the graph of a demand curve. You can give the students information in different forms and ask them to compute an elasticity in each case. The second area of confusion is that linear demand curves are not of constant elasticity (except when perfectly elastic or inelastic). You can demonstrate using an equation and a graph; that although the slope is constant, the price/quantity ratio is changing, which changes the elasticity as price falls. This is illustrated well in Figure 2.10 and also illustrated with the constant elasticity demand function in Solved Problem 2.3.

Although own-price elasticities are covered in principles, income and cross-price elasticities generally are not. Thus you should budget significant class time to discuss them. When covering income and cross-price elasticities, consider using the following approach: Choose a product and ask the students what factors might

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influence demand (choose something that has clear substitutes and complements, such as a computer or a food item). Once you get a list, put a hypothetical demand equation on the board. If you have a computerized classroom, you can bring in data and estimate a demand equation for the class. It is good to do this, as it seems to take some of the abstraction out of demand analysis. Either way, once you have an equation, review how an own-price elasticity can be determined from this equation and use that as a springboard into the cross-price and income elasticities. It is useful to change the units of one of the variables, show how the coefficients would change, and demonstrate that the elasticity would remain unchanged. Once you discuss this, consider having the class work the following as an in-class problem:

> The demand for boxes of nails is estimated to be $Q = 100 - 5p + 2I$, where income is measured in thousands of dollars. If $p = 4$, and $I = 10$, what is the income elasticity? If the equation is then re-estimated using just dollars instead of thousands of dollars, what will be the effect on the coefficient for I, and the income elasticity? How would the income elasticity change if the price were reduced to $2?

Although we frequently ignore the negative sign in the own-price elasticity of demand, the negative signs in both the income and cross-price elasticities are more important, and students often need to be reminded of when the negative sign is required and when it is redundant.

Discussion of the own-price elasticity of supply will be similar to the discussion of demand elasticity. It is useful to point out that the size of the shift in supply can be determined from supply elasticities other than price. Equation 2.6 provides an opportunity to show input price elasticities.

In the discussion of taxes and tax incidence, students need to be clear on two general points. The first is that the after-tax equilibrium is independent of whether the tax is levied on firms or consumers. The second is that the incidence is dependent on the elasticities of supply and demand. In this instance, using the special cases of perfectly inelastic and perfectly elastic supply and demand curves may be very helpful. You can then extend this to empirical examples. A federal tax on cigarettes would raise large amounts of revenue but would not discourage smoking as much as if demand were elastic. A good contrast for this is the 1990 Federal Luxury Tax, which raised significant revenues from taxes on high-priced automobiles but devastated the U.S. boating industry (see Additional Applications on the next page).

When discussing floors and ceilings, stress the definitions using simple graphs as illustrations. Although it seems counterintuitive to some students that an effective floor must be *above* the equilibrium price and an effective ceiling must be *below,* suggest that they use this as a mnemonic device. In this section, try to engage the class in a discussion of unintended or secondary effects of government intervention. This issue deserves significant class discussion time. Most students have not thought much about the consequences of ceilings and floors beyond the simple price effects. The text has a good description of the unfortunate side effects of gasoline price controls. Another good example for discussing secondary effects is rent control. On the supply side, incentives for landlords to provide efficient levels of upkeep and safety measures in rent-controlled buildings are distorted. On the demand side, time spent searching and undesired doubling-up reduce consumer satisfaction. Secondary effects of floors are also worth noting. You can discuss the text's example of the possible negative effects of minimum wages. Again, students are likely to view minimum wages as strictly a benefit to workers because they have not considered that job loss will mean that some workers are harmed rather than helped by the establishment of minimums or increases in their level (although relatively recent empirical results suggest only a small effect, which may be offset by the macroeconomic effects of increased consumer spending).

In the section on when to use the supply-and-demand model, be sure to define and discuss transaction costs. Most students will not be familiar with this term from principles, and it has important implications on the

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functioning of thin markets and markets where there is substantial uncertainty.

■ Additional Applications

Tax Revenues from Federal Luxury Taxes

In 1990, *ad valorem* taxes were imposed on many luxury goods. The tax was 10 percent of the amount over $100,000 paid for yachts, over $250,000 paid for planes, over $10,000 for furs and jewels, and over $30,000 for cars.[1] The idea was to raise tax revenues for the government without harming the poor and middle class.

Due to a mistaken belief about elasticities, the tax on automobiles raised more revenue than expected. This portion of the luxury tax was predicted to raise $25 million in 1991 and $1.5 billion over five years. It actually brought in $98.4 million in the first year alone. Because most of the cars that were taxed were built abroad, the reduced output—sales of Mercedes fell 27 percent and Lexus sales fell 10 percent in the first quarter of 1991—affected few American workers except auto salespeople.

In contrast, the taxes on goods other than cars raised relatively little revenue and caused a substantial loss of domestic output and jobs. As a result, four bills were brought before Congress within a year to remove those taxes. In mid-1993, the taxes were revoked. A 1996 law phased out the luxury auto tax by 2002.

The yachting industry provides an extreme example of the harm to domestic producers. In the first year of the yacht tax, sales of yachts costing more than $100,000 fell by 71 percent (sales of boats costing less than $100,000, which were not affected by the tax, fell 28 percent due to the recession). The yacht tax raised only $7 million, well below the forecast amount, because the drop in sales was not forecast. Congressional analysts made errors in predicting demand and supply elasticities. The demand curve was thought to be less elastic than it was because tax-avoiding behavior and the ability of consumers to shift between goods was ignored. Wealthy boat owners escaped the boat tax by buying yachts in the Bahamas or buying yachts that cost just under $100,000.

Yacht industry employment fell from 160,000 workers at the start of 1991 to 115,000 a little more than a year later. Thus the loss of payroll taxes in this industry far outweighed the increase in luxury tax revenues. According to a study by a trade group, payroll taxes would have fallen by $148 million from 1991 to 1996 had the luxury tax not been removed. Although this is likely to be an overestimate because it assumes that workers would not have found work in other industries, the tax clearly failed to achieve its goal. The unintended effects of this law could have been avoided if Congress had better information about the elasticities of demand and supply.

1. Can you think of commodities other than those discussed that the government could have chosen that would have better achieved their goal?

2. Suppose that instead of taxing commodities, the government decided to simply tax the income of wealthy citizens at a much higher rate. Would this achieve the stated goal?

[1]This section is based on "Senate Panel Kills Tax on Luxury Items," *Los Angeles Times,* June 17, 1992:D1 and D13; Christopher Byron, "The Bottom Line, High and Dry," *New York,* 25(18), May 4, 1992:18, 20; and Bernard Baumohl, "Taxes: Tempest in a Yacht Basin," *Time,* 137(26), July 1, 1991:51.

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Elasticity of Toll Roads in Pennsylvania and New Jersey[2]

Turnpike Commissions in Pennsylvania and New Jersey substantially increased tolls on the turnpikes in those states in 1991 in an effort to cover the increased cost of maintenance and construction of other state roads. Like any consumers faced with a price increase, drivers, especially truckers, began seeking alternative routes. The truckers were upset that they were being targeted by the toll increases because they depend on using the roads to transport goods to major cities like Philadelphia and New York. To save the money that would otherwise go toward paying the increased tolls (as much as $50 per trip), truckers began (and continue) to use back roads instead. Unfortunately, this shift creates congestion, road wear, and driver fatigue due to the increased stress of driving on hilly two-lane highways rather than turnpikes. It also results in additional wear on the trucks as well as higher fuel costs as the trucks sit longer in traffic.

In Pennsylvania, the tolls increased 30 percent. However, revenue did not increase by 30 percent because of the substitution of free roads for turnpikes by cars and trucks alike. Truck traffic on turnpikes fell by 13 percent in response to the increase. In northern New Jersey, on roads that lead directly to New York, tolls were doubled (increased by 100 percent). There, car traffic fell by 7 percent and truck traffic by 12 percent. Some independent truckers gave up completely. "I'm quitting this year" was the response of Jimmy Williams. In addition to the reduction in traffic due to the substitution, the states must now also cope with the increased expenditures required to maintain and improve roads that are not designed to accommodate such heavy volume.

1. For truckers, what is the elasticity of demand for toll roads in Pennsylvania?
2. What are the demand elasticities for cars and trucks in New Jersey? Why do you suppose that they are different from the elasticities in Pennsylvania?
3. How might the increase in tolls affect consumers in Philadelphia and New York?

■ Discussion Questions

[2]Based on Agis Salpukas, "Tolls Up, Trucks Take Back Roads," *New York Times,* September 17, 1991:D1, D6.

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1. Can you think of any cases in which the Law of Demand might not hold?
2. Would you expect most supply curves to have an upward slope? Why or why not?
3. What are some examples of markets that are competitive?
4. In which markets might transactions costs be so high that the market cannot be competitive?
5. Can you think of situations where the government would want to take actions that cause shortages?
6. In what markets and situations would you expect that the quantity demanded would not equal the quantity supplied?
7. Give an example of a product where the long-run elasticity of demand is less than the short-run elasticity.
8. Give an example of a product where the long-run elasticity of supply is less than the short-run elasticity.
9. Higher gasoline taxes have been proposed as a means of reducing gasoline consumption. Do you think that this policy would be effective? Does the time period considered matter?
10. Why might a government prefer to collect sales taxes from firms rather than consumers?
11. Why might a government prefer one type of sales tax (*ad valorem* or specific) to the other?
12. The governor of the state of New York has proposed a statewide $15 minimum wage. Assuming that other states do not change their minimum wages, how do you think that this would affect workers in the state of New York?

■ Additional Questions and Problems

1. Suppose you are planning to conduct a study of the running shoe market. List the factors that you believe would cause changes in the demand for running shoes. In each case, note whether the relationship would be positive (direct) or negative (inverse). Also list the factors that you believe would affect the supply, again noting the nature of the relationship.
2. In each case below, identify the effect on the market for steak.

a. An increase in the price of lamb
b. A decrease in the population
c. An increase in consumer income
d. A decrease in the price of steak sauce
e. An increase in advertising by chicken producers

3. In each case below, identify the effect on the market for coal.

a. The development of a new, lower cost mining technique
b. An increase in wages paid to coal miners
c. The imposition of a $2 per ton tax on coal

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d. A widespread news report that demand for coal will be much lower next year
e. A new government regulation requiring air purifiers in all work areas

4. In a competitive labor market, demand for workers is $Q_D = 10{,}000 - 100W$, and supply is $Q_S = 2{,}000 + 1{,}900W$, where Q is the quantity of workers employed and W is the hourly wage. What is the initial equilibrium wage and employment level? Suppose that the government decides that $5 per hour is the minimum allowable wage in any market. How would this new minimum wage alter this market? What would the new employment level be? What would happen to total payments to labor? Would there be any excess supply of labor? If so, how much?

5. For each sentence below describing changes in the tangerine market, note whether the statement is true, false, or uncertain, and explain your answer. You will find it helpful to draw a graph for each case.

a. If consumer income increases and worker wages fall, quantity will rise, and prices will fall.
b. If orange prices decrease and taxes on citrus fruits decrease, quantity will fall, and prices will rise.
c. If the price of canning machinery (a complement) increases and the growing season is unusually cold, quantity and price will both fall.

6. If demand for show tickets is described by the equation $Q_D = 100 - p$, and supply is $Q_S = 20 + p$, find the equilibrium price and quantity. How would your answer change if the supply curve shifted to $Q_S' = 10 + p$ due to increases in actor salaries?

7. Suppose the demand for onion ice cream was described by the equation $Q_D = 20 - p$, and the supply was described by $Q_S = -40 + p$. What are the equilibrium price and quantity? Show your answer using a graph.

8. If demand for toy drums is described by the equation $Q_D = 300 - 5p$, and supply is $Q_S = 60 + 3p$, find the equilibrium price and quantity. How would your answer change if a decrease in consumer income shifted the demand curve to $Q_D' = 220 - 5p$?

9. A new chemical cleaning solution is introduced to the market. Initially, demand is $Q_D = 1{,}000 - 2p$, and supply is $Q_S = 100 + p$. Determine the equilibrium price and quantity. The government then decides that no more than 300 units of this product should be sold per period and imposes a quota at that level. How does this quota affect the equilibrium price and quantity? Show the solution using a graph and calculate the numerical answer.

10. Demand for park visits is $Q^*_0 = 10{,}000 - 100P$. If park visits are free, how many visitors will attend? How will your answer change if the park adds a $20 admission fee? Show using a graph.

11. A firm introduces a new model of MP3 player, which can play both audio and video files. The price is the same as that of a previous model that can only play audio files. What would happen to the market of the previous model? What if the new model is more expensive than the previous one?

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12. In a competitive labor market, demand for workers is $Q_D = 9{,}900 - 100W$, and supply is $Q_S = 2{,}000 + 1{,}900W$, where Q is the quantity of workers employed, and W is the hourly wage. Suppose the government decides to impose a wage ceiling of \$3 per hour. What would the equilibrium be in this labor market?

13. What would you predict about the elasticities of demand and supply for emeralds? Be sure to state your reasons in each case.

14. Explain why demand curves that are linear (straight lines) generally do not have a constant elasticity. What types of linear demand curves do have a constant elasticity?

15. If the price of eggs increases from \$1.50 per carton to \$1.75, and the quantity demanded decreases from 25 to 20, what is the elasticity of demand?

16. If the equation for the demand for bow ties is $Q = 200 - 10p$, what is the elasticity of demand when $p =$ \$10?

17. If the price of coffee increases from \$0.60 to \$0.80 per cup and the quantity supplied increases from 50 cups to 100 cups, what is the elasticity of supply?

18. Suppose that demand for inkjet printers is estimated to be $Q = 1000 - 5p + 10p_X - 2p_Z + 0.1Y$.

    If $p = 80$, $p_X = 50$, $p_Z = 150$, and $Y = 20{,}000$; answer the following:

    a. What is the price elasticity of demand?
    b. What is the cross-price elasticity with respect to commodity *X?* Give an example of what commodity *X* might be.
    c. What is the cross-price elasticity with respect to commodity *Z?* Give an example of what commodity *Z* might be.
    d. What is the income elasticity?

19. Suppose the demand for antibiotics is $Q = 100{,}000$. What is the elasticity of demand? If a specific tax of \$1 per dose were levied, who would bear the burden of the tax?

20. Use a graph to show that the incidence of a \$1/lb. tax on grapes is the same whether the tax is shown as a shift in the supply curve (tax on sellers) or the demand curve (tax on buyers). Under what circumstances would the incidence of the tax be split equally between buyers and sellers?

21. Suppose a tax on beans of \$0.05 per can is levied on firms. As a result of the tax, the equilibrium price increases from \$0.20 to \$0.22. What fraction of the incidence falls on consumers? On firms? Suppose the supply elasticity is 0.6. What must the demand elasticity be?

22. If the market demand curve for triple-scoop ice cream cones is $Q_D = 60 - 8p$, find the price elasticity of demand when $p =$ \$4.

23. Suppose the market supply curve of wagons is $Q_S = -62.5 + 0.5p^2$. The demand curve is $Q_D = 325 - 2p^2$. Determine the incidence of a small tax on consumers.

24. Show that when demand is perfectly elastic, consumer tax incidence is zero.

25. Show that the supply function $Q = Ap^{\varepsilon}$ has constant elasticity.

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■ Answers to Additional Questions and Problems

1. Possible responses include:

Demand: Price of running shoes (–)
Sock prices (–)
Prices of other sneaker types (+)
Number of people who are regular runners (+)
Income (+)

Supply: Worker wages (–)
Increases in leather prices (–)
Removal of import tariffs (+)
Unit tax on running shoes (–)

2. a. The demand curve shifts to the right.
b. The demand curve shifts to the left.
c. The demand curve shifts to the right.
d. The demand curve shifts to the right.
e. The demand curve shifts to the left.

3. a. The supply curve shifts to the right.
b. The supply curve shifts to the left.
c. The supply curve shifts to the left.
d. The supply curve shifts to the left.
e. The supply curve shifts to the left.

4. Without minimum wages, the equilibrium is

$$10{,}000 - 100W = 2{,}000 + 1{,}900W$$
$$W^* = 4$$
$$Q^* = 9{,}600.$$

With the new minimum wage of $5, employment will equal the amount of labor demanded at the minimum wage.

$$Q_d = 10{,}000 - 100(5) = 9{,}500.$$

Total payments to labor would increase from $38,400 to $47,500. Excess supply of labor would equal $2{,}000 = 2{,}000 + 1{,}900(5) - 9{,}500$. Thus, in addition to the 100 people who would lose the jobs they had before the minimum, an additional 1,900 people would now want jobs that would be unobtainable at the higher wage rate.

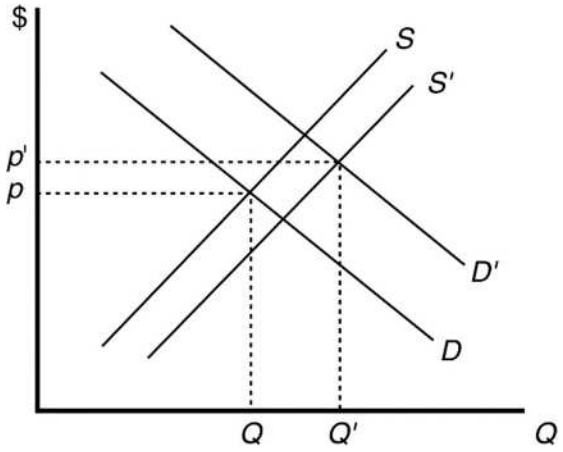
5. In each case, you must draw a graph that shows the original supply and demand curves, plus the new curves after the changes. You must then consider whether it matters how far the curve shifts in response to the change in the parameter indicated.

a. Uncertain. In this case, both the supply and the demand curves shift to the right. Quantity will definitely increase, but whether prices rise, fall, or remain constant depends on the relative sizes of the supply and demand shifts. In the following figure , because the demand shift is relatively

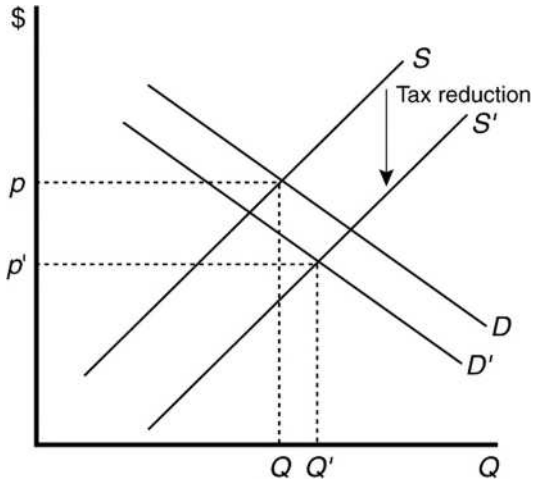
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larger than the shift in supply, prices increase.



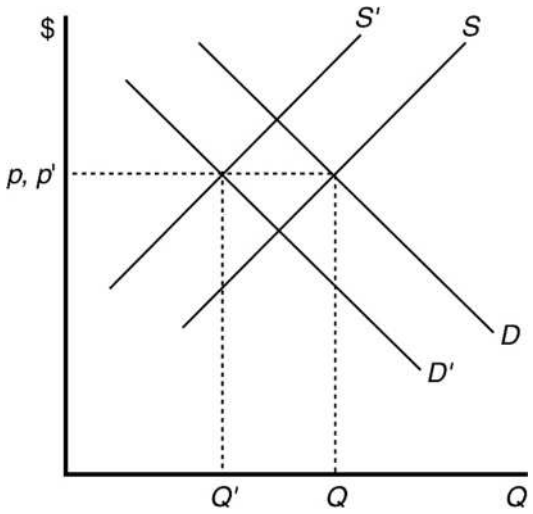
b. False. The supply curve shifts right due to the decrease in taxes, and the demand curve shifts left due to the decrease in orange prices. Prices will be lower, and the change in quantity depends on the magnitude of the shifts. See the following figure. In this case, the large rightward shift in supply compared to the relatively small shift of the demand curve causes quantity to increase.



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c. Uncertain. In this case, the demand and supply curves both shift to the left. Quantity decreases, but price may rise, fall, or remain unchanged depending on the relative magnitude of the shifts. See the following figure. In this case, price remains unchanged.



6. Set $Q_D = Q_S$ and solve.

For $Q_S = 20 + p$

$100 - p = 20 + p$

$p^* = 40$

$Q^* = 60$

For $Q' = 10 + p$

$100 - p = 10 + p$

$p^* = 45$

$Q^* = 55$

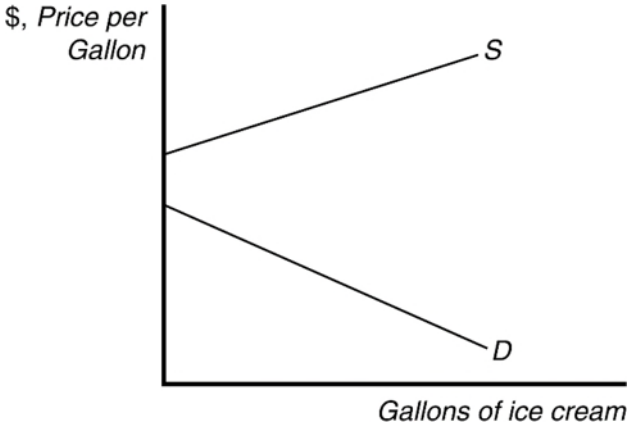
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7. Set $Q_S = Q_D$ and solve.

$$P^* = 30$$
$$Q^* = -10$$

Equilibrium quantity is zero because the demand curve lies below the supply curve at all prices where output is positive.



8. Set $Q_D = Q_S$ and solve.

For $Q_D = 300 - 5p$

$$300 - 5p = 60 + 3p$$
$$p^* = 30$$
$$Q^* = 150 \text{ units.}$$

For $Q_D' = 220 - 5p$

$$220 - 5p = 60 + 3p$$
$$p^* = 20$$
$$Q^* = 120$$

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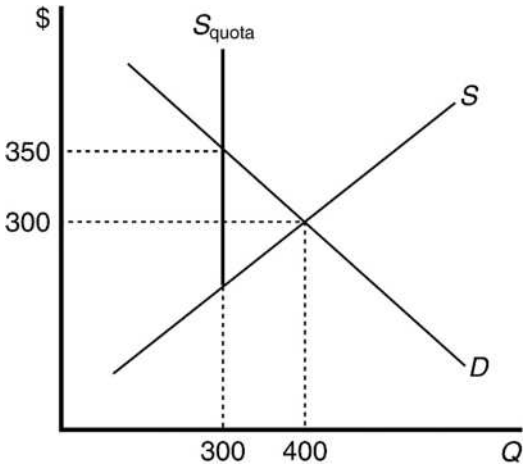
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9. The equilibrium solution with no government intervention is

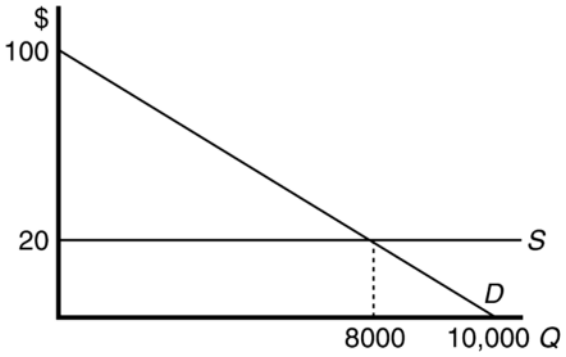
$$1{,}000 - 2p = 100 + p$$
$$p^* = 300$$
$$Q^* = 400$$

When the quota is imposed at 300 units, supply cannot exceed that level, regardless of price. Thus the supply curve becomes vertical at 300 units. The new equilibrium quantity is 300, and price is determined by where the supply curve with the quota (S_{quota}) intersects the demand curve. To solve for the price, plug the quota value (300) into the demand equation.

$$1{,}000 - 2p = 300$$
$$p^* = 350$$



10. When park visits are free, the equilibrium quantity is 10,000 = 10,000 – 100(0). With a $20 entrance fee, quantity falls to 8,000.



11. The demand curve of the previous model shifts to the right. If the new model is more expensive, the demand curve for the previous model shifts to the right still but with a smaller magnitude.

12. Without the wage ceiling, the equilibrium is given by

$$10{,}000 - 100W = 2{,}000 + 1{,}900W,$$

where $W = 4$ and $Q = 9{,}600$. With the wage ceiling of $3 per hour, the market wage rate will be $W = 3$, and the amount of labor employed will be 7,700.

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13. The demand for emeralds is elastic because they would be categorized as luxury goods rather than necessities. Emeralds are also substitutable in most cases for other precious gems, which increases their elasticity. Supply is likely to be quite inelastic for two reasons. First, there are only a few places in the world where emeralds can be found. Second, of those found, only a small percentage are of sufficient quality to be used in jewelry. Supply elasticity would be larger if extraction costs vary at different mines.

14. Elasticities that are calculated from linear demand curves are a function of two things. The first is the slope of the curve, and the second is the ratio p/Q. While the slope of a linear demand curve remains constant, the ratio of price to output varies along the curve due to the negative slope. The only exceptions are when the demand curve is flat, in which case price does not vary, and the demand curve is perfectly elastic, and when the demand curve is vertical, in which case quantity does not vary and the demand curve is perfectly inelastic.

15. $\varepsilon = (-5/0.25)(1.5/25) = -1.2$

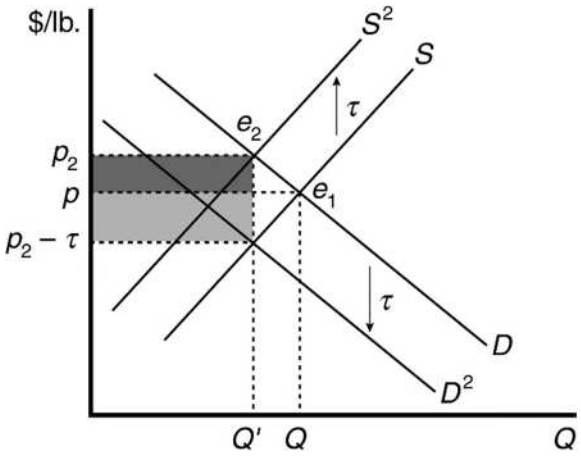
16. $\varepsilon = -10(10/100) = -1$

17. $\eta = (50/0.2)(0.6/50) = 3$

18. a. $\varepsilon = -400/(1{,}000 + 500 - 300 + 2{,}000 - 400) = -400/2{,}800 = -0.143$
    b. $\varepsilon_X = 500/2{,}800 = 0.179$
    c. $\varepsilon_Z = -300/2{,}800 = -0.107$
    d. $\xi = 2{,}000/2{,}800 = 0.714$

19. Because quantity does not depend on price, demand is perfectly inelastic, and the elasticity is zero. Consumers would bear the full burden of any specific tax.

20. In the following figure, the initial equilibrium is at e_1. A tax of \$1/lb. can be shown by shifting the supply curve up by \$1 (S^2) or by shifting the demand curve down by \$1(D^2). In either case, price paid by consumers is the same (p_2). The upper shaded area is the incidence on consumers; the lower shaded area is the incidence on suppliers. Using Equation 2.27, if the supply elasticity is equal to the demand elasticity, the incidence would fall equally on buyers and sellers.



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21. The incidence on consumers is $\iota = 0.02/0.05 = 0.4$. Thus the incidence on firms is 0.6. If the supply elasticity is 0.6, using formula (2.26), the demand elasticity must be -0.9.

22. $\varepsilon = -32/28 = -1.143$.

23. $dS/dp = p$. $dD/dp = -4p$. Thus $dp/d\tau = p/[p - (-4p)] = 1/5$.

24. The tax incidence is calculated as $\eta/(\eta - \varepsilon)$. For perfectly elastic demand, ε is negative infinity. Hence the consumer tax incidence is zero.

25. $dQ/dp = A\varepsilon p^{\varepsilon - 1}$. Hence $(dQ/dp)(p/Q) = A\varepsilon p^{\varepsilon - 1}p/(Ap^{\varepsilon}) = \varepsilon$, which is a constant.

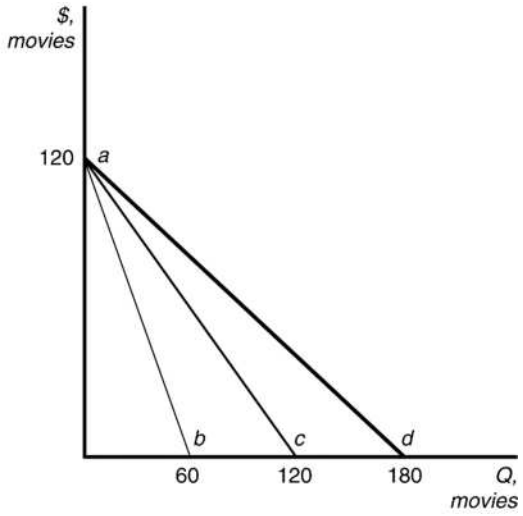
■ Answers to Exercises in the Text

1.1 $Q = 171 - 20p + 20p_b + 3p_c + 2Y = 171 - 20p + 20(3) + 3(3\frac{1}{3}) + 2(12.5) = 266 - 20p$.

1.2 The demand curve for pork is $Q = 171 - 20p + 20p_b + 3p_c + 2Y$. As a result, $\partial Q/\partial Y = 2$. A \$100 increase in income causes the quantity demanded to increase by 0.2 million kg per year.

1.3 The derivative of demand with respect to income is $\frac{\partial Q}{\partial Y} = 0.01$. Thus a \$1,000 increase in income results a 10 unit increase in avocadoes demanded. Graphically, this would be a parallel shift of the demand curve rightward.

1.4 In the figure below, *ac* is the demand function for college students, and line *ab* is the demand function for other town residents. Line *ad* is the total demand function.



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1.5 Summing the demand curves yields the total demand for corn:

$$Q = \begin{cases} 1{,}487 - 22.1\,p, p \geq 27.56 \\ 7{,}734.5 - 248.8\,p, p < 27.56 \end{cases}$$

1.6 The total demand function is $Q = 1.4p^{-2} + 1.4p^{-3.7}$. At a price of \$1.00, Apple Store customers demand $Q_A = 1.4 * 1^{-2} = 1.4$ apps, and Google Play customers demand $Q_A = 1.4 * 1^{-3.7} = 1.4$ apps, for a total of 2.8 million apps.

2.1 Supply: $Q = 178 + 40p - 60p_h$. Replacing p_h with \$3 per kg gives us a supply function $Q = 178 + 40p - 60 \times \$3 = 40p - 2$. That is, the slope of the supply curve does not change from Equation 2.7, but the whole supply curve shifts to the left.

2.2 The derivative of supply with respect to the price of fertilizer is $\frac{\partial Q}{\partial p_f} = -20$. Thus, a \$1.10 increase in income results a 22 unit decrease in avocadoes supplied. Graphically, this would be a parallel shift of the supply curve.

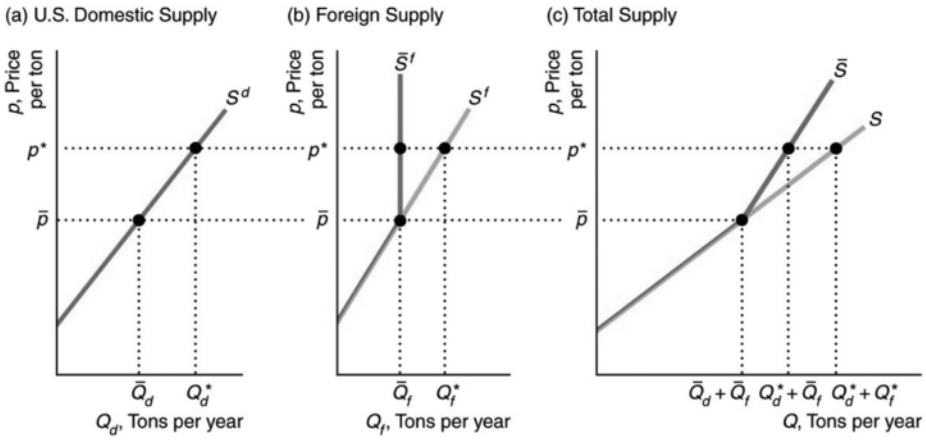
2.3 The world supply is:

$$Q = Q_a + Q_r = (10 + 10p) + (5 + 20p) = 15 + 30p.$$

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2.4 In the following figure, the no-quota total supply curve, S in panel c, is the horizontal sum of the U.S. domestic supply curve, S^d, and the no-quota foreign supply curve, S^f. At prices less than $\bar{p}$, foreign suppliers want to supply quantities less than the quota, $\bar{Q}$. As a result, the foreign supply curve under the quota, $\bar{S}^f$, is the same as the no-quota foreign supply curve, S^f, for prices less than $\bar{p}$. At prices above $\bar{p}$, foreign suppliers want to supply more but are limited to $\bar{Q}$. Thus the foreign supply curve with a quota, $\bar{S}^f$, is vertical at $\bar{Q}$ for prices above $\bar{p}$. The total supply curve with the quota, $\bar{S}$, is the horizontal sum of S^d and $\bar{S}^f$. At any price above $\bar{p}$, the total supply equals the quota plus the domestic supply. For example, at p^*, the domestic supply is Q_d^* and the foreign supply is $\bar{Q}_f$, so the total supply is $Q_d^* + \bar{Q}_f$. Above $\bar{p}$, $\bar{S}$ is the domestic supply curve shifted $\bar{Q}$ units to the right. As a result, the portion of $\bar{S}$ above $\bar{p}$ has the same slope as S^d. At prices less than or equal to $\bar{p}$, the same quantity is supplied with and without the quota, so $\bar{S}$ is the same as S. At prices above $\bar{p}$, less is supplied with the quota than without one, so $\bar{S}$ is steeper than S, indicating that a given increase in price raises the quantity supplied by less with a quota than without one.



3.1 The statement "Talk is cheap because supply exceeds demand" makes sense if we interpret it to mean that the quantity supplied of talk exceeds the quantity demanded at a price of zero. Imagine a downward-sloping demand curve that hits the horizontal, quantity, axis to the left of where the upward-sloping supply curve hits the axis. (The correct aphorism is "Talk is cheap until you hire a lawyer.")

3.2 The equilibrium price is that price where quantity demanded equals quantity supplied:

$$110 - 20p = 20 + 10p$$

$$90 = 30p$$

$$p = 3.$$

The equilibrium price is $p = 3$. Substitute this into either the demand or supply equation to find the equilibrium quantity. For example, substituting into the demand equation,

$$Q = 110 - 20p$$

$$Q = 110 - 20(3)$$

$$Q = 110 - 60$$

$$Q = 50 \text{ units}.$$

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3.3 Equating the right sides of the supply and demand functions and using algebra, we find:

$$0.75\ \ln(p) = 2.4 + 0.15\ \ln(p_t)$$

$$\ln(p) = 3.2 + 0.2\ \ln(p_t).$$

We then set $p_t = 110$, and solve for $\ln(p)$:

$$\ln(p) = 3.2 + 0.2(4.7),$$

and exponentiate $\ln(p)$ to obtain the equilibrium price:

$$p \approx \$62.80/\text{ton}.$$

Substituting p into the supply curve, we determine the equilibrium quantity:

$$Q \approx 11.91 \text{ million short tons/year}.$$

3.4 Set quantity demanded equal to quantity supplied:

$$171 - 20p + 20p_b + 3p_c + 2Y = 178 + 40p - 60p_h$$

Solving for p yields:

$$p = -\frac{7}{60} + \frac{1}{3}p_b + \frac{1}{20}p_c + \frac{1}{30}Y + p_h$$

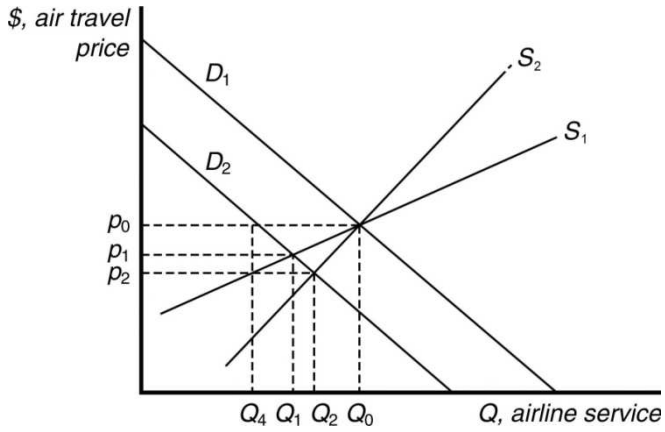
Solving for q yields:

$$q = \frac{520}{3} + \frac{40}{3}p_b + 2p_c + \frac{4}{3}Y - 20p_h$$

Inserting prices of other goods yields P=\$3.30 and Q = 220.

4.1 The supply shock is unusually good luck, or an unexpected increase in the number of lobsters in the ocean. The supply curve shifts to the rights, and thus the price falls.

4.2 The demand curve shifts to the left from D_1 to D_2 by 30 percent, which is the distance between Q_0 and Q_4. For supply curve S_1, the price drops from p_0 to p_1, a change of less than 30 percent. For a steeper supply curve S_2, the price decreases to p_2, a larger decrease, yet still smaller than 30 percent. Accordingly, the equilibrium quantity changes less than 30 percent as well.



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4.3 The increased use of corn for producing ethanol will shift the demand curve for corn to the right. This increases the price of corn overall, reducing the consumption of corn as food.

4.4 The equilibrium price is that price where quantity demanded equals quantity supplied:

$$220 - 2p = 20 + 3p - 20r$$
$$200 + 20r = 5p$$
$$p = 40 + 4r.$$

The effect of a change in r on the equilibrium price is

$$\frac{\partial p}{\partial r} = 4.$$

The equilibrium price is $p = 40 + 4r$. Substitute this into either the demand or supply equation to find the equilibrium quantity. For example, substituting into the demand equation,

$$Q = 220 - 2p$$
$$Q = 220 - 2(40 + 4r)$$
$$Q = 220 - 80 - 8r$$
$$Q = 140 - 8r.$$

The effect of a change in r on the equilibrium quantity is

$$\frac{\partial Q}{\partial r} = -8.$$

4.5 a. The inverse demand function is: $P = 1000 - Q + \frac{Y}{20}$, then the demand function is:

$$Q = 1000 - P + \frac{Y}{20}$$

The inverse supply function is: $P = \frac{Q}{2} + \frac{Y}{40}$, then the supply function is:

$$Q = 2P - \frac{Y}{20}$$

Setting the quantity demanded equal the quantity supplied, we have:

$$1000 - P + \frac{Y}{20} = 2P - \frac{Y}{20} \quad \Rightarrow \quad P^* = \frac{1000}{3} + \frac{Y}{30} \quad \Rightarrow \quad Q^* = 2P^* - \frac{Y}{20} = \frac{2000}{3} + \frac{Y}{60}$$

Therefore the equilibrium price and quantity in terms of Y are:

$$\begin{cases} P^* = \frac{1000}{3} + \frac{Y}{30} \\ Q^* = \frac{2000}{3} + \frac{Y}{60} \end{cases}$$

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b. $\frac{dP^*}{dY} = \frac{1}{30} > 0$, therefore a decrease in median income leads to a decrease in the equilibrium rental price.

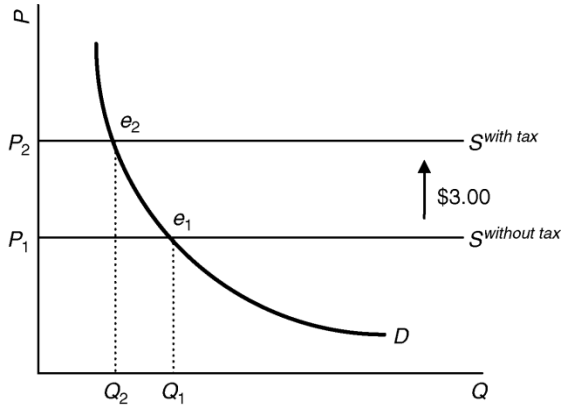
4.6 a. The demand function is $Q = 20{,}000P^{-0.42}$, and the inverse supply function is: $P = 1.5P_w$; therefore, the equilibrium price and quantity are:

$$P^* = 1.5\ P_w$$

$$Q^* = 20{,}000\ (1.5\ P_w)^{-0.4} = 16{,}868.3P^{-0.42}$$

Therefore, $\frac{dQ^*}{dP_w} = 16{,}868.3\ (-0.42)\ P^{-1.4} = -7084.69\text{P}^{-1.42}$

b. As shown in the figure, the total \$3.00 specific tax shifts up the supply curve by \$3.00. Therefore the tax increases equilibrium retail price by \$3.00 and decreases equilibrium retail quantity from Q_1 to Q_2, where:



Math: Suppose the total specific tax is $\tau = 3.00$.

Because equilibrium retail price $P = 1.5P_w + \tau$, then $\frac{\partial P}{\partial \tau} = 1 > 0$, which implies that the specific tax increases equilibrium retail price.

Because equilibrium retail quantity $Q = 2000 \cdot (1.5P_w + \tau)^{-0.42}$, then:

$$\frac{\partial Q}{\partial \tau} = 2000 \cdot (-0.42) \cdot (1.5P_w + \tau)^{-1.42} < 0,$$

which implies that the specific tax decreases equilibrium retail quantity.

c. With the specific tax in place, the equilibrium price and quantity of cigarettes are:

$$\begin{cases} P^* = 1.5P_w + \tau \\ Q^* = 2000 \cdot (1.5P_w + \tau)^{-0.42}. \end{cases}$$

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Then we have:

$$\frac{\partial Q^*}{\partial P_w} = 2000 \cdot (-0.42) \cdot 1.5 \cdot (1.5P_w + \tau)^{-1.42} = -1260 \cdot (1.5P_w + \tau)^{-1.42}.$$

Therefore:

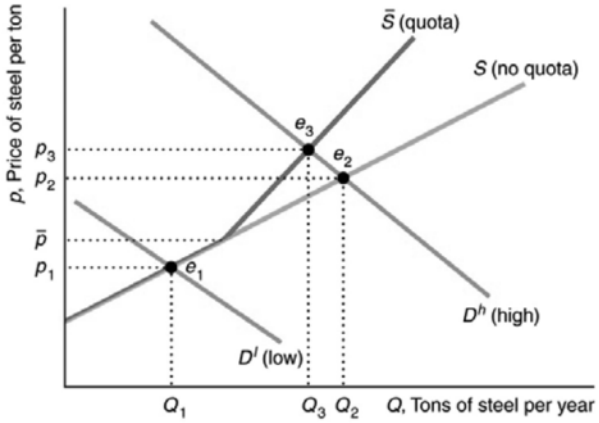
$$\begin{aligned}\frac{\partial(\frac{\partial Q^*}{\partial P_w})}{\partial \tau} &= \frac{\partial(-1260 \cdot (1.5P_w + \tau)^{-1.42})}{\partial \tau} \\ &= -1260 \cdot (-1.42) \cdot (1.5P_w + \tau)^{-2.42} \\ &= 1789.2 \cdot (1.5P_w + \tau)^{-2.42}.\end{aligned}$$

Because the total specific tax is $\tau = 3.00$, then:

$$\frac{\partial(\frac{\partial Q^*}{\partial P_w})}{\partial \tau} = 1789.2 \cdot (1.5P_w + 3)^{-2.42} > 0,$$

which implies that the change in the wholesale price will have a less negative effect on the equilibrium quantity if the tax rate increases.

4.7 The following figure reproduces the no-quota total American supply curve of steel, S, and the total supply curve under the quota, $\bar{S}$, which we derived in the answer to the previous question. At a price below $\bar{p}$, the two supply curves are identical because the quota is not binding: It is greater than the quantity foreign firms want to supply. Above $\bar{p}$, $\bar{S}$ lies to the left of S. Suppose that the American demand is relatively *low* at any given price so that the demand curve, D^l, intersects both the supply curves at a price below $\bar{p}$. The equilibria both before and after the quota is imposed are at e_1, where the equilibrium price, p_1, is less than $\bar{p}$. Thus if the demand curve lies near enough to the origin that the quota is not binding, the quota has no effect on the equilibrium. With a relatively *high* demand curve, D^h, the quota affects the equilibrium. The no-quota equilibrium is e_2, where D^h intersects the no-quota total supply curve, S. After the quota is imposed, the equilibrium is e_3, where D^h intersects the total supply curve with the quota, $\bar{S}$. The quota raises the price of steel in the United States from p_2 to p_3 and reduces the quantity from Q_2 to Q_3.



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4.8 The equilibrium wage is that wage where demand equals supply:

$$100 - w = 10 + 2w - T$$

$$90 + T = 3w$$

$$w = 30 + 0.333\text{T}.$$

The effect of a change in T on the equilibrium wage is

$$\frac{\partial w}{\partial T} = 0.333.$$

The equilibrium wage is $w = 30 + 0.333T$. Substitute this into either the demand or supply equation to find the equilibrium quantity. For example, substituting into the demand equation,

$$Q = 100 - w$$

$$Q = 100 - (30 + 0.333T)$$

$$Q = 70 - 0.333T.$$

The effect of a change in T on the equilibrium quantity is

$$\frac{\partial Q}{\partial T} = -0.333.$$

5.1 The demand elasticity is $-2.65/21 = -0.13$ for prenatal smokers.

5.2 The price elasticity of demand is the percentage change in the quantity demanded, Q, in response to a given percentage change in price, p, at a particular point on the demand curve:

$$\varepsilon = \frac{\partial Q}{\partial p}\frac{p}{Q}.$$

a. Differentiating the first demand curve with respect to p,

$$\frac{\partial Q}{\partial p} = -2.$$

Substituting this into the elasticity definition with $p = 10$ and $Q = 20$,

$$\varepsilon = -2 \times (0.5)$$

$$\varepsilon = -1.$$

b. Differentiating the second demand curve with respect to p,

$$\frac{\delta Q}{\delta p} = -20p^{-3}$$

Substituting this into the elasticity definition with $p = 10$ and $Q = 20$,

$$\varepsilon = -.01$$

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5.3 To find the point at which the curves intersect, set the two demand curves equal to each other.

$$1.4p^{-2} = 1.4p^{-3.7}$$

Thus p = \$1, and q = 1.4 million apps.

The price elasticity of demand is the percentage change in the quantity demanded, Q, in response to a change in price.

$$\varepsilon = \frac{\partial Q}{\partial p}\frac{p}{Q}.$$

Differentiating the demand curve for Apple with respect to p,

$$\frac{\partial Q_A}{\partial p} = -2.8p^{-3}$$

Substituting this into the elasticity definition,

$$\varepsilon = -2.8p^{-3}\frac{p}{Q_A}$$

Next, substituting $1.4p^{-2}$ into the elasticity equation,

$$\varepsilon = -2.8p^{-3}\frac{p}{1.4p^{-2}}$$

$$\varepsilon_A = -2$$

Similarly, $\varepsilon_P = -3.7$.

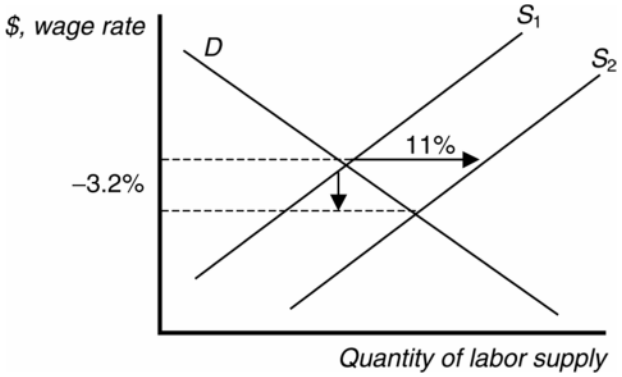
Because the elasticity of demand for both small firms and large firms is constant along the demand curves, the elasticity of demand for small firms and the elasticity of demand for large firms is the same regardless of where they intersect each other.

5.4 The expected percentage price change will be equal to the percentage change in quantity divided by the price elasticity. 10.4/(–0.626) = –16.61. The increase in supply would cause the price of beef to fall by 16.61 percent. Any other price change is likely a result of a change in demand.

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5.5 The numbers suggest that labor demand is inelastic. The supply curve shifts to the right by 11 percent, yet the decrease in equilibrium wage is only 3.2 percent.



5.6 Price elasticity is the percentage change in quantity divided by the percentage change in price. $\varepsilon = -8.3/21 = -0.395$. An elasticity coefficient less than 1 indicates an inelastic demand.

5.7 Suppose Q is the number of insured and ΔQ is the change in the number of insured. An increase in the number of uninsured is the same as a decrease in the number of insured. Therefore, an increase in the number of uninsured by 300,000 can be denoted by $\Delta Q = -300{,}000$; i.e., number of insured has decreased by 300,000. Now we know:

$$\varepsilon = \Delta Q\%/\Delta P\% = (\Delta Q/Q)/(\Delta P/P)$$

and that

$$\Delta P/P = 0.01.$$

When

$$Q = 200{,}000{,}000,$$

we have:

$$\begin{aligned}\varepsilon &= (\Delta Q/Q)/(\Delta P/P)\\ &= (-300{,}000/200{,}000{,}000)/0.01\\ &= -0.15.\end{aligned}$$

When $Q = 220{,}000{,}000$, we have:

$$\begin{aligned}\varepsilon &= (\Delta Q/Q)/(\Delta P/P)\\ &= (-300{,}000/220{,}000{,}000)/0.01\\ &= -0.1364.\end{aligned}$$

This shows that the price elasticity depends on the number of people who are insured.

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5.8 The elasticity of demand is $(dQ/dp)(p/Q)$ = (–9.5 thousand metric tons per year per cent) × (45 cents/1275 thousand metric tons per year) ≈ –0.34. That is, for every 1 percent fall in the price, a third of a percent more coconut oil is demanded. The cross-price elasticity of demand for coconut oil with respect to the price of palm oil is $(dQ/dP_p)(P_p/Q) = 16.2 \times (31/1275) \approx 0.39$.

5.9 The price elasticity of supply is the percentage change in the quantity supplied, Q, in response to a given percentage change in price, p, at a particular point on the supply curve:

$$\eta = \frac{\partial Q}{\partial p}\frac{p}{Q}.$$

Let supply be linear: $Q = a + bp$. Differentiating the supply curve with respect to p,

$$\frac{\partial Q}{\partial p} = b.$$

Substituting this into the elasticity definition,

$$\eta = b\left(\frac{p}{Q}\right).$$

When supply intersects the price axis, $Q = 0$ and η approaches infinity in its limit (as it approaches the price axis). When supply intersects the quantity axis, $p = 0$ and $\eta = 0$.

5.10 The demand curve is $Q = 117.52 - 0.392p$. The supply curve without ANWR production is $Q = 70.48 + 0.392p$. The supply curve with ANWR is $Q = 71.28 + 0.392p$.

Thus before any shocks, the equilibrium price is $58.98 with ANWR and $60 without ANWR, as in the Solved Problem.

The shock will change the supply function to $Q = 46.48 + 0.392p$. The supply curve with ANWR is $Q = 47.28 + 0.392$p.

If supply is not augmented by ANWR-oil, price will rise to $90.61. With the additional 0.8 million gallons from ANWR, the post oil-shock price will be $89.59. Drilling in the ANWR hardly provides much of a price buffer.

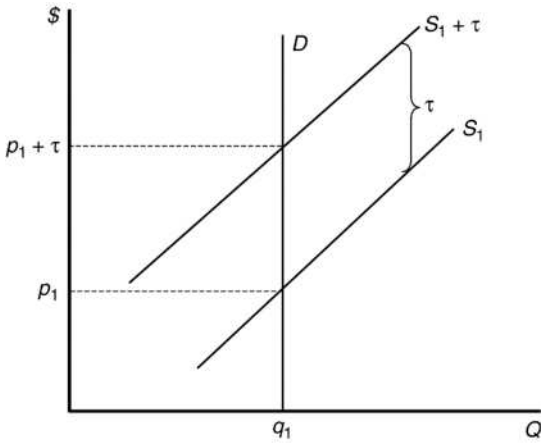
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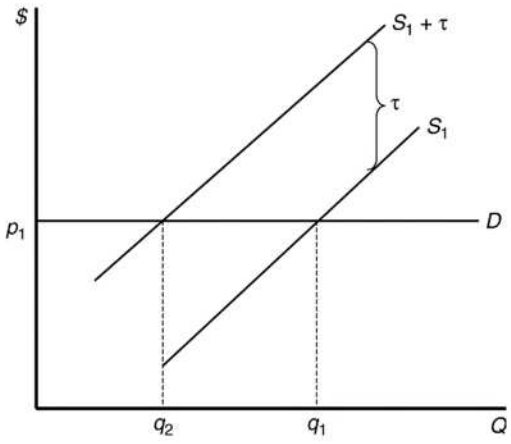
6.1 Use the following equation to solve for the change in price.

$$\frac{dP}{d\tau} = \frac{\eta}{\eta - \varepsilon}.$$

a. If demand is perfectly inelastic, the demand curve is vertical. The supply curve shifts up by \$1, and all of the incidence falls on consumers. Price increases by \$1, and there is no change in quantity. Since $\varepsilon = 0$, $dP/d\tau = 1$.



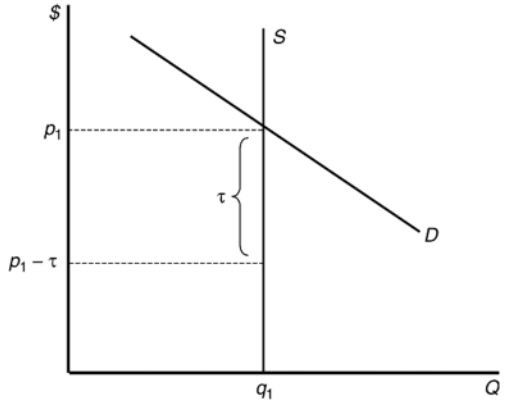
b. The demand curve is horizontal when perfectly elastic. The supply curve shifts up by \$1. Price paid by consumers remains at p (the pre-tax level). Price received by sellers is $p - \tau$ (the price less the tax). Quantity falls to the intersection of the new supply curve and the original demand curve. Suppliers absorb the entire burden of the tax because consumers have no willingness to pay higher prices. Since $\varepsilon \to -\infty$, $dP/d\tau = 0$.



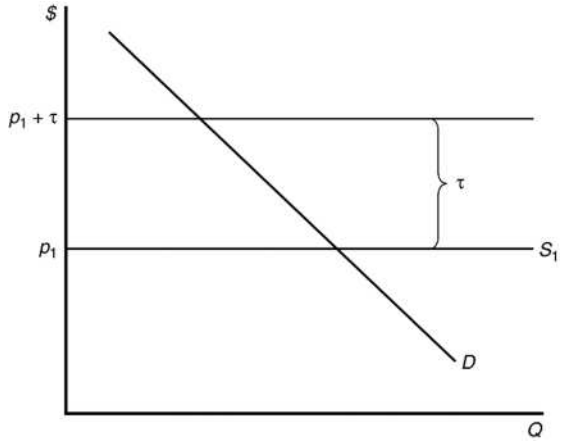
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c. When supply is perfectly inelastic, the supply curve is vertical. Thus, shifting the supply curve upward would have no effect on the equilibrium quantity or price paid by consumers. Sellers would bear the entire burden of the tax. Since $\eta = 0$, $dP/d\tau = 0$.



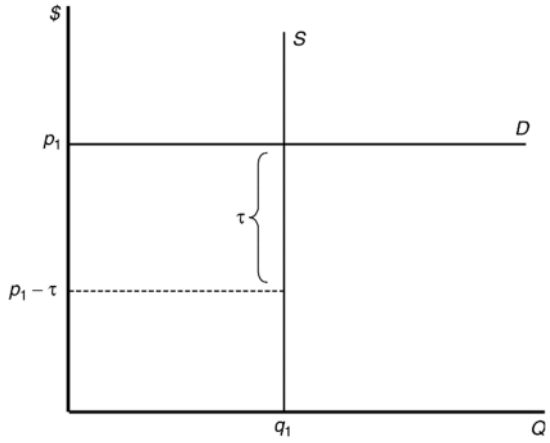
d. When supply is perfectly elastic, the supply curve is horizontal. The supply curve shifts up by \$1 increasing price by \$1. The quantity falls and the incidence falls entirely on the consumer because $\eta \to \infty$, $dP/d\tau = 1$.



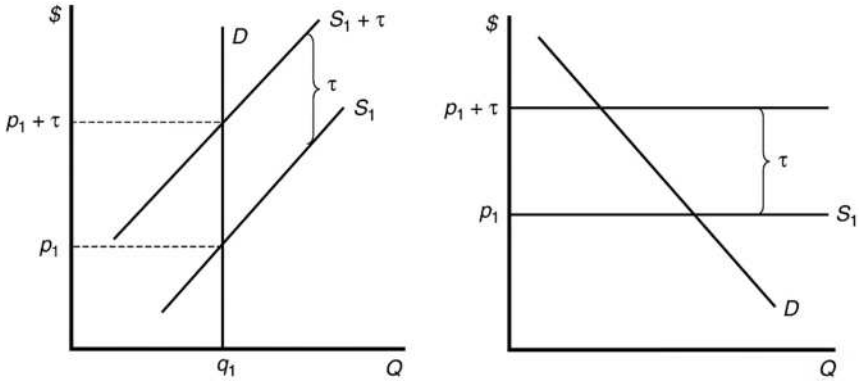
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e. If the demand curve is perfectly elastic (horizontal), and the supply curve is perfectly inelastic (vertical), the effect of a tax would be no change in equilibrium quantity and no change in price paid by consumers, and sellers would bear the entire burden of the tax because $\varepsilon \to -\infty$ and $\eta = 0$, $dP/d\tau = 0$.



6.2 When the supply curve is upward sloping and the demand curve is vertical (perfectly inelastic demand), or when the demand is downward sloping and the supply curve is horizontal (perfectly elastic supply) the firms can pass the tax burden completely to the consumers.



6.3 The incidence of a tax on consumers is the share of the tax that falls on consumers. The incidence that falls on consumers is

$$\frac{dp}{d\tau},$$

where τ is the tax. For small changes, this is approximately equal to

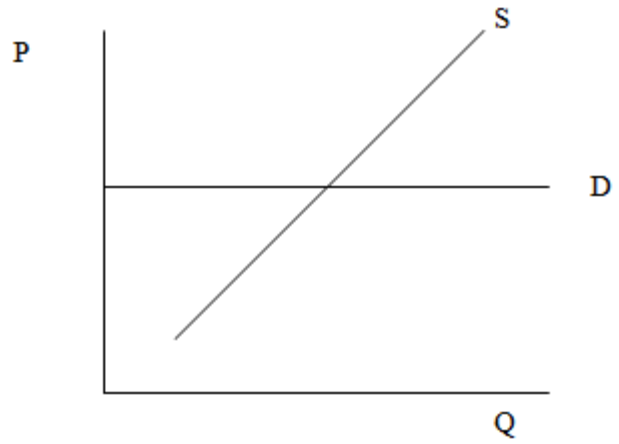
$$\frac{dp}{d\tau} = \frac{\eta}{\eta - \varepsilon},$$

where ε is the elasticity of demand and η is the elasticity of supply.

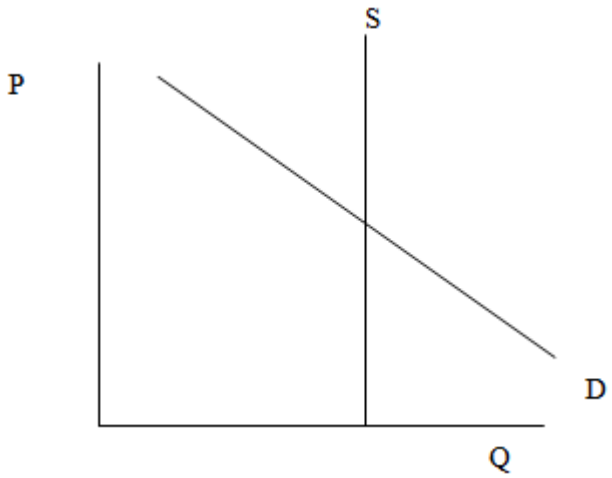
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If the pass-through of a tax is 0 percent, then the incidence of the tax on consumers is 0. Assuming the supply curve is upward sloping, the incidence of the tax on consumers will equal zero as ε approaches infinity (when demand is infinitely elastic or horizontal).



Assuming the demand curve is downward sloping, the incidence of the tax on consumers will equal zero when η equals zero (when supply is perfectly inelastic or vertical).



In both cases, a tax on consumers will shift the demand curve downward (or the demand curve will pivot downward, if the tax is an *ad valorem* tax), lowering the market price by an amount equal to the size of the tax paid by consumers.

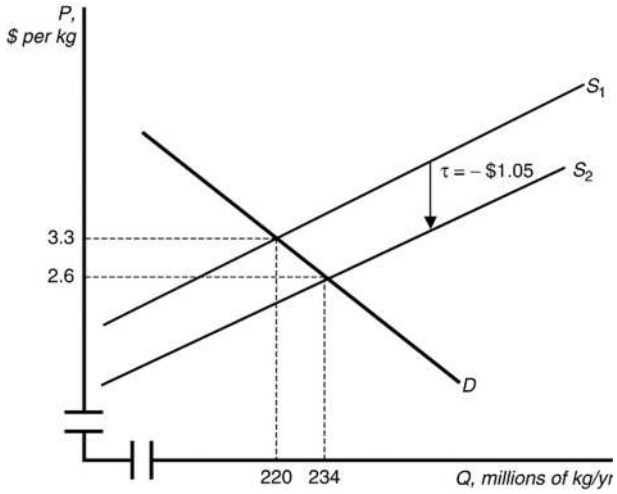
6.4 We showed that, in a competitive market, the effect of a specific tax is the same whether it is placed on suppliers or demanders. Thus if the market for milk is competitive, consumers will pay the same price in equilibrium regardless of whether the government taxes consumers or stores.

6.5 Tax incidence for almonds: $12/(12 + 0.47) = 0.96$; for cotton, $0.73/(0.73 + 0.68) = 0.52$; for processing tomatoes, $0.64/(0.64 + 0.26) = 0.71$.

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6.6 A subsidy is essentially a negative tax. The supply curve shifts down by the amount of the tax and the new equilibrium is determined by $286 - 20P = 88 + 40\,(p + 1.05)$. The new equilibrium occurs at a price of \$2.60 and a quantity of 234. Consumers receive \$0.70 of the \$1.05 subsidy.



6.7 a. A government subsidy paid to employers will shift the labor demand curve up by an amount equal to the size of the subsidy. The new equilibrium will be at a higher wage with more workers.

b. A reduction in the government subsidy paid to employers will shift the labor demand curve down by an amount equal to the decrease in the size of the subsidy. The new equilibrium will be at a lower wage with fewer workers (compared to the equilibrium with the original subsidy).

c. The incidence of a subsidy on employers is the share of the subsidy that employers realize in the form of lower wages. The incidence of the subsidy on workers is the share of the subsidy that employees realize in the form of higher wages. If the elasticity of demand for workers is ε and the elasticity of supply for workers is η, then the incidence of the subsidy for workers is

$$\frac{dw}{ds} = \frac{-\varepsilon}{\eta - \varepsilon}.$$

6.8 Differentiating quantity, $Q(p(\tau))$, with respect to τ, we learn that the change in quantity as the tax changes is $(dQ/dp)(dp/d\tau)$. Multiplying and dividing this expression by p/Q, we find that the change in quantity as the tax changes is $\varepsilon(Q/p)(dp/d\tau)$. Thus the closer ε is to zero, the less the quantity falls, all else the same.

Because $R = p(\tau)Q(p(\tau))$, an increase in the tax rate changes revenues by

$$\frac{dR}{d\tau} = \frac{dp}{d\tau}Q + p\frac{dQ}{dp}\frac{dp}{d\tau},$$

using the chain rule. Using algebra, we can rewrite this expression as

$$\frac{dR}{d\tau} = \frac{dp}{d\tau}\left(Q + p\frac{dQ}{dp}\right) = \frac{dp}{d\tau}Q\left(1 + \frac{dQ}{dp}\frac{p}{Q}\right) = \frac{dp}{d\tau}Q\left(1 + \varepsilon\right).$$

Thus the effect of a change in τ on R depends on the elasticity of demand, ε. Revenue rises with the tax, given an inelastic demand ($0 > \varepsilon > -1$), and falls with an elastic demand, $\varepsilon < -1$.

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6.9 The reduction in the quantity of alcohol consumed depends on both the elasticity of supply and the elasticity of demand. The more *inelastic* the demand curve, the less that the quantity demanded will fall. The more *inelastic* the supply curve, the less that the price increase due to the tax will be passed on to consumers, all other things equal. Thus, we can consider the two polar cases: first, if demand is perfectly inelastic, consumption will not fall, no matter what the tax increase. Likewise, if supply is perfectly inelastic, the tax will not be passed on to the consumers. We know that the more inelastic group will pay the most of the tax, but for consumption to actually fall, both demand and supply must be relatively elastic.

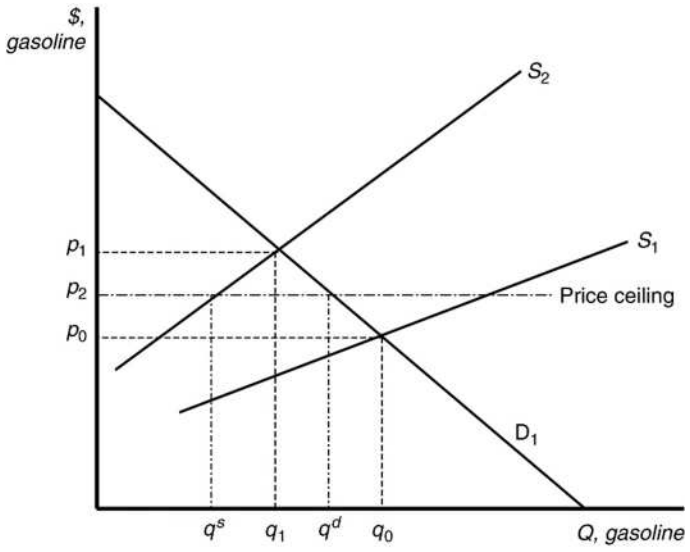
6.10 a. Demand is $Q = 12 - (p + t)$, and supply is $Q = 9 + 0.5(p + t)$. Setting quantity supplied equal to quantity demanded gives:

$$P = 1.5 + \frac{1}{3}t$$

$$Q = 10 - \frac{1}{3}t$$

b. Substituting into the equations above, the new price is \$2.25, and the new quantity is 9.75. Prior to the tax, the equilibrium price was \$2, and the equilibrium quantity was 10. Thus, consumers pay 0.25 of each 0.75 tax, or 1/3 of the tax.

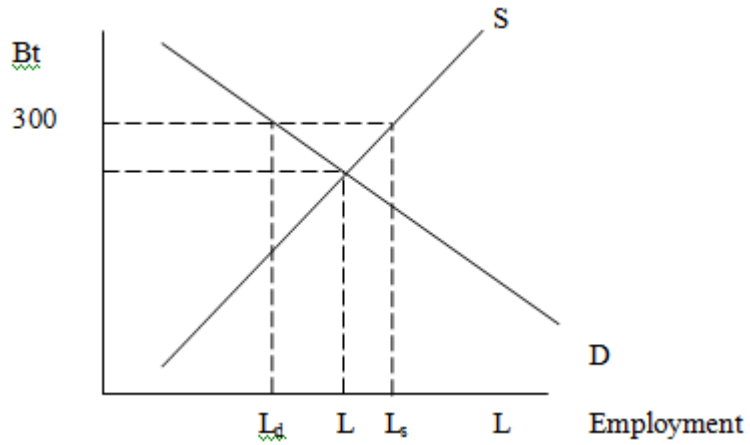
7.1 In the absence of price controls, the leftward shift of the supply curve as a result of Hurricane Katrina would push market prices up from p_0 to p_1 and reduce quantity from q_0 to q_1. At a government-imposed maximum price of p_2, consumers would want to purchase q^d units, but producers would only be willing to sell q^s units. The resulting shortage would impose search costs on consumers making them worse off. The reduced quantity and price also reduced firms' profits.



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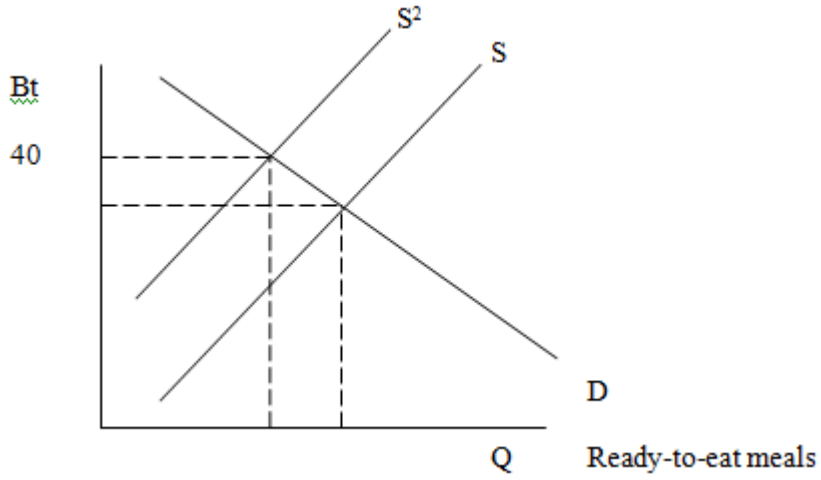
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7.2 a. The minimum wage raises the wage above the equilibrium level. This reduces the quantity of labor demanded (where the Bt300 minimum wage intersects the labor demand curve) and increases the quantity of labor supplied (where the Bt300 minimum wage intersects the labor supply curve).



Unemployment equals excess labor. That is, unemployment equals the quantity of labor supplied minus the quantity of labor demanded: $L_s - L_d$.

b. The minimum wage shifts the supply curve up, as production costs increase, until the point where the demand curve intersects the new supply curve is at a price of Bt40 for ready-to-eat meals.



c. The price controls lower the price of meals below the equilibrium level. This increases the quantity demanded (where the maximum price with the price controls intersects the demand curve) and decreases the quantity supplied (where the maximum price intersects the supply curve).

d. As the price of meals demanded decreases, owners of restaurants will demand fewer workers, shifting the labor demand curve to the left.

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7.3 The interest rate is the price of loanable funds. As with the case of rent controls, the imposition of a binding price ceiling causes a shortage. That is, $q^d > q^s$. The amount of funds actually lent will be q^s which is less than the equilibrium amount that we see in markets without price ceilings.

7.4 We can determine how the total wage payment, $W = wL(w)$, varies with respect to w by differentiating. We then use algebra to express this result in terms of an elasticity:

$$\frac{dW}{dw} = L + w\frac{dL}{dw} = L\left(1 + \frac{dL}{dw}\frac{w}{L}\right) = L(1+\varepsilon),$$

where ε is the elasticity of demand of labor. The sign of dW/dw is the same as that of $1 + \varepsilon$. Thus total labor payment decreases as the minimum wage forces up the wage if labor demand is elastic, $\varepsilon < -1$, and increases if labor demand is inelastic, $\varepsilon > -1$.

8.1 The supply-and-demand model is useful for making predictions in perfectly competitive markets. That is, the supply-and-demand model is applicable in markets in which everyone is a price taker, firms sell identical products, everyone has full information about the price and quantity of goods, and the costs of trading are low.

Markets in which the supply-and-demand model has proved useful include agriculture, finance, labor, construction, services, wholesale, and retail—markets with many firms and consumers and where firms sell identical products.

a. The market for apples is a competitive, agricultural market.

b. The market with convenience stores is a competitive, retail market.

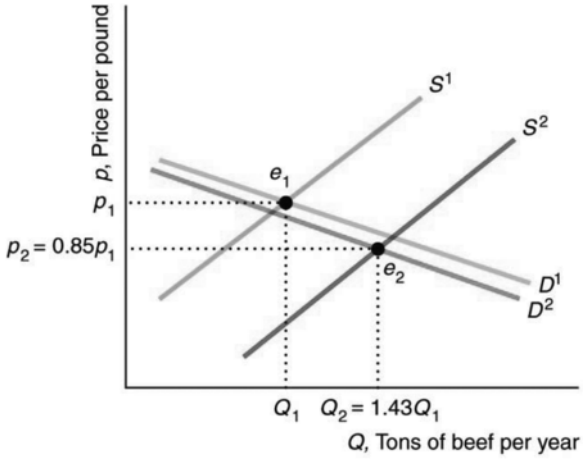
c. & d. The supply-and-demand model is not appropriate in markets in which there are only one or a few sellers (such as electricity), firms produce differentiated products (such as music CDs), consumers know less than sellers about quality or price (such as used cars), or there are high transaction costs (such as nuclear turbine engines). Electronic games are differentiated products supplied by three dominant firms.

9.1 If the supply curve were vertical (perfectly inelastic) with a downward-sloping demand curve or if the demand curve were vertical with an upward-sloping supply curve, then the change in the equilibrium quantity would not depend on the sizes of the shifts. In the first instance (where the supply curve is vertical), the equilibrium quantity would increase, and in the second case, the equilibrium quantity would decrease. Similarly, if the supply curve were horizontal (infinitely elastic) with a downward-sloping demand curve or if the demand curve were horizontal with an upward-sloping supply curve, then the change in the equilibrium quantity would not depend on the sizes of the shifts. In the first case (with a horizontal supply curve), the equilibrium quantity would decrease; in the second instance, the equilibrium quantity would increase.

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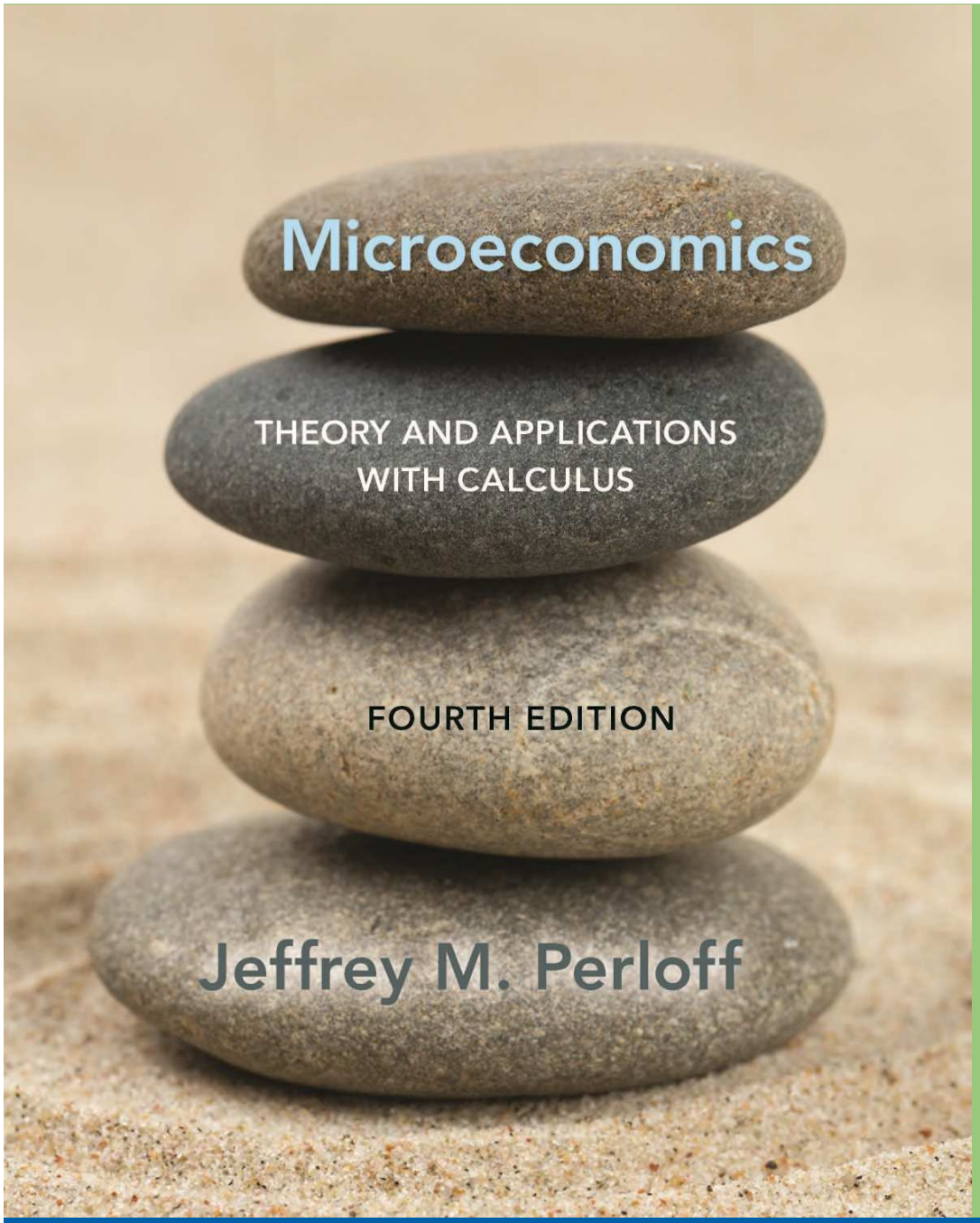
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9.2 Shifts of both the U.S. supply and the U.S. demand curves affected the U.S. equilibrium. U.S. beef consumers' fear of mad cow disease caused their demand curve (shown in the figure) to shift slightly to the left from D^1 to D^2. In the short run, total U.S. production was essentially unchanged. Because of the ban on exports, beef that would have been sold in Japan and elsewhere was sold in the United States, causing the U.S. supply curve to shift to the right from S^1 to S^2. As a result, the U.S. equilibrium changed from e_1 (where S^1 intersects D^1) to e_2 (where S^2 intersects D^2). The U.S. price fell 15 percent from p_1 to $p_2 = 0.85p_1$, while the quantity rose 43 percent from Q_1 to $Q_2 = 1.43Q_1$. *Comment*: Depending on exactly how the U.S. supply and demand curves had shifted, it would have been possible for the U.S. price and quantity to have both fallen. For example, if D^2 had shifted far enough left, it could have intersected S^2 to the left of Q_1, and the equilibrium quantity would have fallen.



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Chapter 2

Supply and Demand

Talk is cheap because supply exceeds demand.

ALWAYS LEARNING

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Chapter 2 Outline

Challenge:	Quantities and Prices of Genetically Modified Foods
2.1	Demand
2.2	Supply
2.3	Market Equilibrium
2.4	Shocking the Equilibrium: Comparative Statistics
2.5	Elasticities
2.6	Effects of a Sales Tax
2.7	Quantity Supplied Need Not Equal Quantity Demanded
2.8	When to Use the Supply-and-Demand Model
	Challenge Solution

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Challenge: Quantities and Prices of Genetically Modified Foods

- Background:
  - The decision whether to permit firms to grow and sell genetically modified (GM) foods affects the supply and demand for food.
- Questions:
  - Will the use of GM seeds lead to lower prices and more food sold?
  - What happens to prices and quantities sold if consumers refuse to buy GM crops?

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2.1 Demand

- The ***demand function*** for a good or service describes the mathematical correspondence between quantity demanded for the good or service, its price, the prices of substitute and complementary products, consumers' income, and other factors that influence demand.

- Example: The quantity demanded for coffee, Q, varies with the price of coffee, p, the price of sugar, p_s, and consumers' income, Y, so that coffee demand, D, is

$$Q = D(p, p_s, Y)$$

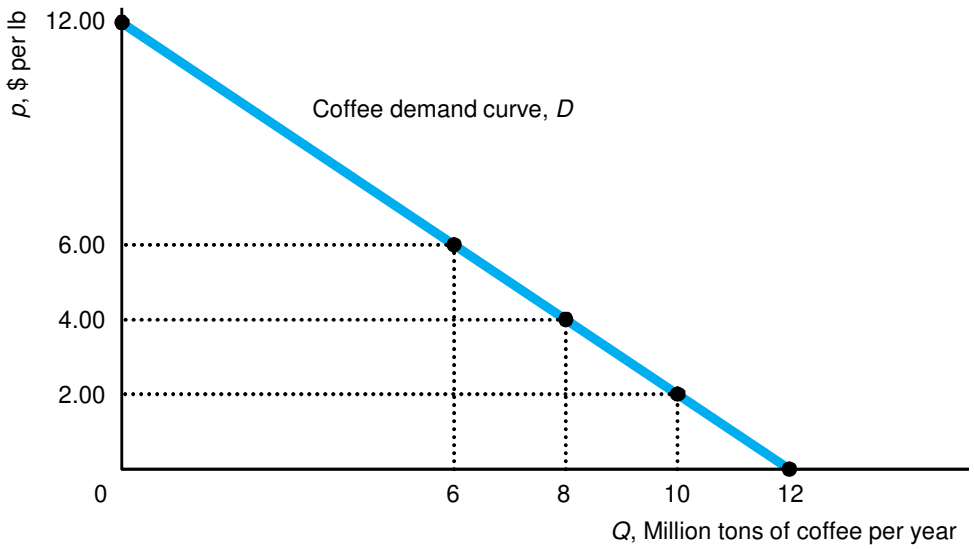
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2.1 Demand Example: Coffee

Assumptions about p_s
Y to simplify equation

- p_b = \$0.20/lb
- Y = \$35 thousand

$$\begin{aligned} Q &= 8.56 - p - 0.3p_s + 0.1Y \\ &= 8.56 - p - (0.3 \times 0.2) + (0.1 \times 35) \\ &= 12 - p. \end{aligned}$$



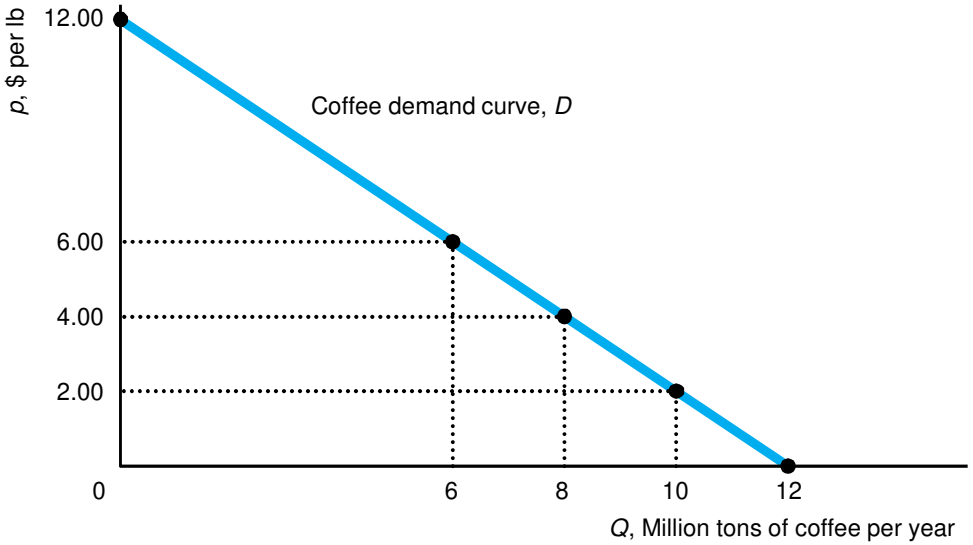
$$\frac{dQ}{dp} = -1 \Longrightarrow \text{slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta p}{\Delta Q} = \frac{\$1 \text{ per lb}}{-1 \text{ million tons per year}} = -\$1 \text{ per million tons per year}..$$

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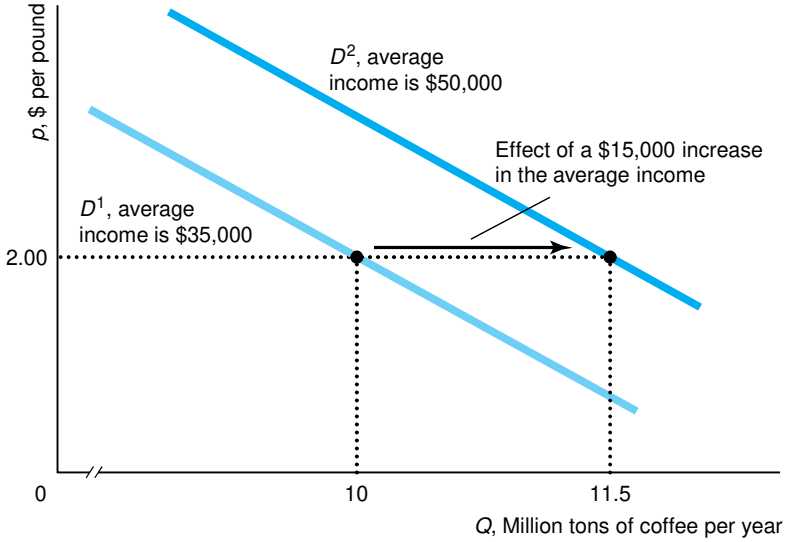
2.1 Demand Example: Coffee

- Changing the own-price of coffee simply moves us along an existing demand curve.

$$Q = 12 - p$$



- Changing one of the things held constant (e.g. p_c, and Y) shifts the entire demand curve.
- p_b ↑ to \$50,000

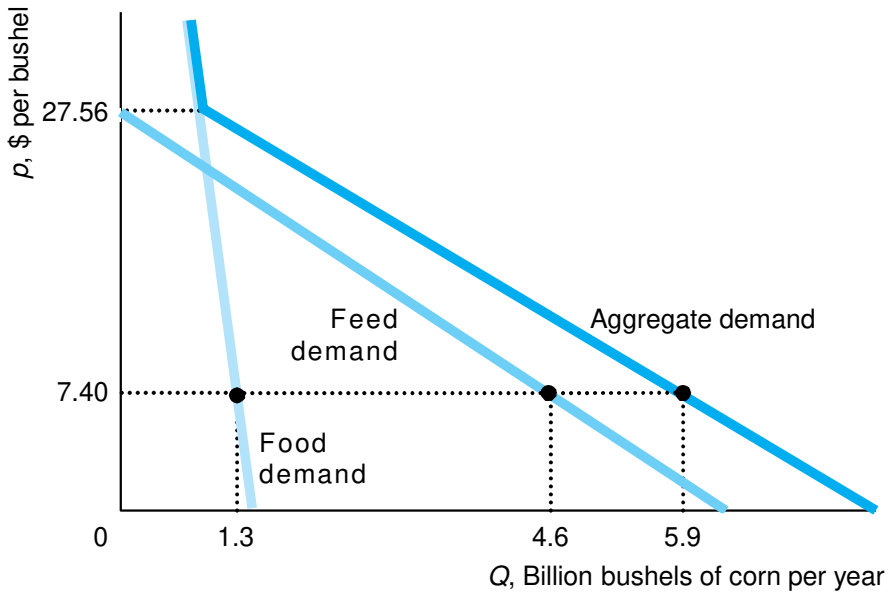


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2.1 Aggregating Demand Curves

Sum individual demand curves to get an aggregated demand

- At each price, add the quantities of the individual demand curves



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2.2 Supply

- The quantity of a good or service that firms supply depends on price and other factors such as the cost of inputs that firms use to produce the good or service.
- The ***supply function*** describes the mathematical relationship between quantity supplied (Q), price (p) and other factors that influence the number of units offered for sale:

$$Q = S(p, p_c)$$

  - p = price of coffee in dollars per lb
  - p_c = price of cocoa in dollars per lb

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2.2 Supply

- We often work with a linear supply function.
- Example: estimated supply function for coffee

$$Q = 9.6 + 0.5p - 0.2p_c$$

  - Q = quantity of coffee supplied (lbs per year)
  - p = price of coffee (in dollars per lb)
  - p_c = price of cocoa, an input (in dollars per lb)

- Graphically, we can only depict the relationship between Q and p, so we hold the other factors constant.

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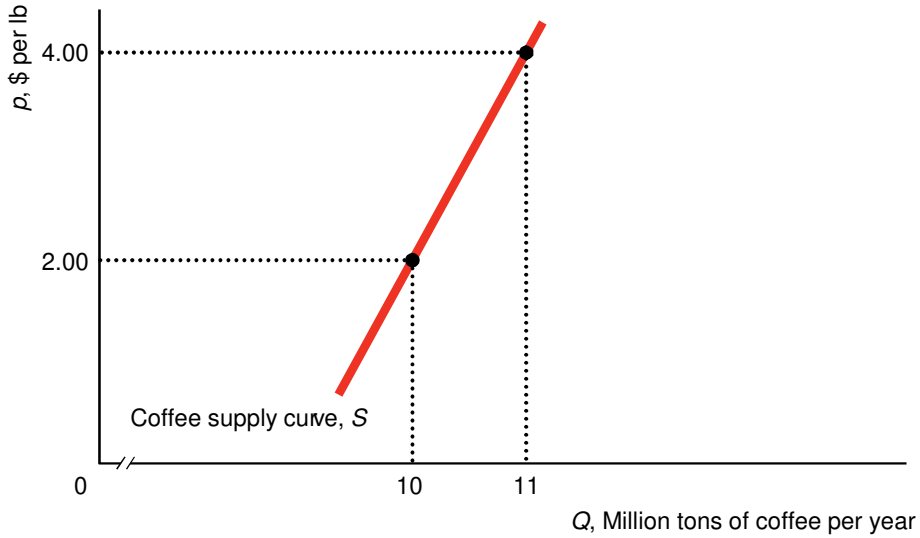
2.2 Supply Example: Coffee

- Assumption about p_c to simplify equation
- p_c = \$3/lb

$$Q = 9.6 + 0.5p - 0.2p_c$$

$$\downarrow$$

$$Q = 9.0 + 0.5p$$

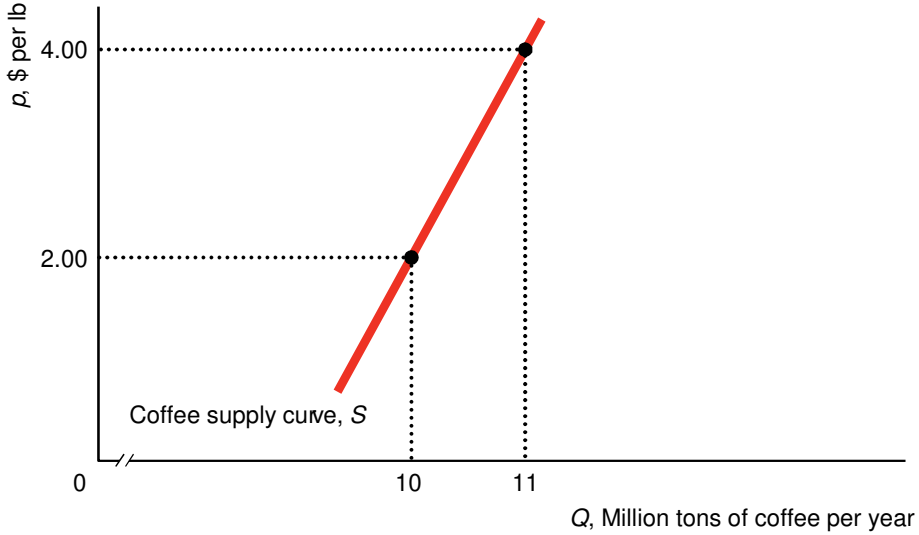


$$\frac{dQ_s}{dp} = 0.5 \Longrightarrow \frac{dp}{dQ_s} = 2 = slope$$

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2.2 Supply Example: Coffee

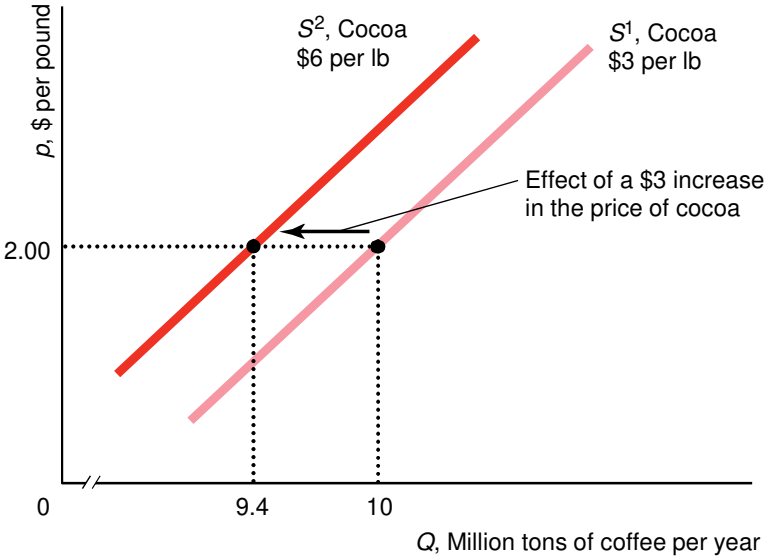
- Changing the own-price of coffee simply moves us along an existing supply curve.



- Changing p_c shifts the entire supply curve.

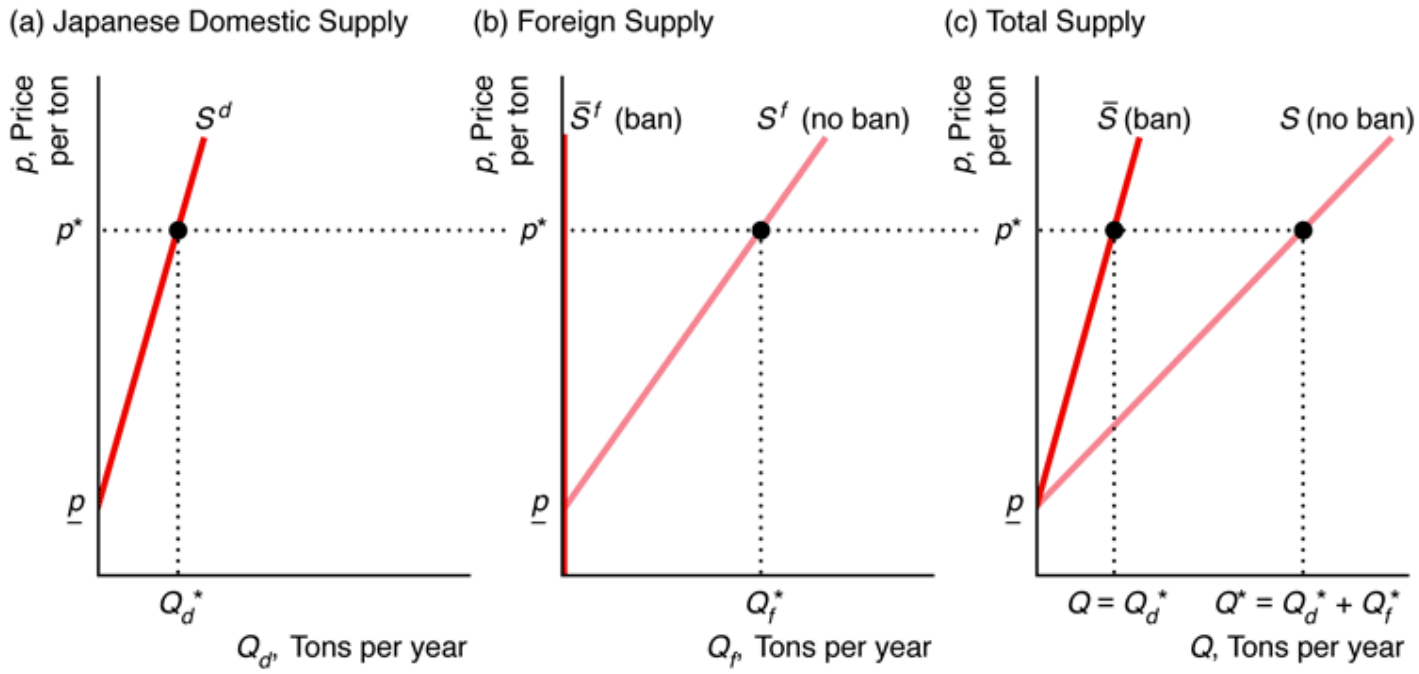
p_c ↑ to \$6/lb

$$Q = 8.4 + 0.5p$$



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2.2 Summing Supply Functions Example: Domestic and Foreign Supply of Rice



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2.3 Market Equilibrium

- The interaction between consumers' demand curve and firms' supply curve determines the market price and quantity of a good or service that is bought and sold.
- Mathematically, we find the price that equates the quantity demanded, Q_d, and the quantity supplied, Q_s:
  - Given $Q_D = 12 - p$ and $Q_S = 9 + 0.5p$, find p such that $Q_d = Q_s$:

$p = \$2.00$ ⇒

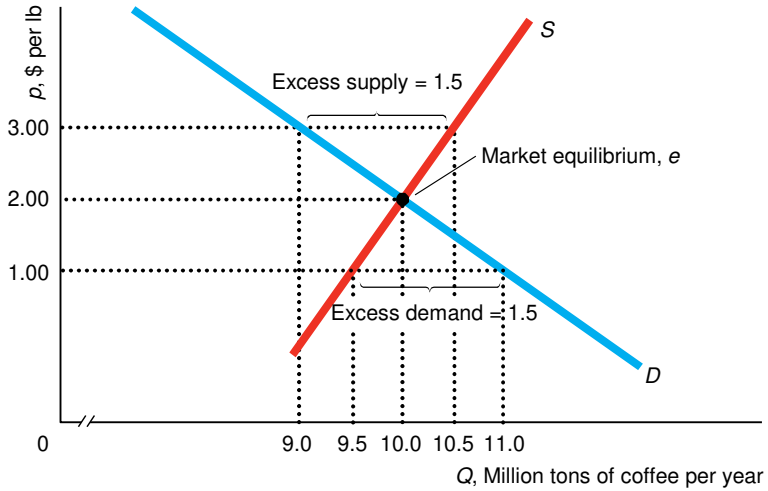
$$Q_d = Q_s$$
$$12 - 2 = 9 + (0.5 \times 2)$$
$$10 = 10.$$

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2.3 Market Equilibrium

- Graphically, market equilibrium occurs where the demand and supply curves intersect.
  - At any other price, excess supply or excess demand results.
  - Natural market forces push toward equilibrium Q and p.



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Stephanie Lindsey, 5/6/2013

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2.4 Shocking the Equilibrium: Comparative Statics

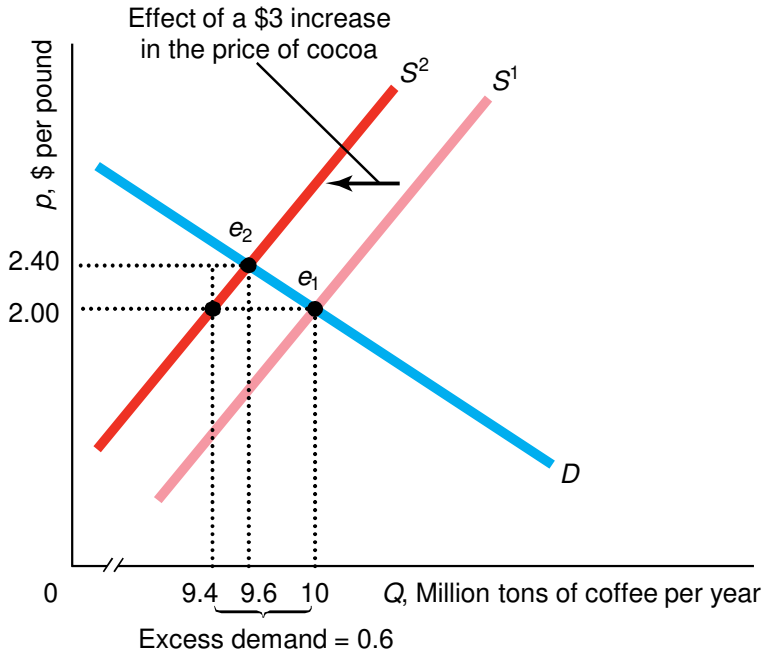
- Changes in a factor that affects demand, supply, or a new government policy alters the market price and quantity of a good or service.
- Changes in demand and supply factors can be analyzed graphically and/or mathematically.
  - Graphical analysis should be familiar from your introductory microeconomics course.
  - Mathematical analysis simply utilizes demand and supply functions to solve for a new market equilibrium.
- Changes in demand and supply factors can be large or small.
  - Small changes are analyzed with calculus.

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2.4 Shocking the Equilibrium: Comparative Statics with Discrete (Relatively Large) Changes

- Graphically analyzing the effect of an increase in the price of cocoa
  - When an input gets more expensive, producers supply less coffee at every price.



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2.4 Shocking the Equilibrium: Comparative Statics with Discrete (Relatively Large) Changes

- Mathematically analyzing the effect of an increase in the price of sugar $Q_S = 8.4 + 0.5p$
  - If p_s increases by \$3.00, new p_s = \$6.00 and

$$Q_S = Q_D$$
$$8.4 + 0.5p = 12 - p \quad \Longrightarrow \quad Q_S = Q_D = 9.6$$
$$p = \$2.40$$

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2.4 Shocking the Equilibrium: Comparative Statics with Small Changes

- Demand and supply functions are written as general functions of the price of the good, holding all else constant: $Q = D(p)$
- Supply is also a function of some exogenous (not in firms' control) variable, *a*: $Q = S(p, a)$
- Because the intersection of demand and supply determines the price, *p*, we can write the price as an implicit function of the supply-shifter, *a*:

$$Q = D(p(a)) \quad Q = S\big(p(a), a\big)$$

- In equilibrium: $D(p(a)) = S(p(a), a)$

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2.4 Shocking the Equilibrium: Comparative Statics with Small Changes

- Given the equilibrium condition $D(p(a)) = S(p(a), a)$, we differentiate with respect to *a* using the chain rule to determine how equilibrium is affected by a small change in *a*:

$$\frac{\mathrm{d}D\big(p(a)\big)}{\mathrm{d}p}\frac{\mathrm{d}p}{\mathrm{d}a} = \frac{\partial S\big(p(a), a\big)}{\partial p}\frac{\mathrm{d}p}{\mathrm{d}a} + \frac{\partial S\big(p(a), a\big)}{\partial a}$$

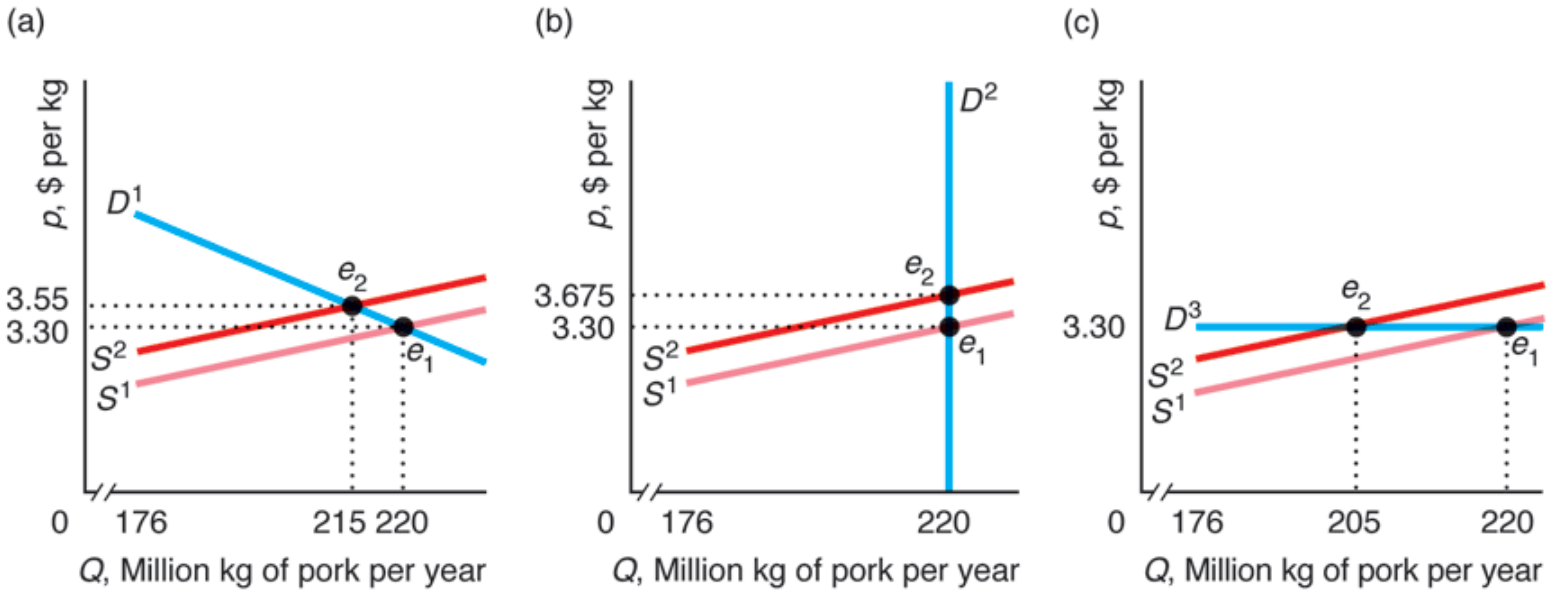
- Rearranging:

$$\frac{\mathrm{d}p}{\mathrm{d}a} = \frac{\dfrac{\partial S}{\partial a}}{\dfrac{\mathrm{d}D}{\mathrm{d}p} - \dfrac{\partial S}{\partial p}}$$

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2.5 Elasticities

- The shape of demand and supply curves influence how much shifts in demand or supply affect market equilibrium.
  - Shape is best summarized by elasticity.



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2.5 Elasticities

- Elasticity indicates how responsive one variable is to a change in another variable.
- The price elasticity of demand measures how sensitive the quantity demanded of a good, Q_d, is to changes in the price of that good, p.

$$\varepsilon = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in price}} = \frac{\Delta Q / Q}{\Delta p / p} = \frac{\partial Q}{\partial p} \frac{p}{Q}$$

- If $Q_d = a - bp$, then $\varepsilon = \frac{dQ}{dp} \frac{p}{Q} = -b \frac{p}{Q}$ and elasticity can be evaluated at any point on the demand curve.

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2.5 Example: Elasticity of Demand

- Previous corn demand was $Q = 15.6 - 0.5p$
- Calculating price elasticity of demand at equilibrium (p=\$7.20 and Q=12):

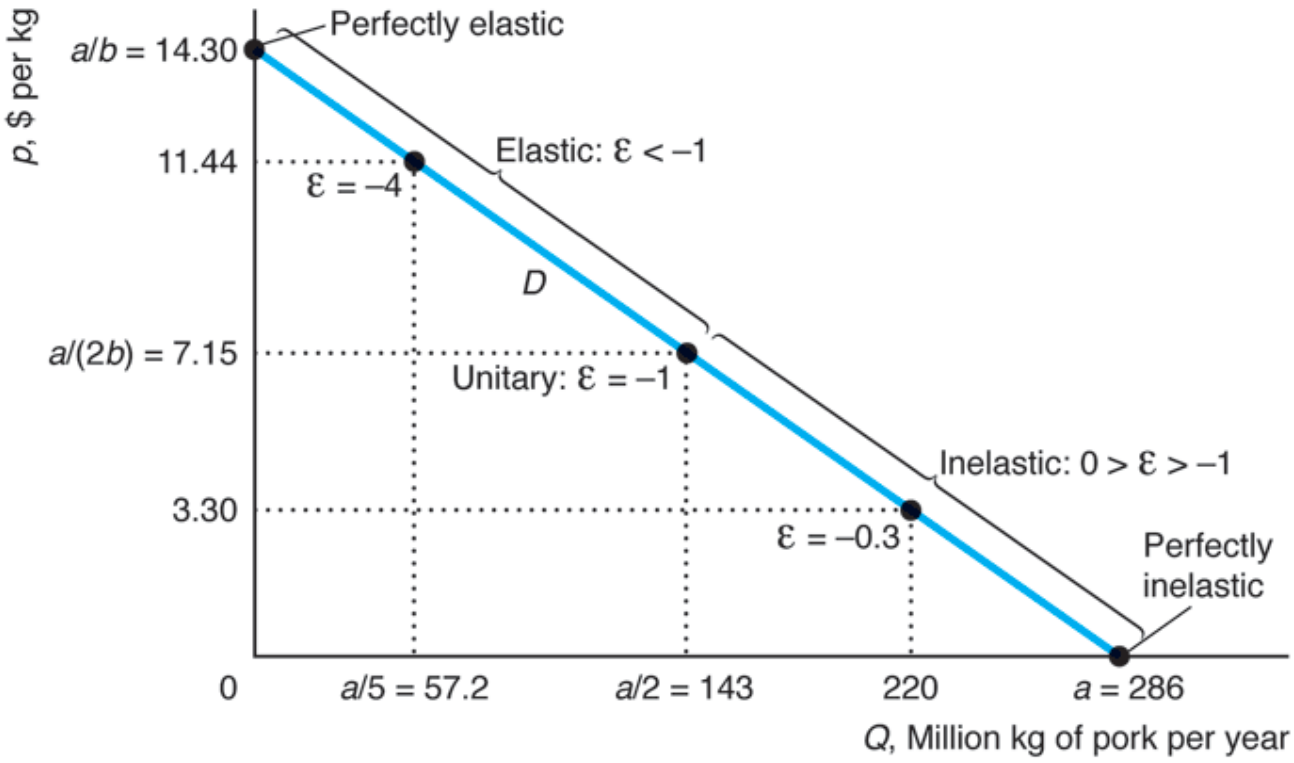
$$\varepsilon = -b\frac{p}{Q} = -0.5 \times \frac{7.20}{12} = -0.3.$$

- Interpretation:
  - negative sign consistent with downward-sloping demand
  - a 1% increase in the price of corn leads to a 0.3% decrease in quantity of corn demanded

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2.5 Demand Elasticity

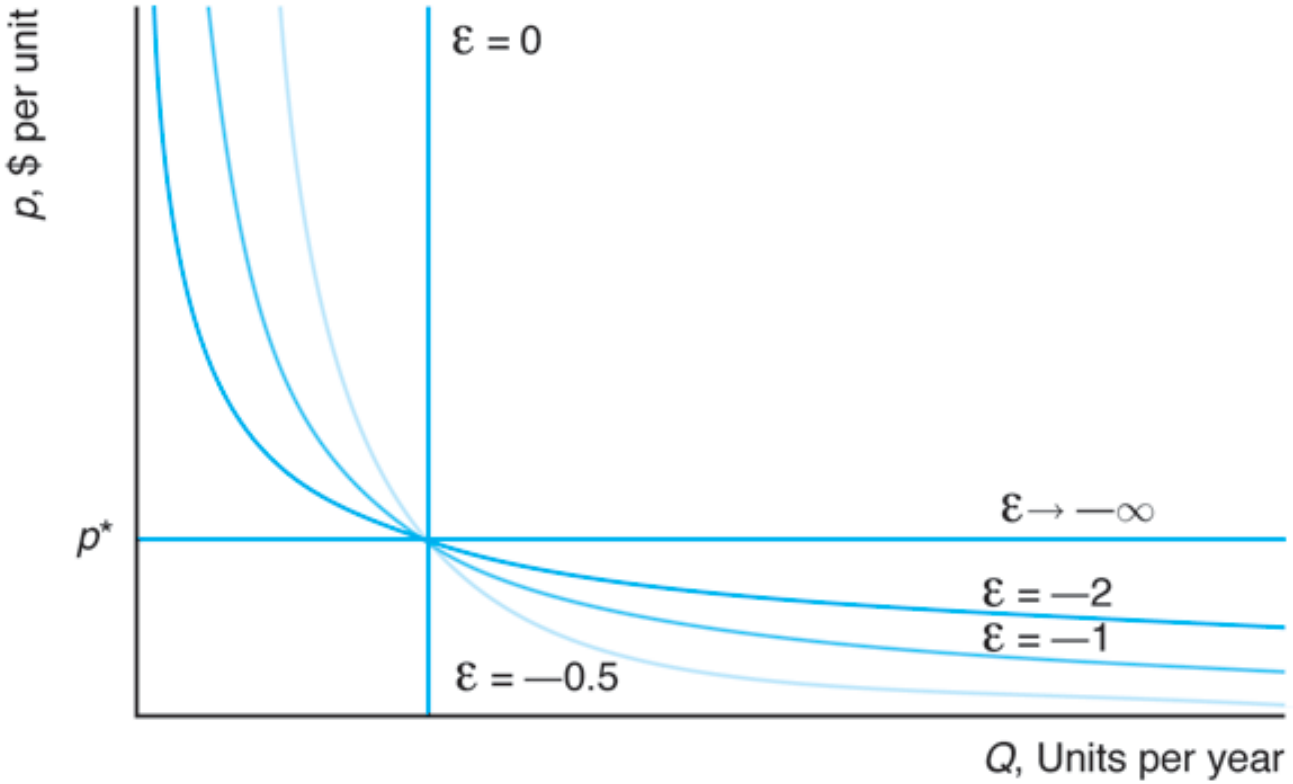
- Elasticity of demand varies along a linear demand curve



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2.5 Demand Elasticity

- On a given supply curve, elasticity of demand remains constant



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2.5 Elasticities

- There are other common elasticities that are used to gauge responsiveness.
  - income elasticity of demand

$$\xi = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in income}} = \frac{\Delta Q / Q}{\Delta Y / Y} = \frac{\partial Q}{\partial Y}\frac{Y}{Q}$$

  - cross-price elasticity of demand

$$\frac{\text{percentage change in quantity demanded}}{\text{percentage change in price of another good}} = \frac{\Delta Q / Q}{\Delta p_o / p_o} = \frac{\partial Q}{\partial p_o}\frac{p_o}{Q}$$

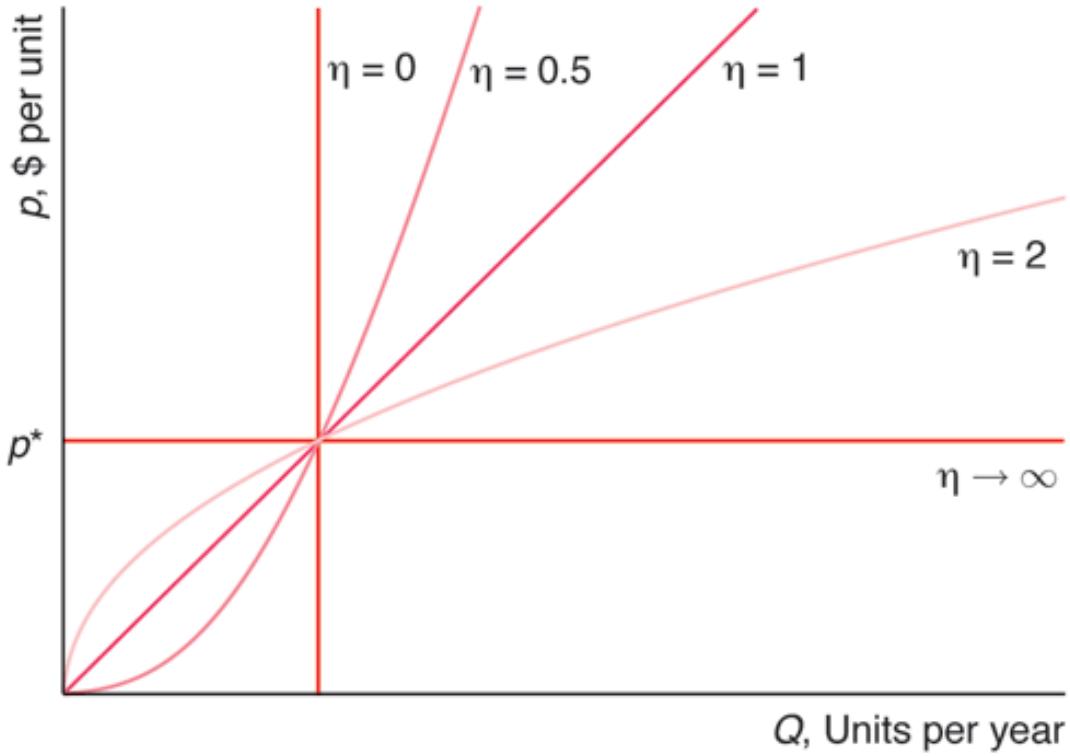
  - elasticity of supply

$$\eta = \frac{\text{percentage change in quantity supplied}}{\text{percentage change in price}} = \frac{\Delta Q / Q}{\Delta p / p} = \frac{\partial Q}{\partial p}\frac{p}{Q}$$

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2.5 Constant Elasticity of Supply Curve

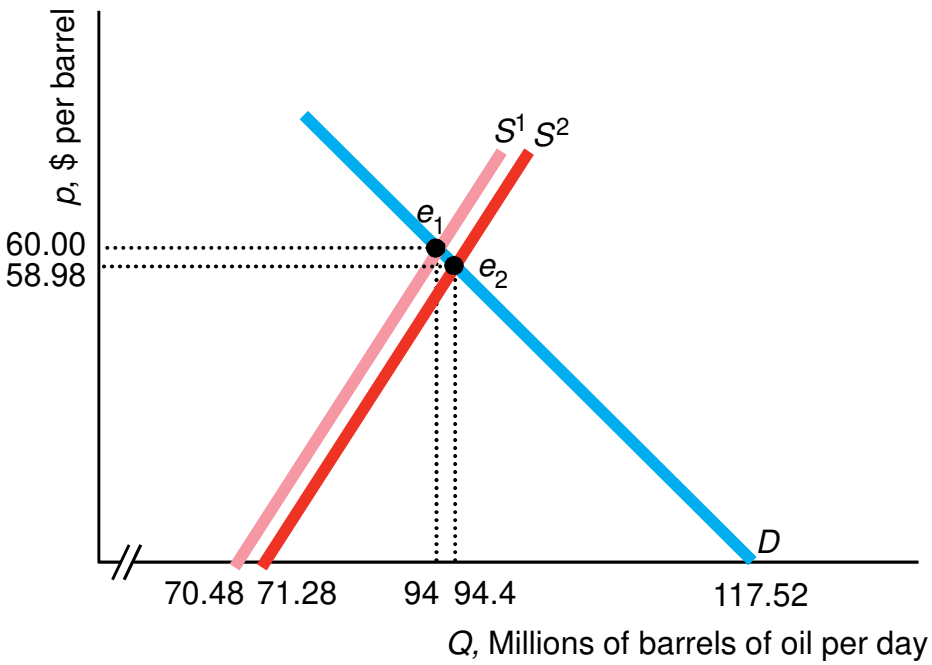
- On a given supply curve, elasticity of supply is constant.



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2.5 MyEconLab Solved Problem

- What would be the effect of Arctic National Wildlife Refuge production on the world equilibrium price of oil?
- An increase in supply results in a decrease in the equilibrium price and an increase in the equilibrium quantity.



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2.6 Effects of a Sales Tax

- Two types of sales taxes:
  - ***Ad valorem tax*** is in percentage terms
    - California's state tax rate is 8.25%, so a $100 purchase generates $8.25 in tax revenue
  - ***Specific (or unit) tax*** is in dollar terms
    - U.S. gasoline tax is $0.18 per gallon
  - Ad valorem taxes are much more common.

- The effect of a sales tax on equilibrium price and quantity depends on elasticities of demand and supply.

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2.6 Important Questions About Tax Effects

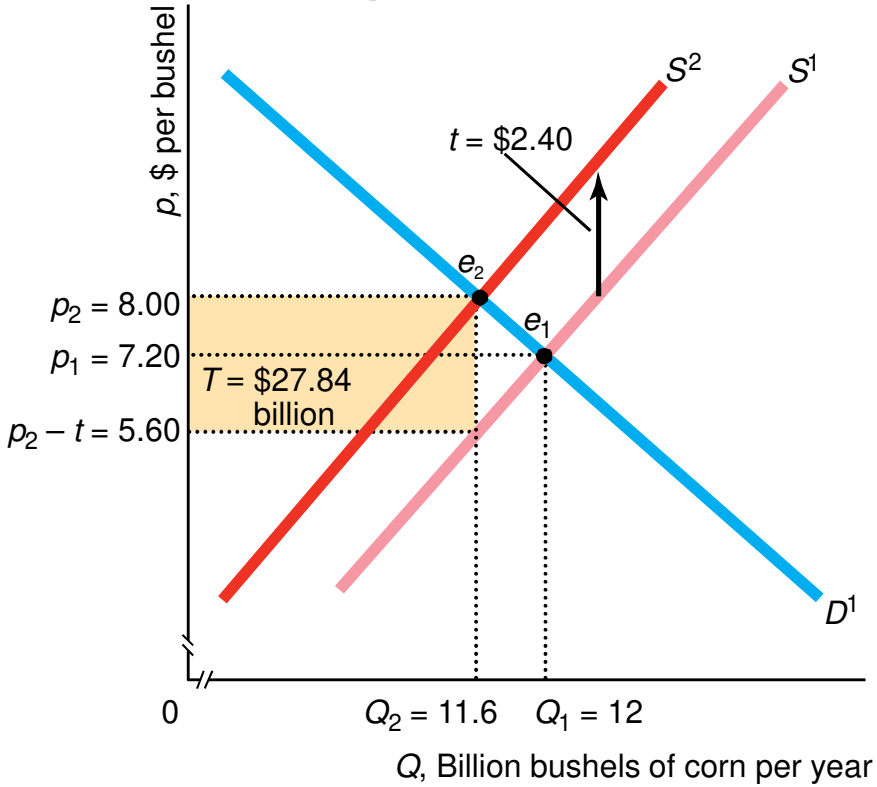
- Does it matter whether the tax is collected from producers or consumers?
  - Tax incidence is not sensitive to *who* is actually taxed.
  - A tax collected from producers shifts the supply curve back.
  - A tax collected from consumers shifts the demand curve back.
  - Under either scenario, a tax-sized wedge opens up between demand and supply and the incidence analysis is identical.
- Does it matter whether the tax is a unit tax or an ad valorem tax?
  - If the ad valorem tax rate is chosen to match the per unit tax divided by equilibrium price, the effects are the same.

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2.6 Equilibrium Effects of a Specific Tax Collected from Producers

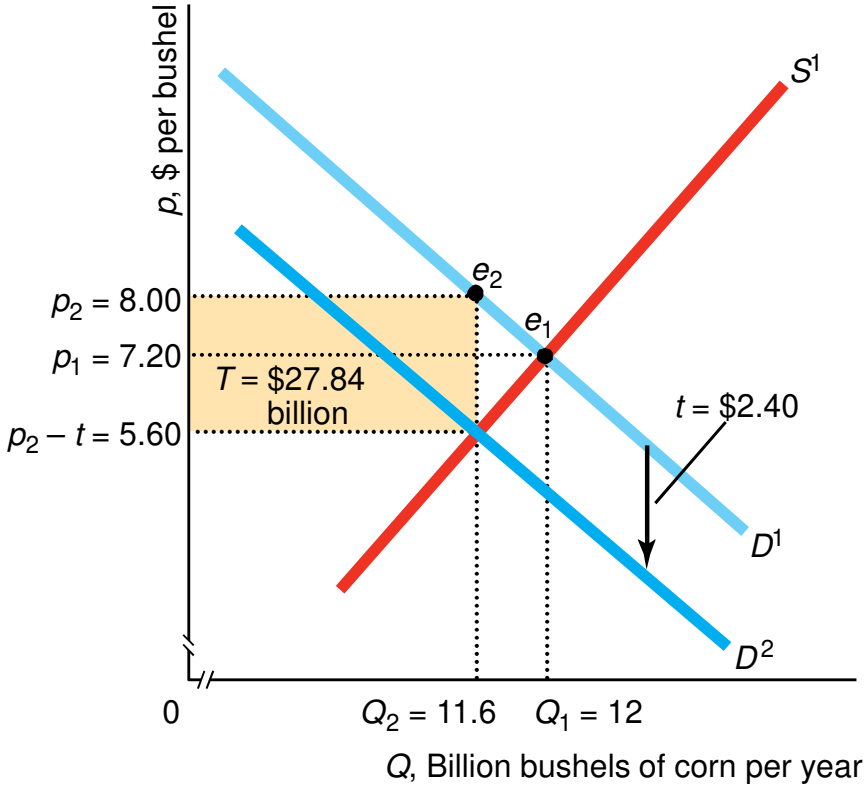
- Consider the effect of a $2.40 per unit (specific) sales tax on the corn market that is collected from corn producers.



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2.6 Equilibrium Effects of a Specific Tax Collected from Consumers

- Consider the effect of a $2.40 per unit (specific) sales tax on the corn market that is collected from corn consumers.



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2.6 How Specific Tax Effects Depend on Elasticities

- If a unit tax, τ, is collected from producers, the price received by producers is reduced by this amount and our equilibrium condition becomes:

$$D(p(\tau) = S(p(\tau) - \tau)$$

- Differentiating with respect to τ:

$$\frac{dD}{dp}\frac{dp}{d\tau} = \frac{dS}{dp}\frac{d\left(p(\tau) - \tau\right)}{d\tau} = \frac{dS}{dp}\left(\frac{dp}{d\tau} - 1\right)$$

- Rearranging indicates how the tax changes the price consumers pay:

$$\frac{dp}{d\tau} = \frac{\dfrac{dS}{dp}}{\dfrac{dS}{dp} - \dfrac{dD}{dp}}$$

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2.6 How Specific Tax Effects Depend on Elasticities

- The equation $\frac{dp}{d\tau} = \frac{\frac{dS}{dp}}{\frac{dS}{dp} - \frac{dD}{dp}}$ can be expressed in terms of elasticities by multiplying through by p/Q:

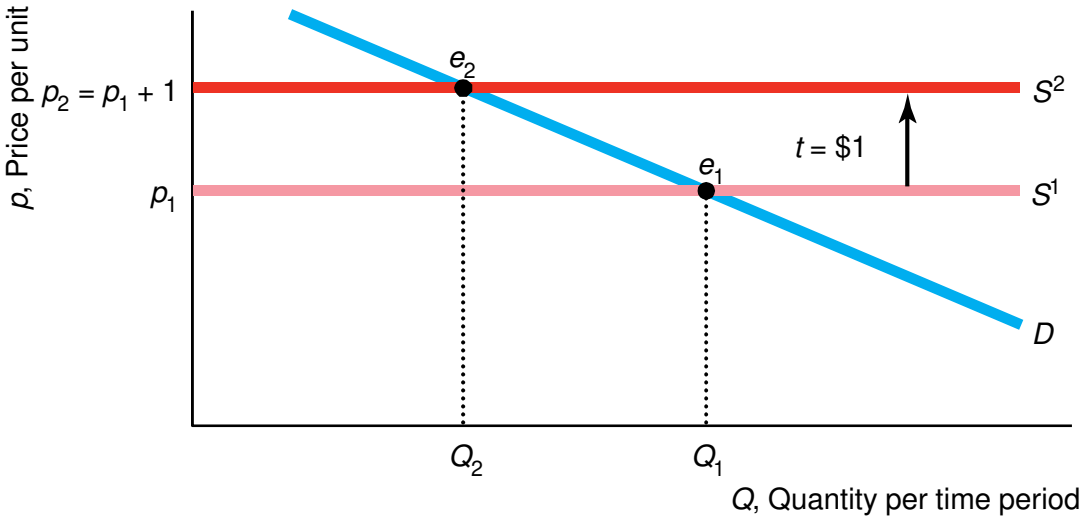
$$\frac{dp}{d\tau} = \frac{\frac{dS}{dp}\frac{p}{Q}}{\frac{dS}{dp}\frac{p}{Q} - \frac{dD}{dp}\frac{p}{Q}} = \frac{\eta}{\eta - \varepsilon}$$

- *Tax incidence on consumers*, the amount by which the price to consumers rises as a fraction of the amount of the tax, is now easy to calculate given elasticities of demand and supply.
- *Tax incidence on firms*, the amount by which the price paid to firms rises, is simply $1 - dp/d\tau$

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2.5 MyEconLab Solved Problem

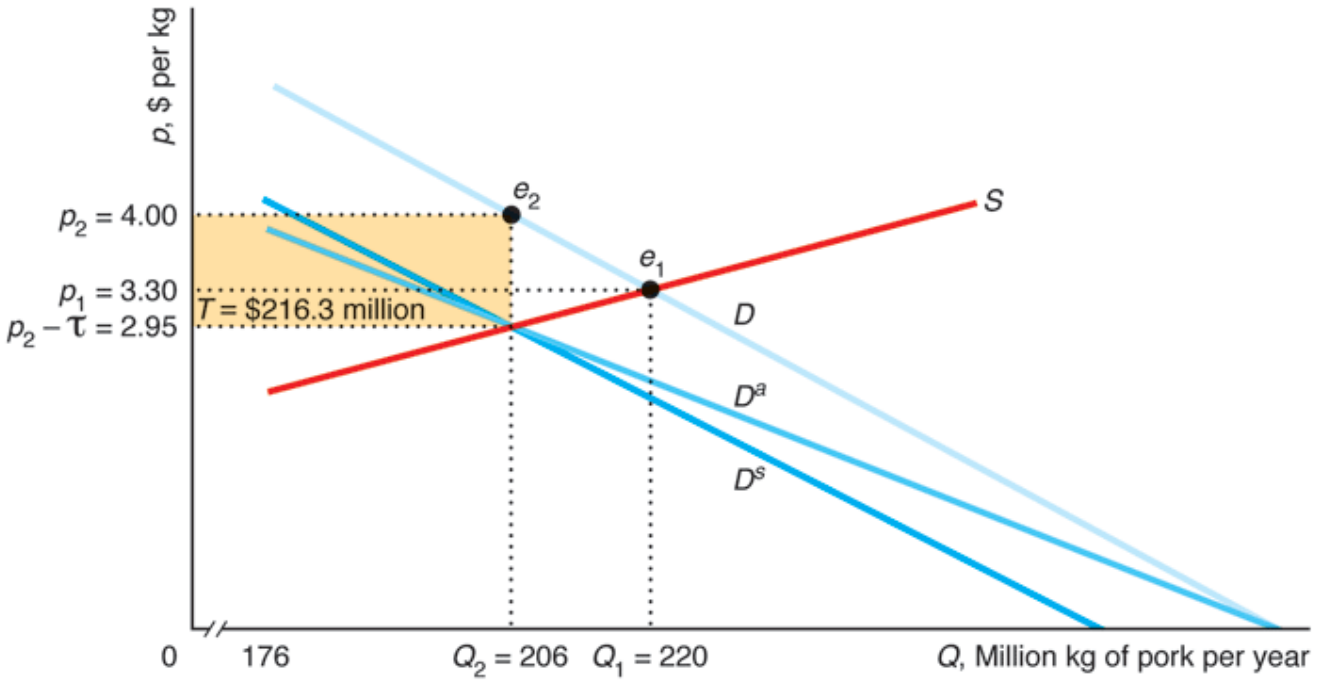
- If the supply curve is perfectly elastic and demand is linear and downward sloping, what is the effect of a $1 specific tax collected from producers?
- Equilibrium price increases by $1 and equilibrium quantity decreases.



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2.6 Important Questions About Tax Effects

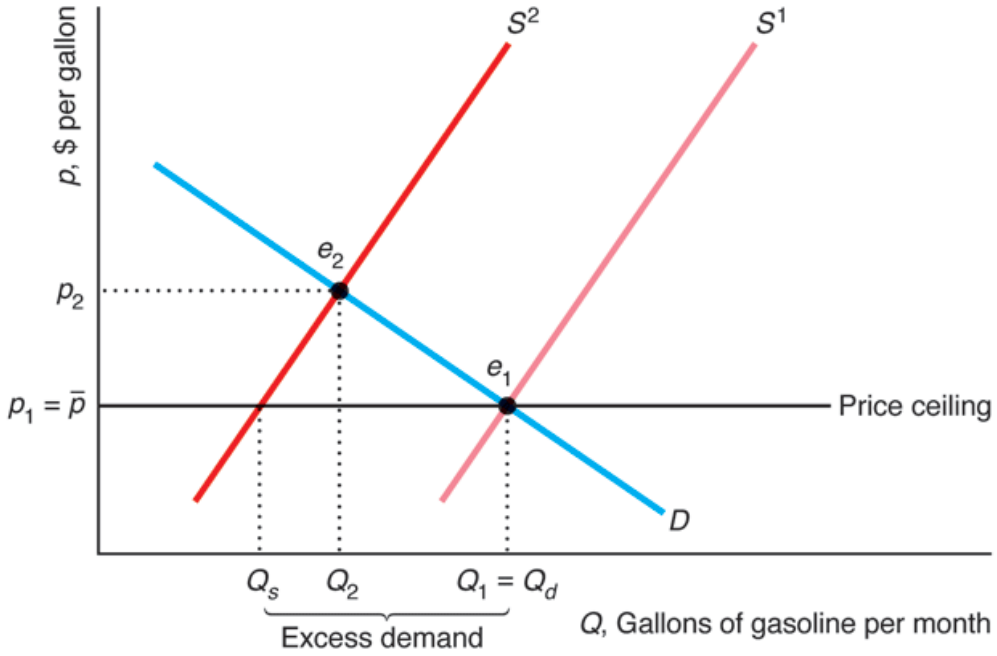
- Does it matter whether the tax is a unit tax or an ad valorem tax?



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2.7 Quantity Supplied Need Not Equal Quantity Demanded

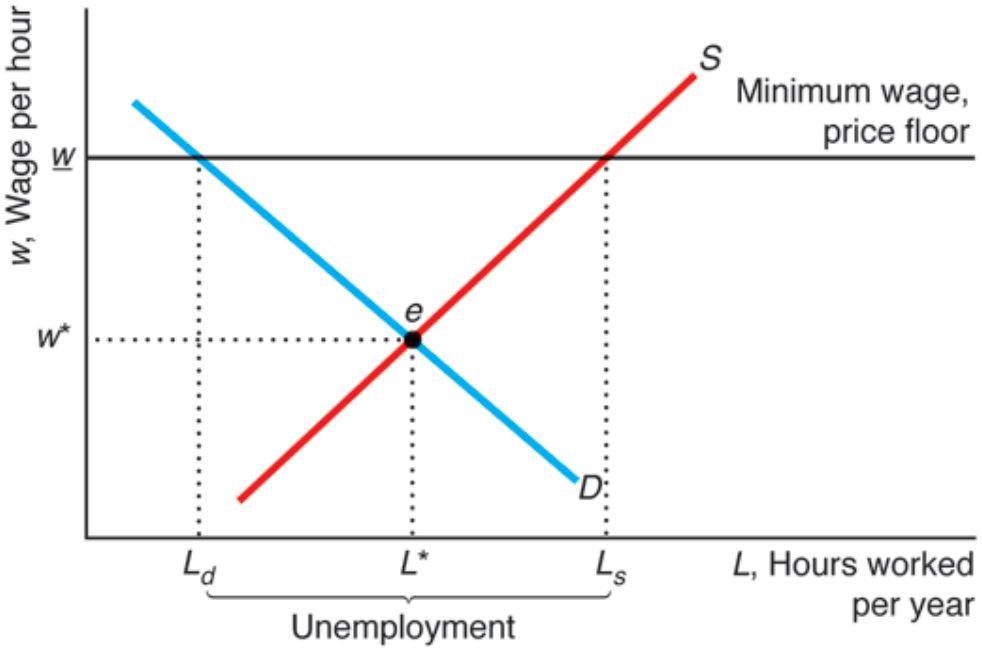
- Price determines whether $Q_s = Q_d$
- A ***price ceiling*** legally limits the amount that can be charged for a product.
  - Effective ceilings force the price below equilibrium price.



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2.7 Quantity Supplied Need Not Equal Quantity Demanded

- Price determines whether $Q_s = Q_d$
- A ***price floor*** legally inflates the price of a product above some level.
  - Effective floor forces the price above equilibrium price.



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2.8 When to Use the Supply-and-Demand Model

- This model is appropriate in markets that are perfectly competitive:
  1. There are a large number of buyers and sellers.
  2. All firms produce identical products.
  3. All market participants have full information about prices and product characteristics.
  4. Transaction costs are negligible.
  5. Firms can easily enter and exit the market.

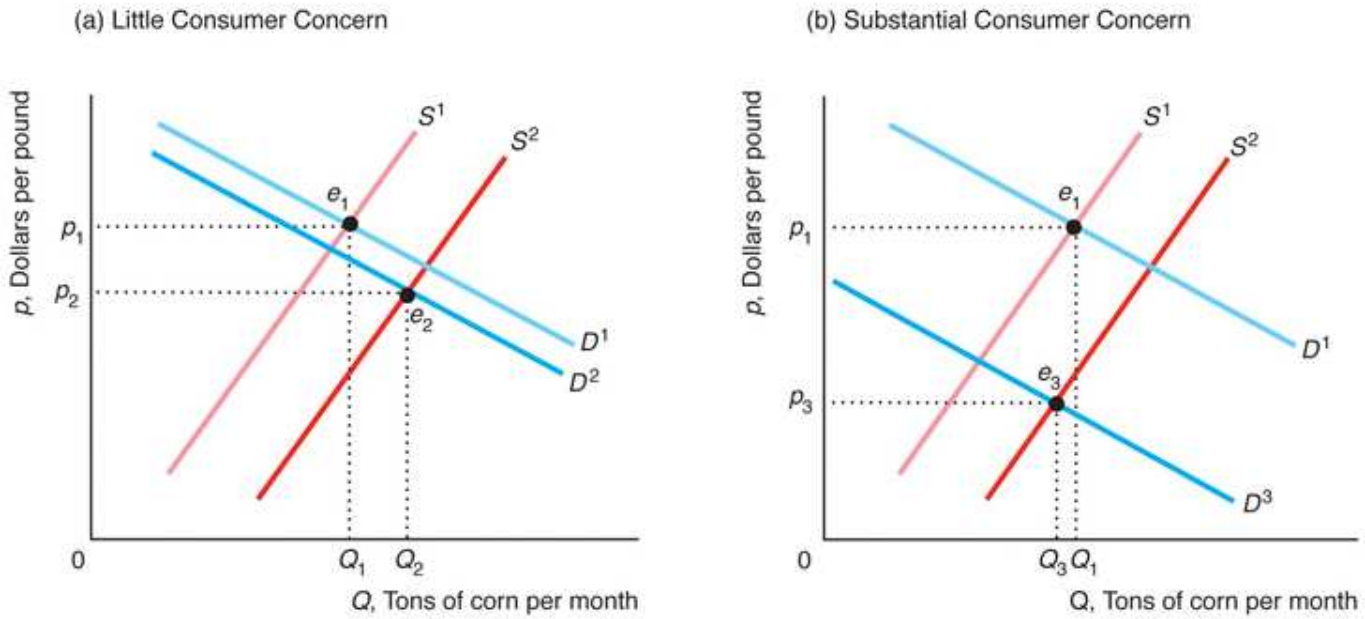
- We will talk more about the perfectly competitive market in Chapter 8.

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Challenge Solution

- With the introduction of GM foods, supply increases and demand decreases. For a given increase in supply, the effect of the decrease in demand on the equilibrium price and quantity depends on the magnitude of the shift in demand.



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