

Instructor's Resource Manual  
By

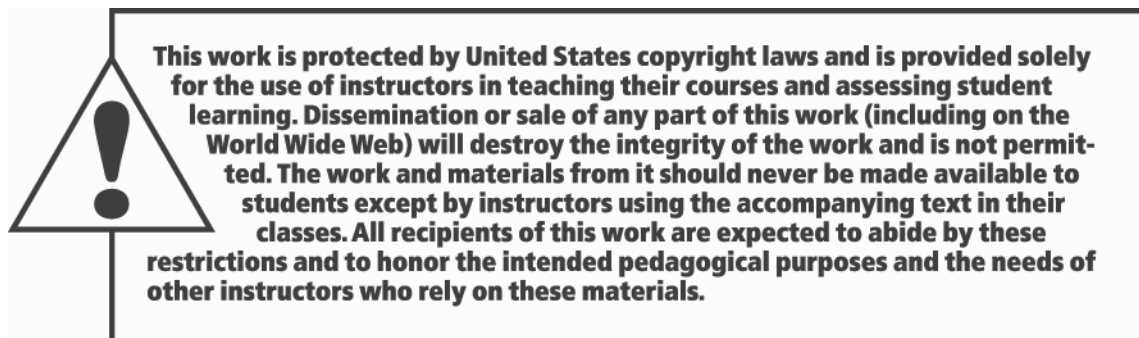
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For

Microeconomics: Theory and Applications  
with Calculus

Fourth Edition

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# Contents

<b>Chapter 1</b>	Introduction	1
<b>Chapter 2</b>	Supply and Demand	5
<b>Chapter 3</b>	A Consumer's Constrained Choice	41
<b>Chapter 4</b>	Demand	60
<b>Chapter 5</b>	Consumer Welfare and Policy Analysis	85
<b>Chapter 6</b>	Firms and Production	111
<b>Chapter 7</b>	Costs	127
<b>Chapter 8</b>	Competitive Firms and Markets	148
<b>Chapter 9</b>	Properties and Applications of the Competitive Model	170
<b>Chapter 10</b>	General Equilibrium and Economic Welfare	195
<b>Chapter 11</b>	Monopoly and Monopsony	211
<b>Chapter 12</b>	Pricing and Advertising	238
<b>Chapter 13</b>	Game Theory	257
<b>Chapter 14</b>	Oligopoly and Monopolistic Competition	279
<b>Chapter 15</b>	Factor Markets	302
<b>Chapter 16</b>	Uncertainty	318
<b>Chapter 17</b>	Property Rights, Externalities, Rivalry, and Exclusion	336
<b>Chapter 18</b>	Asymmetric Information	352
<b>Chapter 19</b>	Contracts and Moral Hazards	360



# Chapter 1

## Introduction

### ■ Chapter Outline

#### 1.1 Microeconomics: The Allocation of Scarce Resources

##### Trade-Offs

Which goods and services to produce.

How to produce.

Who gets the goods and services.

##### Who Makes the Decisions

##### How Prices Determine Allocations

**Application:** Twinkie Tax

#### 1.2 Models

**Application:** Income Threshold Model and China

##### Simplifications by Assumption

##### Testing Theories

##### Maximizing Subject to Constraints

##### Positive Versus Normative

#### 1.3 Uses of Microeconomic Models

### ■ Teaching Tips

You might begin the first class by discussing with the students the role of the intermediate microeconomics class in the larger curriculum. Encourage the students to be interactive by asking questions, bringing in examples from the newspaper, and questioning concepts that seem untrue or unrealistic. For many professors, a primary goal of the course is to get students to think like economists. The material in Chapter 1 should help the students to understand what is required to do so. You might want to ask your students the policy questions listed below as a kind of pretest. Simply ask them to write down the best answer they can for now, and then put their answers away. You can then return to these answers later in the semester.

Some suggested policy questions (be sure to ask only questions that you will address later in the course):

1. How do minimum wages affect wages, employment, and unemployment?
2. Is the consumer price index (CPI) a good measure of inflation?
3. Why do stores offer coupons instead of simply reducing the price by the value of the coupon?
4. How do taxes affect consumers and businesses?

5. Why do some workers prefer set wages rather than commissions, even if they might make more working on commission?
6. Agree or disagree: We should strive to be a zero pollution society.

On a more pragmatic level, I stress to the students that success in the class is heavily dependent on their approach to the material. Specifically, I emphasize that memorization is an extremely ineffective tool for studying economics and that students who memorize material are very prone to confusion and “drawing a blank” on exams. I try to persuade them that a much better approach is to press for understanding. I also stress that understanding usually comes only through active engagement with the material, both in class and out. The problems in the text, as well as the additional problems available in this manual and the Study Guide, will benefit the students in this regard. The conceptual and technical questions throughout these problem sets are designed to facilitate student understanding.

I also emphasize the importance of coming to class regularly. Paul Romer’s article, “Do Students Go to Class? Should They?” in the *Journal of Economic Perspectives* (vol. 7, no. 3, Summer 1993:167–74) shows that perfect class attendance is worth between one and two grade points, and attendance at all rather than half of classes is worth between 0.67 and 1.24 grade points. Referring to this evidence might add some weight to your argument.

Finally, I recommend that all students bring a protractor and a few colored pencils to class to aid their note taking. One of the most frequent problems for students who are struggling is sloppy lecture notes. A protractor is great for drawing lines and curves and has the added benefit of being transparent. Colored pencils are a big help when students are taking notes on graphs with many different lines, such as income and substitution effects and long- and short-run cost.

Chapter 1 serves as an introduction to the text as well as a refresher of some basic economic concepts and definitions. This is a good chapter to get started on during the first day, as most students will not have read it before class. It will give you the opportunity to get a feeling for the students’ recall of these basic concepts.

I usually start by asking the class for a definition of economics. If you get several suggestions that do not include the concept of scarcity, consider writing them on the board. Ask the class if they can think of what central idea is missing from the definitions given. The discussion of scarcity and the questions of what, how, and for whom to produce should lead you directly into a discussion of the role of prices as an allocation mechanism.

In the discussion of prices and markets, I try to get the students to offer examples from recent events where prices have risen or fallen sharply (a good current example is oil prices). Another possibility is to ask the students why some prices are so high (e.g., diamonds) and others are so low (water, to start on that classic paradox). Ideally, you will end up in a discussion of the ways in which supply and demand interact to allocate resources. I also like to talk briefly about market failure and why the United States is a mixed economy rather than a pure market economy. The Twinkie tax application is a good example for discussion purposes.

When discussing allocation of goods and services, an effective counterpoint to the market system is consideration of the centrally planned economy. Examples can include China’s version of central planning, as well as Cuba and North Korea. Many students have very little knowledge of how centrally planned economies operate, the difficulties they face in meeting the demands of their citizens, and how these difficulties relate to the current political changes.

The discussion of economic models is very important. Most students do not have a sound understanding of the construction and purpose of an economic model. Stress the point that economic models are allegories used to describe behaviors and outcomes that would otherwise be unnecessarily complicated. Rather than try to duplicate the actual phenomenon, economists use models to make predictions about the behavior of firms and individuals. Perhaps the most important point to make regarding models is that they are simplified through the use of assumptions. You might choose a typical market and describe the wide variety of complex interactions that would have to be quantified in order to produce a complete model. Then describe the circumstances under which a very simple economic model can make satisfactory predictions (where “satisfactory” can be defined a number of ways, such as the coefficient of determination in a regression model). You may also want to discuss interactions that are too difficult to model and why. For example, modeling behavior in unstable political climates is difficult because of the large influence of events that cannot be forecast. Finally, you might discuss the use of models to test theories and make predictions. Often students have a somewhat jaded view of economists and their predictions. I like to point out that although predictions often turn out to be incorrect, the error can frequently be traced to incorrect assumptions made at the time of the prediction. For example, suppose a forecasting model is constructed to predict baseball game attendance. Assuming a bright sunny day, attendance at a baseball game is predicted to be 40,000. If only 10,000 fans show up on game day, it could be that the model is bad, but it could also be that the weather is cool with a steady rain. In this case, the assumption, not the model, was flawed.

Chapter 1 also introduces the difference between positive and normative economics. It does not take long to cover, and a brief discussion of this point is worth the time. You might begin by asking students the distinction between positive and normative problems. I often find that students either do not know at all or are very unsure about their responses. To get the class thinking, use current societal problems as discussion points. Ask the class what would be a fair price for an Ebola vaccine. The variety of responses shows the normative nature of the question, but there is no disagreement that the vaccine should be produced in the least costly way possible, regardless of how the gains are shared. Note that most problems have both positive and normative aspects and that by separating objective issues from subjective ones, we can more easily understand and approach the problems and find effective solutions. The text example of the wisdom of food price controls in Africa during droughts makes this point well.

When covering Section 1.3 (Uses of Microeconomic Models), you might discuss the effect of subprime mortgages on the housing market, or draw on examples from current events that require the use of models. I like to draw the distinction between structural models that may be used, for example, to determine an elasticity, and forecasting models that emphasize predictive power over theoretical correctness. If the students’ backgrounds in statistics are weak, you may have to keep this discussion at a broad conceptual level. This section provides a great opportunity to make the subject matter come alive for the students.

This text is designed to be used in courses where calculus is a prerequisite. I find that, even though students have all taken calculus, they don’t remember much of it. I find it useful to spend some time reviewing the rules of algebra and the basics of calculus. Also, it is necessary to be able to take partial derivatives, and these are rarely covered in the introductory calculus course.

## ■ Discussion Questions

1. If water is needed to survive and diamonds are simply for jewelry, then why are diamonds so expensive and water so inexpensive?
2. Discuss the positive and normative aspects of the economics of the SNAP (food stamp) program.
3. Are prices the best way to allocate pharmaceutical products?
4. Suppose you wanted to build a model to predict hurricanes. Which would be better, a model that resulted in more false-positive predictions (storm is predicted but does not occur) or more false negatives (storm occurs but is not predicted)? Why?
5. What assumptions might you make to simplify the task of building an economic model of the grape market?



# Chapter 2

## Supply and Demand

### ■ Chapter Outline

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

#### 2.1 Demand

##### 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

How Government Import Policies Affect Supply Curves

#### 2.3 Market Equilibrium

##### Finding the Market Equilibrium

Forces That Drive a Market to Equilibrium

#### 2.4 Shocking the Equilibrium: Comparative Statics

Comparative Statics with Discrete (Relatively Large) Changes

**Application:** Occupational Licensing

Comparative Statics with Small Changes

**Solved Problem 2.1**

Why the Shapes of Demand and Supply Curves Matter

#### 2.5 Elasticities

##### Demand Elasticity

Elasticities Along the Demand Curve

**Solved Problem 2.2**

**Application:** The Demand Elasticities for Google Play and Apple Apps

**Solved Problem 2.3**

Other Demand Elasticities

Supply Elasticity

**Solved Problem 2.4**

Long Run Versus Short Run

Demand Elasticities over Time

Supply Elasticities over Time

**Application:** Oil Drilling in the Arctic National Wildlife Refuge

**Solved Problem 2.5**

2.6 Effects of a Sales Tax

Equilibrium Effects of a Specific Tax

The Same Equilibrium No Matter Who is Taxed

Who Pays the Tax?

**Solved Problem 2.6**

**Application:** Subsidizing Ethanol

The Similar Effects of Ad Valorem and Specific Taxes

2.7 Quantity Supplied Need Not Equal Quantity Demanded

Price Ceiling

**Application:** Venezuelan Price Ceilings and Shortages

Price Floor

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.

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

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

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.<sup>1</sup> 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?

<sup>1</sup>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.

## Elasticity of Toll Roads in Pennsylvania and New Jersey<sup>2</sup>

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

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<sup>2</sup>Based on Agis Salpukas, “Tolls Up, Trucks Take Back Roads,” *New York Times*, September 17, 1991:D1, D6.

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

- 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?



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  $Q = Ap^e$  has constant elasticity.

## ■ 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

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

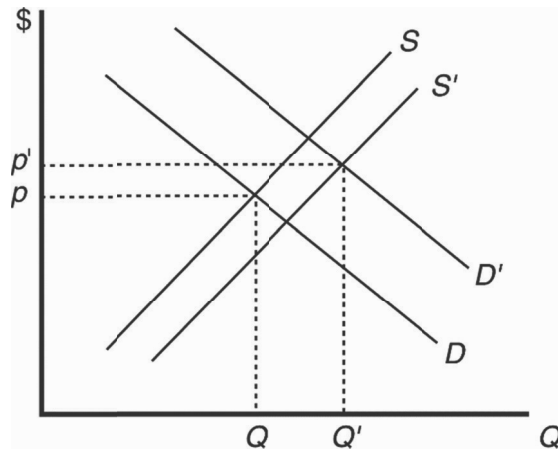
With the new minimum wage of \$5, employment will equal the amount of labor demanded at the minimum wage.

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

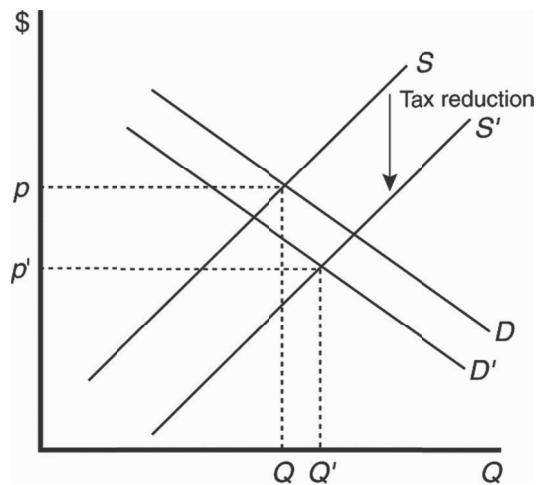
Total payments to labor would increase from \$38,400 to \$47,500. Excess supply of labor would equal  $2,000 = 2,000 + 1,900(5) - 9,500$ . Thus, in addition to the 100 people who would lose the jobs they had before the minimum, an additional 1,900 people would now want jobs that would be unobtainable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

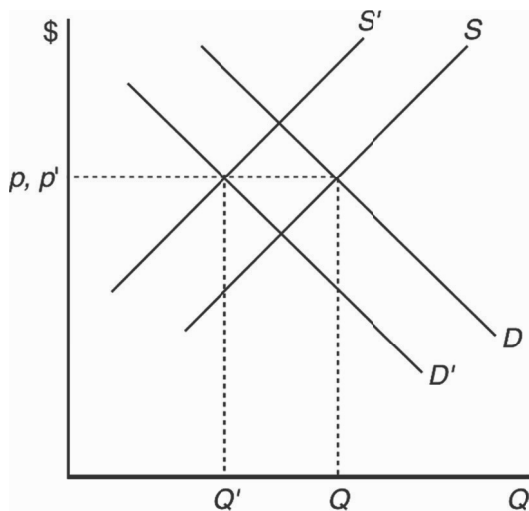
larger than the shift in supply, prices increase.



- 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.



- 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  $Q' = 10 + p$

$$100 - p = 10 + p$$

$$p^* = 45$$

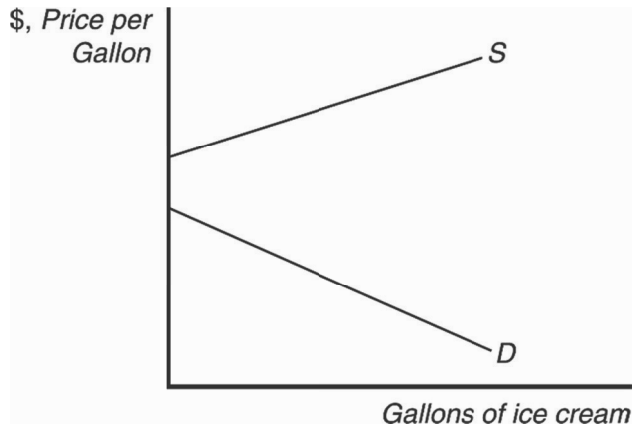
$$Q^* = 55$$

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  $Q_D' = 220 - 5p$

$$220 - 5p = 60 + 3p$$

$$p^* = 20$$

$$Q^* = 120$$

9. The equilibrium solution with no government intervention is

$$1,000 - 2p = 100 + p$$

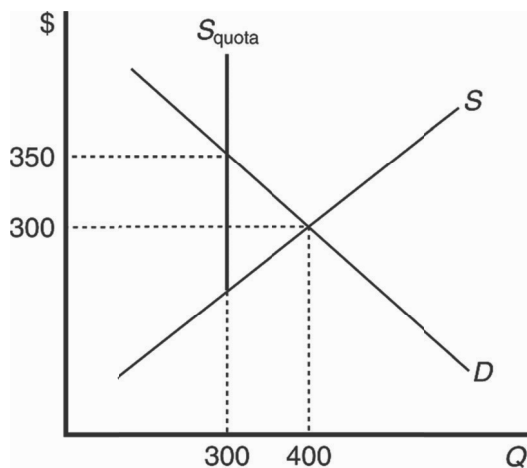
$$p^* = 300$$

$$Q^* = 400$$

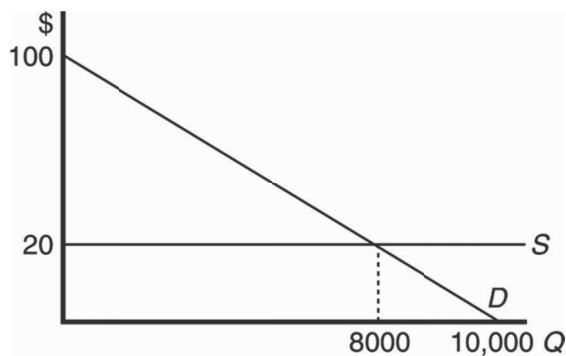
When the quota is imposed at 300 units, supply cannot exceed that level, regardless of price. Thus the supply curve becomes vertical at 300 units. The new equilibrium quantity is 300, and price is determined by where the supply curve with the quota ( $S_{\text{quota}}$ ) intersects the demand curve. 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.

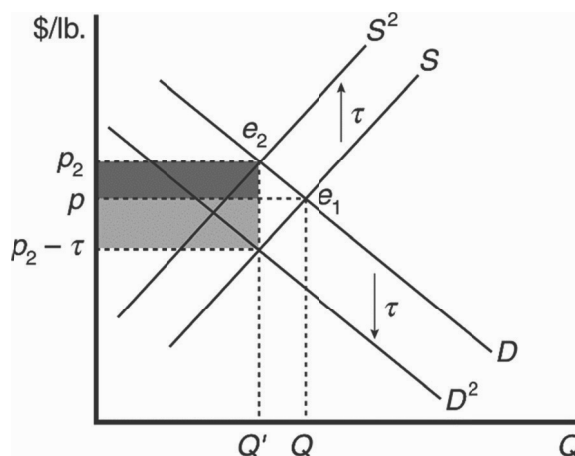


11. The demand curve of the previous model shifts to the right. If the new model is more expensive, the demand curve for the previous model shifts to the right still but with a smaller magnitude.
12. Without the wage ceiling, the equilibrium is given by

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

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.

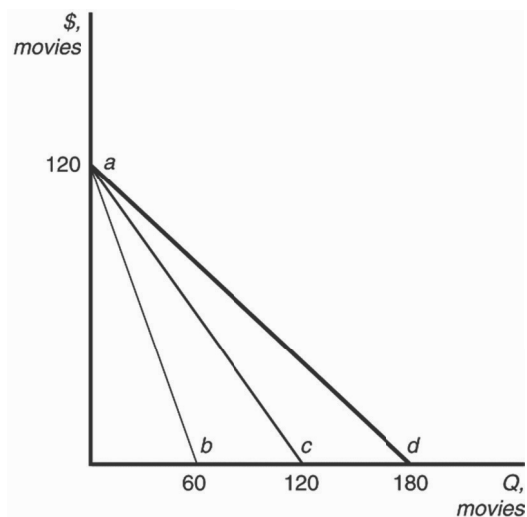
13. The demand for emeralds is elastic because they would be categorized as luxury goods rather than necessities. Emeralds are also substitutable in most cases for other precious gems, which increases their elasticity. Supply is likely to be quite inelastic for two reasons. First, there are only a few 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.



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,  $\varepsilon$  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 avocados 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.





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

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

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.

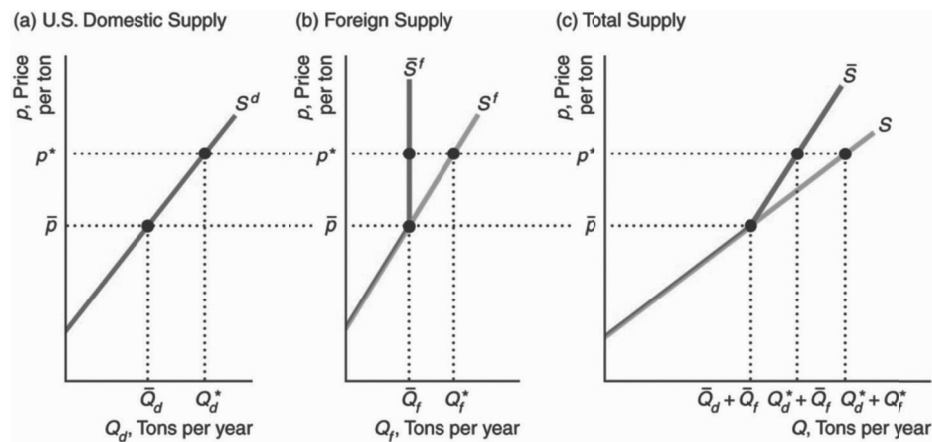
2.1 Supply:  $Q = 178 + 40p - 60p_h$ . Replacing  $p_h$  with \$3 per kg gives us a supply function  $Q = 178 + 40p - 60 \times \$3 = 40p - 2$ . That is, the slope of the supply curve does not change from Equation 2.7, but the whole supply curve shifts to the left.

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 avocados supplied. Graphically, this would be a parallel shift of the supply curve.

2.3 The world supply is:

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

- 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:

$$\begin{aligned} 110 - 20p &= 20 + 10p \\ 90 &= 30p \\ p &= 3. \end{aligned}$$

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,

$$\begin{aligned} Q &= 110 - 20p \\ Q &= 110 - 20(3) \\ Q &= 110 - 60 \\ Q &= 50 \text{ units.} \end{aligned}$$

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:

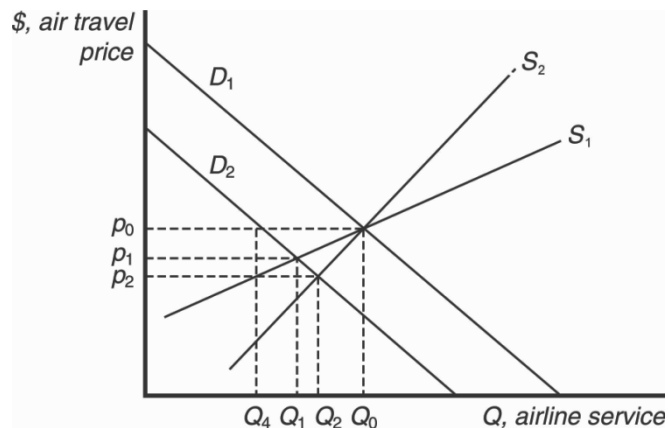
$$p = -\frac{7}{60} + \frac{1}{3}p_b + \frac{1}{20}p_c + \frac{1}{30}Y + p_h$$

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 right, 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.



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:

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

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

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

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

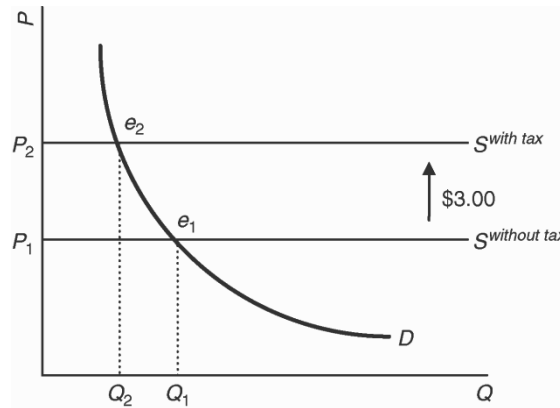
- 4.6 a. The demand function is  $Q = 20,000P^{-0.42}$ , and the inverse supply function is:  $P = 1.5P_w$ ; therefore, the equilibrium price and quantity are:

$$P^* = 1.5 P_w$$

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

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

- 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:

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

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:

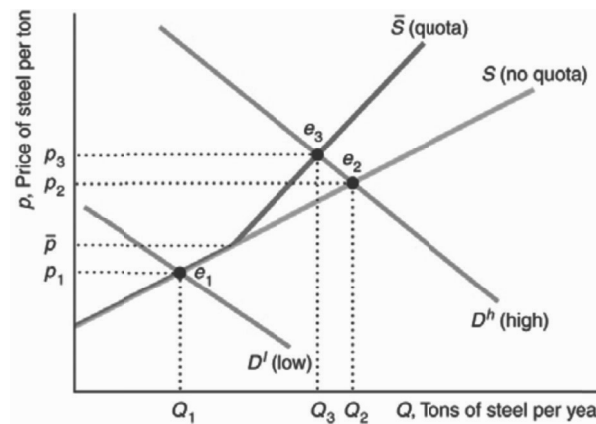
$$\begin{aligned} \frac{\partial(\frac{\partial Q^*}{\partial P_w})}{\partial \tau} &= \frac{\partial(-1260 \cdot (1.5P_w + \tau)^{-1.42})}{\partial \tau} \\ &= -1260 \cdot (-1.42) \cdot (1.5P_w + \tau)^{-2.42} \\ &= 1789.2 \cdot (1.5P_w + \tau)^{-2.42}. \end{aligned}$$

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  $Q_3$ .



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

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

$$90 + T = 3w$$

$$w = 30 + 0.333T.$$

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  $Q = 20$ ,

$$\varepsilon = -.01$$

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,

$$\begin{aligned}\varepsilon &= -2.8p^{-3} \frac{p}{1.4p^{-2}} \\ \varepsilon_A &= -2\end{aligned}$$

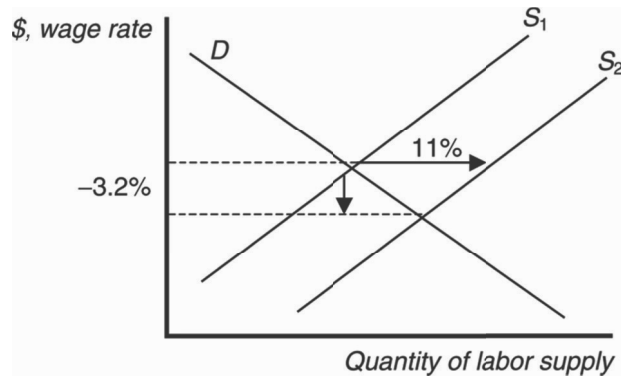
Similarly,  $\varepsilon_P = -3.7$ .

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.



- 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  $\Delta Q$  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.

5.8 The elasticity of demand is  $(dQ/dp)(p/Q) = (-9.5 \text{ thousand metric tons per year per cent}) \times (45 \text{ cents}/1275 \text{ thousand metric tons per year}) \approx -0.34$ . 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  $\eta$  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  $Q = 47.28 + 0.392p$ .

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.