Chapter 8
Competitive Firms and Markets

■ Chapter Outline

8.1 Competition
- Price Taking
- Why a Firm's Demand Curve Is Horizontal
- Deviations from Perfect Competition
- Derivation of a Competitive Firm's Demand Curve
- Why Perfect Competition Is Important

8.2 Profit Maximization
- Profit
- Two Steps to Maximizing Profit

8.3 Competition in the Short Run
- Short-Run Competitive Profit Maximization
- Short-Run Firm Supply Curve
- Short-Run Market Supply Curve
- Short-Run Competitive Equilibrium

8.4 Competition in the Long Run
- Long-Run Competitive Profit Maximization
- Long-Run Firm Supply Curve
- Long-Run Market Supply Curve
- Long-Run Competitive Equilibrium

■ Teaching Tips

Chapter 8 begins the study of markets. You might take 10 minutes or so on the day you begin this section to talk with the class about market structure in its broadest terms. Introduce the spectrum of market structures by briefly defining the competitive, monopolistically competitive, oligopoly, and monopoly market structures. By doing so, you will answer some questions in advance about markets that do not fit into the competitive model.

If you ask the students for a list of characteristics that describe a competitive market, or a firm in such a market, you are likely to get a combination of assumptions (e.g., free entry and exit, perfect information) and outcomes (e.g., lack of market power, zero long-run profits). Probably the most common mistake that students make at this stage is to confuse assumptions and outcomes. It is important that students understand that price taking behavior is not assumed, or a choice that firms make, but an outcome that is driven by the assumptions that are made.

Before beginning the material on short- and long-run profit maximization, you may want to review the difference between economic profit and business profit. Throughout the chapter, the text uses the word profit to mean economic profit.

Most of the material on short-run profit maximization is straightforward and should not be cause for much confusion. The possible exception is the shut-down rule. You may find that no matter how much you emphasize to the class that the firm must cover its variable cost, some still remember it as the firm needing to cover fixed cost to avoid shut-down. You may reduce this confusion by the use of a simple example. You might describe a firm where the only fixed cost is a mortgage payment and the only variable cost is the payroll. It makes intuitive sense that as long as the firm can make the payroll every week, even if they can only pay part of their mortgage, they can hang on and hope for higher prices. However, once the firm can't even cover their payroll, they must shut down.

When covering the firm and market short-run supply curves, you might emphasize that the point at which the supply curve is cut off at the lower end is not arbitrary, but a function of the average variable cost curve and shut-down point. The section of the chapter that covers short-run supply contains a good discussion of the effect of changes in input prices and taxes on equilibrium output levels. You may want to work through some examples, such as the supply of vegetable oil example in Figure 8.6.

When discussing the long run, it is vital that the class understands that the assumptions of the model, particularly free entry and exit, are the force that drives the competitive engine. Firms are forced by the continual push of actual or potential competition to produce efficiently and maximize profits. You can use statistics from agriculture to show that farmers have been forced over time to become increasingly efficient producers in order to remain solvent. As technology increases, output per acre increases, increasing output and reducing prices. Falling prices create the incentive to cut costs. Cutting costs increases supply, which creates even more downward pressure on prices. The cycle is continuous, as farmers face constant downward pressure on long-run profits. This has caused a continuous increase in average farm size, the disappearance of many small, unproductive farms, and enormous increases in productivity. For example, from 1955 to 1986, labor input per acre of corn fell by over three times, while output per acre more than doubled. During the same time period, labor input per hundredweight of turkeys fell from 4.4 to 0.2.[1] This is a good place to remind the class of the normative economic issues created by the force of markets. Although the efficiency of the agriculture industry results in low food prices, they can be forced so low that many family farms cannot survive. You might try to get the class to weigh in on whether normative solutions such as price supports, which save farms but create higher prices, are a good thing or should be abolished. You may also want to discuss the computer industry, where prices for PC computing power have fallen at an average rate of about 30% per year. In this case, despite the fact that some of the assumptions of the perfectly competitive market are not met, consumers still derive great benefit from the forces of markets.

Canada's Response to Increased International Competition in World Agriculture Markets[2]

Canada is a major producer of wheat. Because the agricultural sector is so large relative to the size of the population, they are also major exporters. Not surprisingly, they push hard for open access to foreign markets. Between 1990 and 2000, agricultural goods and food by-product exports increased by more than 100%. To continue this trend, they will have to not only win the battle for lower tariffs, but also battle falling world prices brought about by increases in production (farmed acreage) and productivity.

[1] U.S. Department of Agriculture statistics, reported in Agriculture by Daniel B. Suits in *The Structure of American Industry,* 9th ed. Adams and Brock, eds. Prentice Hall, Englewood Cliffs, NJ. 1995:21.

[2] Competition and Subsidies in Global Markets, at http://www.agr.gc.ca/cb.apf/bgd_comp_e.html.

As noted above, productivity in agriculture has skyrocketed due to increases in mechanization, fertilizers, and biotechnology. In some areas, soil that was previously thought untellable is now planted acreage. In addition, the recent economic downturn and former Soviet State's inability to pay for imports have dampened world demand. The effect on wheat prices has been dramatic. Prices have fallen roughly 75% since 1970. Although agricultural subsidies in the United States and the European Union are commonly blamed as major culprits in the fall of grain prices, they may only be responsible for one-fourth of the decline. As low-cost producers continue to emerge throughout the world, Canada's agricultural sector will continue to experience the heavy pressure of falling prices. In order to remain competitive, Canadian farmers will have to continue to increase their own productivity. Thus the problem of U.S. farmers, and their continual contribution to lower prices in an effort to maintain profitability through productivity increases, is played out on the world stage as well.

1. Should international financial institutions such as the WTO intervene in international agriculture markets to stabilize prices? Who would be helped, and who would suffer if it did?

2. Could the Canadian government act alone to affect the fate of Canadian farmers on international markets? If so, how?

■ Additional Applications

Barriers to Exit—The Steel Trap[3]

If firms incur a cost to exit the market, they may not shut down in the short run even if their revenues do not cover variables costs. The firms stay in operation, at least for a while, so that they can avoid paying the exit costs.

For decades, many *integrated* U.S. steel mills—factories that produce steel from iron ore—were operating at losses. Before the 1950s, U.S. firms could produce at lower costs than international rivals despite having high wages, because their mills were more productive and abundant supplies of coal and iron ore kept their energy and material costs relatively low. In the 1950s and 1960s, discoveries of rich iron ore sources, lower wages, and newly built, state-of-the-art mills enabled many foreign steel firms to produce at lower cost than U.S. firms. As a result, the share of worldwide sales of U.S. integrated steel firms fell from 90% in 1960 to less than 65% in the 1980s.

U.S. firms have been too slow to leave the market. Not until the late 1970s did Youngstown Sheet & Tube and the United States Steel Corporation in Youngstown, Ohio, close. The next closing did not occur until 1982. Rather than close, firms have continued to operate aging, inefficient, and unprofitable plants.

A steel firm faces substantial costs in closing a mill and terminating contracts. Union contracts obligate the firm to pay workers severance pay, supplemental unemployment benefits, and make to payments to cover additional pensions and insurance benefits in the future. Usually, union members are eligible for pensions when their age plus years of service equals 75; however, workers laid off due to plant closings are eligible when their age plus years of service equals 70. Thus by not closing plants, firms can substantially reduce pension payments. The United States Steel Corporation's cost of closing down various operations in 1979 was $650 million, of which about $415 million—or $37,000 per laid-off worker—was labor related. These costs have risen 45% since then.

[3]From Mary E. Deily, Exit Barriers in the Steel Market, *Economic Review,* 24(1), Quarter 1, 1988:10–18.

Because they avoided shutting down to avoid exit costs, U.S. steel mills have sold most products at prices below average variable cost since the 1970s. For example, in 1986, the average variable cost of hot-rolled sheets per ton was $305 and the average cost was $406, but the price was only $273. Many of these mills stayed in business for decades despite sizable losses. Eventually, these mills will close unless the recent increase in profitability in the industry continues.

1. Can you think of other firms or industries that would suffer large shut-down costs? What would be the source of these costs?

2. Is it possible that the firms are playing a "waiting game" to see if others will drop out before them? Under what circumstances might this allow a remaining firm to become profitable again?

■ Discussion Questions

1. Give some examples of markets that, based on their characteristics, are likely to be competitive.

2. Should firms use accounting profits or economics profits when deciding how much to produce?

3. Are entry barriers ever desirable? Why?

4. Give examples of avoidable costs and sunk costs.

5. Is competition desirable? Why? (This topic is discussed in the next two chapters.)

6. Give examples of exit barriers. How do they limit or impede exit?

7. A lump-sum tax does not affect a firm's marginal cost. Does it alter the short-run competitive market equilibrium?

8. How do fixed costs affect firms' behaviors in the short run?

9. Should a competitive firm care about the behavior of any one of its rivals (as opposed to all of them collectively)?

■ Additional Questions and Problems

1. Under what circumstances would advertising be pro-competitive? Anti-competitive?

2. Draw a graph showing the average total, average variable, and marginal cost curves for a typical firm. Draw in three prices that result in the firm making positive profits, breaking even, and making negative profits that are less than fixed costs.

3. Suppose your firm is in a competitive industry in long-run equilibrium making substantial long-run profits (as in Figure 8.11). State specifically what will occur as the industry moves toward long-run equilibrium.

4. Suppose you are a wheat farmer, and the local fertilizer salesperson informs you that a new product is available that could boost your output by 15%. Is this good news or bad news? Why?

5. Suppose a perfectly competitive firm has the short-run cost function $C = 125 + q^2$. Use the derivative formula or marginal cost to determine the firm's output level and profit at prices of $30 and $20. At what price does the firm reach the shut-down point?

6. Suppose there are 25 firms in the sandals market, in which market demand elasticity is –1.5. The elasticity of supply is 1. A single firm in this industry decides that because there are only 24 competitors, it might be a good idea to increase prices by 1%.

7. True or false, explain your answer. "The lawn chair industry is a constant cost industry. This means that the law of diminishing returns does not operate, and the marginal cost curve is flat."

8. True or false, explain your answer. "If all firms in an industry have identical variable cost but each pays a different one-time fee to enter the market, all firms will produce identical quantities of output."

9. If each competitive firm in an industry has the short-run cost function $C = 50 + 5q + q^2$, and the market price is \$35, what is the profit-maximizing output level for each firm? What is the total revenue? What are the profits?

10. Suppose, in Question 9, that fixed costs were \$250 instead of \$50. How does this change affect the firm's output decision and profits? Should the firm continue to operate?

11. How does a firm decide whether to shut down production if it has zero fixed cost? What is the implication on entry and exit in this industry?

12. Using formula 8.5 for the elasticity of excess supply, discuss the relationship between market supply elasticity and excess supply? Which one is higher? Under what circumstance will these two be the same?

■ Answers to Additional Questions and Problems

1. Advertising is pro-competitive when it provides information to consumers about prices and product characteristics. Recall that one assumption of perfect competition is knowledge of prices by buyers and sellers. Conversely, high advertising costs can serve as an entry barrier for potential new firms, which would reduce, rather than enhance, competition.

2. See Figure 8.1. At p_3, the firm makes positive profits. At p_2, the firm breaks even and at p_1, the firm realizes losses that are less than fixed costs.

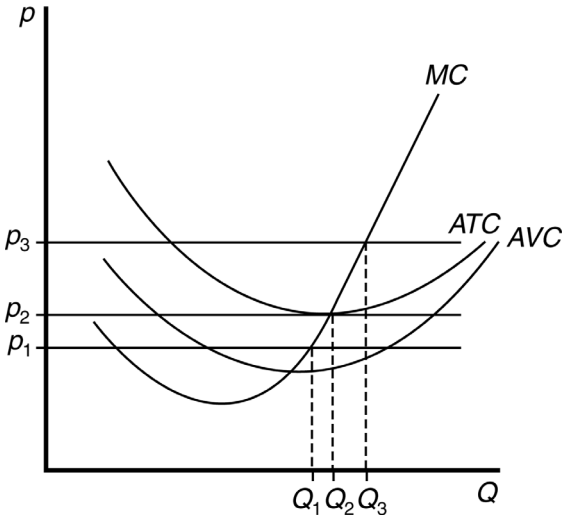

Figure 8.1

3. Refer to Figure 8.11 in the text. Such a firm would be producing 110 units per year at a price of $35. In this case, the firm but not the industry is in long-run equilibrium because $LRMC = p$, but $p > 0$. The existence of substantial profits will attract other firms. As more firms enter, the market supply curve shifts to the right, and prices fall. If all firms have identical cost, firms will continue to enter until economic profits are driven to zero at a price of $24.

4. Unless you are the only farmer who has access to this new technology, this is not good news. Because the fertilizer producers want to maximize their own profits, they will try to sell the new product to all farmers. Thus each farm will be able to increase production per acre. No individual farm would want to be the only one not to employ the new technology, so all have the incentive to purchase it. The new fertilizer will increase output at all farms, shifting the market supply curve to the right, decreasing prices. The situation described here is similar to the recent introduction of bovine somatotrophin (BST) in the dairy industry. BST is a growth hormone that can increase milk production of dairy cows by up to 50%. Farmers organized large-scale protests against its use because of the downward pressure on prices that would inevitably result from such a large increase in supply.

5. The marginal cost equation is $MC = 2q$. When $p = \$30$, $q^* = 15$, $p = \$100$. When $p = \$20$, $q^* = 15$, $p = -\$25$. The firm should keep operating since $TR > TVC$. The firm should shut down when $AVC > MC$ (normally, the minimum point of AVC). In this case, however, variable cost is linear with slope of 1, and MC is linear with slope of 2, making all positive output levels above the shut-down point.

6. The residual demand elasticity is calculated using Equation 8A.2.

$$\varepsilon i = n\varepsilon - (n-1)h_0 = -37.5 - 24 = -61.5.$$

   This shows that a 1% increase in prices will cause quantity demanded to fall by 61.5%.

7. This statement is false. Diminishing marginal returns, which leads to increasing marginal cost, are a short-run phenomenon. They are caused by the overutilization of a fixed input, usually capital. In the long run, all inputs are variable, and constant average cost, which implies constant marginal cost, occurs when firm cost does not increase or decrease as industry output expands or contracts.

8. This statement is true. Fixed costs are irrelevant when determining output levels in the short run. All firms that have chosen to pay the entry fee have the same variable cost, and so also have the same marginal cost. For each firm, then, $MC = p$ will occur at the same output level.

9. Set $MC = MR$ and solve.
   $MC = 2q + 5$
   $MR = 35$
   $2q + 5 = 35$
   $q^* = 15$, $TR = 525$, $TC = 350$, $p = 175$.

10. As in Question 9, set $MC = MR$ and solve. Output is unchanged, but profits fall.
    $MC = 2q + 5$
    $MR = 35$
    $2q + 5 = 35$
    $q^* = 15$, $TR = 525$, $p = -25$.

    Because losses are less than total fixed costs. The firm should continue producing.

11. With zero fixed cost, the firm will shut down production when the price is below the minimum average variable cost. In this case, entry and exit will be instant, depending on if the price is below or about the minimum average cost.

12. Since θ is between zero and one, and ε is usually negative, we have $\eta_\tau = \eta/\theta - \varepsilon(1-\theta)/\theta > \eta$. For $\varepsilon < 0$, we have $\eta = \eta_\tau$ if and only if $\theta = 1$. In other words, only when this country is the only one producing this good.

■ Answers to Questions and Problems in the Text

1. The shutdown rule states that a firm should shut down when it can avoid additional losses by doing so. This occurs when losses would exceed fixed costs. If the firm can cover any portion of fixed costs by continuing production, it should do so.

2. How much the firm produces and whether it shuts down in the short run depend only on the firm's variable costs. (The firm picks its output level so that its marginal cost—which depends only on variable costs—equals the market price, and it shuts down only if market price is less than its minimum average variable cost.) Learning that the amount spent on the plant was greater than previously believed should not change the output level that the manager chooses. The change in the bookkeeper's valuation of the historical amount spent on the plant may affect the firm's short-run business profit but does not affect the firm's true economic profit. The economic profit is based on opportunity costs—the amount for which the firm could rent the plant to someone else—and not on historical payments.

3. Suppose that a U-shaped marginal cost curve cuts a competitive firm's demand curve (price line) from above at q_1 and from below at q_2. By increasing output to $q_2 + 1$, the firm earns extra profit because the last unit sells for price p, which is greater than the marginal cost of that last unit. Indeed, the price exceeds the marginal cost of all units between q_1 and q_2, so it is more profitable to produce q_2 than q_1. We can derive this result using calculus. The second-order condition for a competitive firm requires that marginal cost cut the demand line from below at q^*, the profit-maximizing quantity:

$$dMC(q^*)/dq > 0.$$

4. As shown in Figure 8.2, before low-carb food became popular, the demand curve was D^1; it was not profitable to enter the market since the fixed cost was so high such that short-run average cost was about the market price. If the demand curve shifts rightward to D^2 due to the popularity of low-carb food, the firms make a positive profit in the short run. However, once the low-carb food fell out of the fashion, the demand curve shifted leftward and the firms exited the market.

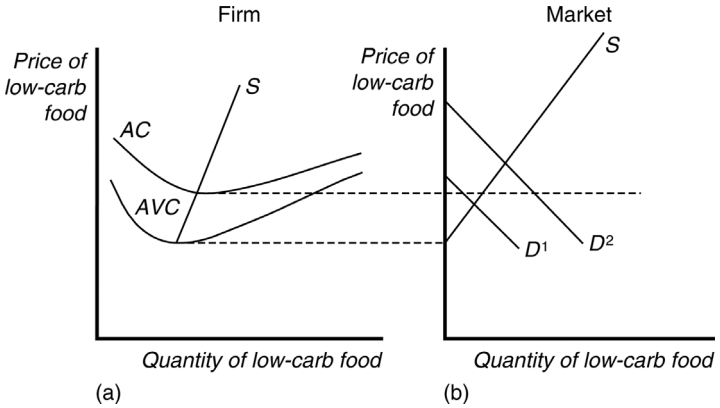

Figure 8.2

5. As shown in Figure 8.3, when demand increases from D_1 to D_2, the price increases as well. If the increase in demand is expected to be temporary, firms will produce Q_1. On the other hand, if the higher demand is expected to be permanent, firms will produce Q_2. In the long run, the market supply curve will be a horizontal line.

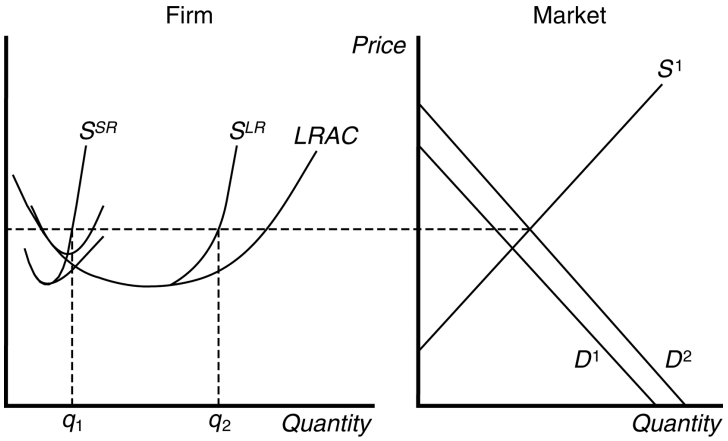

Figure 8.3

6. a. Assuming that the average cost and marginal cost all have a U-shape, a firm's marginal and average costs are likely to rise with extra business.

   b. As shown in Figure 8.4, since the increased demand is only seasonal, it will not affect firms' long-run supply curve and the number of firms in the market if there is considerable entry cost. During peak demand period, firms will operate to the right of the minimum of the short run average cost curve.

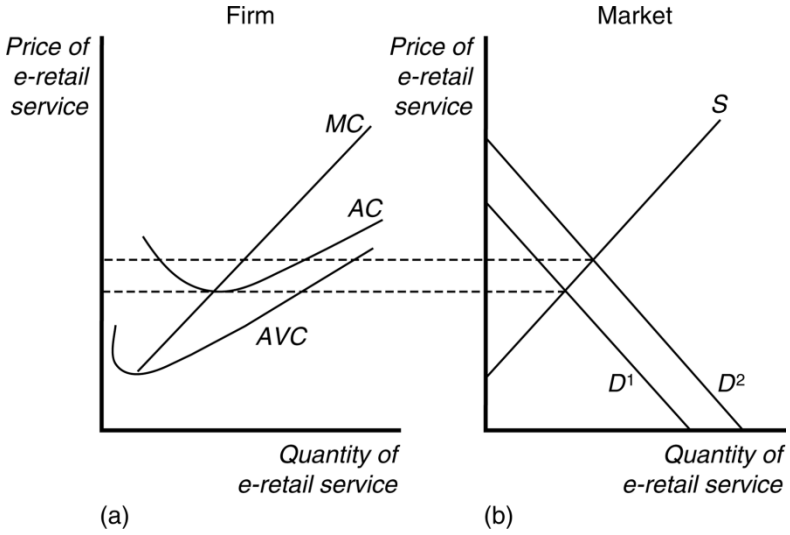

Figure 8.4

7. With a competitive market, firms with higher average cost will be driven out of the market by lower-cost firm firms. The equilibrium profit will be zero. See Figure 8.5. The higher-cost firm with average cost curve AC^1 will be driven out of the market if there exists also lower-cost firm with average cost curve AC^2.

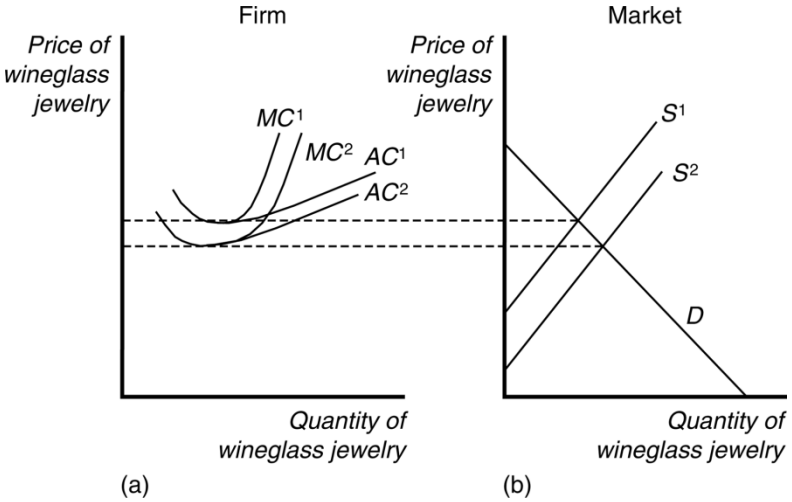

Figure 8.5

8. See Figure 8.6. With a relatively high price for Grade A milk, the firms can produce a large amount of Grade A milk with a lower average cost if they adopt the new technology. Hence the high price of Grade A milk gives the incentive to adopt the technology for its production.

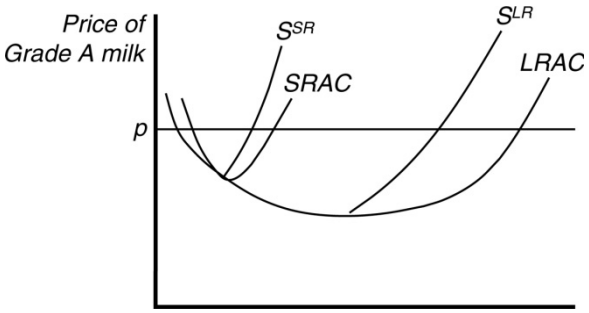

Figure 8.6

9. Some farmers did not pick apples so as to avoid incurring the variable cost of harvesting apples. These farmers left open the question of whether they would harvest in the future if the price rose above the shutdown level. Other more pessimistic farmers did not expect price to rise anytime soon, so they bulldozed their trees, leaving the market for good. (Most farmers planted alternative apples such as Granny Smith and Gala, which are more popular with the public and sell at a price above the minimum average variable cost.)

10. See Figure 8.7. The lower of average minimum variable cost will extend firm's supply curve downward. As a result, the market supply curve shifts rightward.

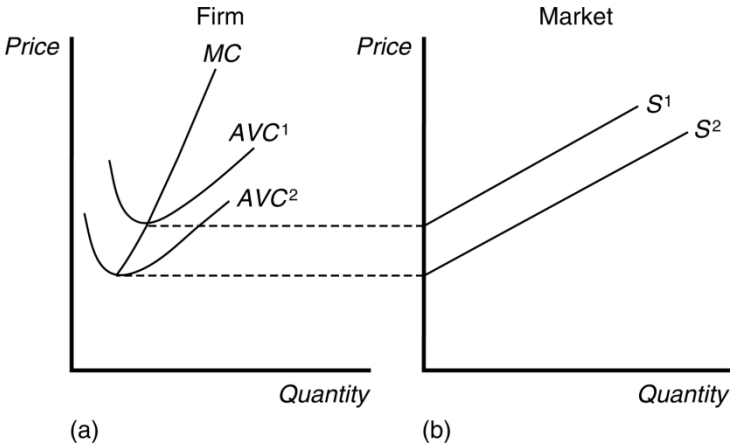

Figure 8.7

11. a. Since Lesotho is a price taker in the world market, the demand curve it faces is a horizontal line.
    b. The increase in Chinese exports shifts its demand curve downward.
    c. The change in exchange rate makes its exports more expensive relatively, and further shifts down its demand curve.
    d. See Figure 8.8. When the price falls below p_1, the firms will experience an economic loss. If the price falls below p_2, the firms will shut down in the short run. If the losses continue in the long run, firms will exit the industry.

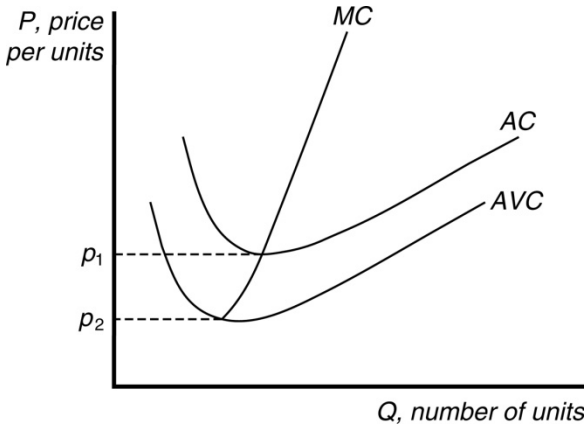

Figure 8.8

12. Figure 8.9 shows the effects of China's entry into the generic art market. Without Chinese exports, the world supply curve starts with country *A*, whose cost is only higher than that of China. With large amount of Chinese exports, the world supply curve is dominated substantially by Chinese exports, as indicated by the first section of the supply curve.

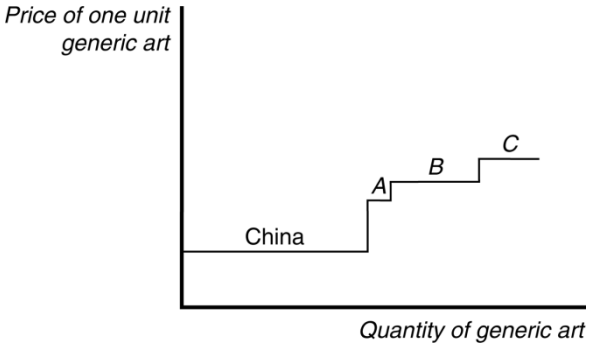

Figure 8.9

13. As shown in Figure 8.10, due to the lower average cost, the long-run average cost curve shifts downward and firms' supply curves shift rightward. As a result, the horizontal market supply curve shifts downward.

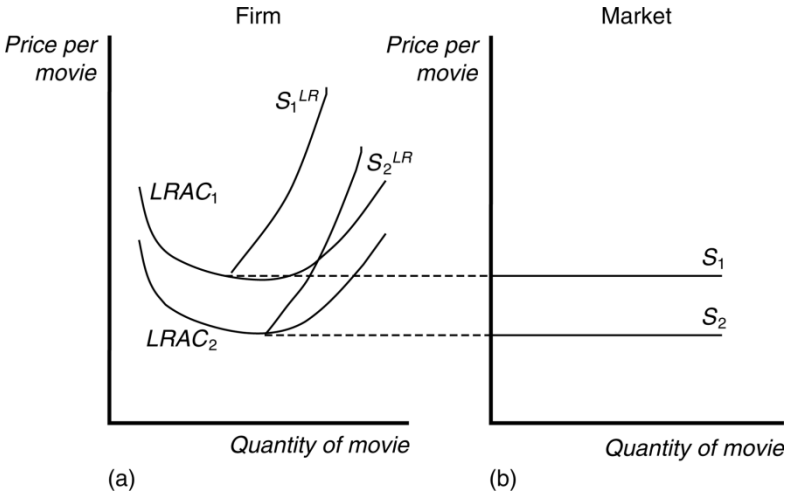

Figure 8.10

14. Audio-PowerPoint answer by James Dearden is also available (8A Kodak Exit Decision).

The firm exits if its profit is negative, i.e.,

$$p(q^*) = P^*q^* - C(q^*) < 0,$$

where q^* is the optimum output. Divide both sides by q^*, and we get:

$$P^* - AC(\mathrm{q}^*) < 0.$$

Therefore the firm exits if the price is less than its average cost.

15. Audio-PowerPoint answer by James Dearden is also available (8B Gasoline Prices).
    a. The marginal cost at the retail level shifts up at each point vertically by the price increase in the wholesale price. We know the supply curve is the portion of *MC* above the minimum average variable cost. Therefore the firm supply curve shifts up vertically by the price increase in the wholesale price.
    b. The market supply curve is the horizontal summation of each individual curve. Therefore the market supply curve also shifts up.
    c. The supply curve shifts up by $\$x$. Assuming the demand curve is downward sloping, the increase in price will be less than $\$x$.
    d. The average cost shifts up by $\$x$, but the price rises by less than $\$x$. Therefore the profit margin becomes smaller.
    e. Suppose that there are two firms—one with high cost and the other with low cost. After the wholesale price increase by $\$x$, the average and marginal cost curves for both firms go up by $\$x$ but the price will increase by less than $\$x$. It is possible that at the optimum level of production ($P = MC$) the high-cost firm loses money (its economic profit is negative), and for the low-cost firm the profit is positive. Therefore the high-cost firm should exit the market.

16. Audio-PowerPoint answer by James Dearden is also available (8C Natural Gas).
    a. We assume there are three Fields: 1, 2, and 3. We also assume that Field 3 is the deepest and Field 2 is less deep, and Field 1 is the shallowest. This implies that the fixed cost and marginal cost of the first field will be lower than that of the other two fields. Let's suppose that *MC* of each field is constant, therefore the cost function will be a positively-sloped straight line. If we put the cost function of each field on top of the other we get a step function. The cost function of the first field will be at the bottom, and for the Field 3 will be on the top. At each step the cost function rises by the fixed cost.
    b. See Figure 8.11. The marginal cost curve will be a step function. If $P^* > MC^1$, the firm will produce q^1. If $P^* > MC^2$, it will produce q^2, and so on.

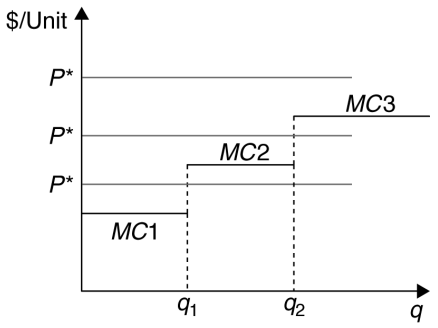

Figure 8.11

17. One reason that firms increase the price of coffee only 14% may be that the demand of coffee is elastic. On the other hand, since the roast coffee producers do not have good substitute for raw coffee beans, they have to bear the burden of a large portion of the increase in raw coffee beans.

18. a. See Figure 8.12, the firm's supply curve shifts leftward due the storm. As a result, the market supply curve shifts leftward as well.
    b. Whether Tomato Fest suffered an economic loss in this case depends on the demand elasticity, which determines how the price responds to a lower supply. In this situation, an "economic loss" is defined as negative profit.

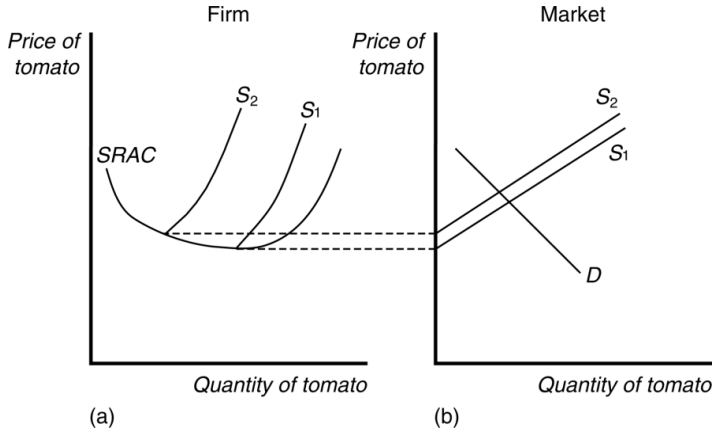

Figure 8.12

19. As shown in Figure 8.13, the profit first increases with the days of vacations and then decreases with it. The profit is maximized if D^* days of vacations are taken.

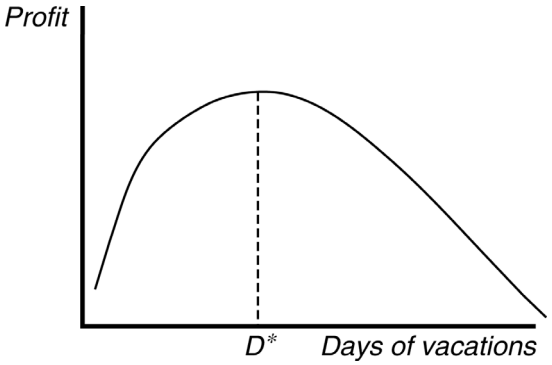

Figure 8.13

20. If the world demand curve crosses the supply curve in the flat section of the Brazil supply, there will be a unique equilibrium price and likely multiple equilibrium quantities along that section. Similarly, if the world demand curve crosses the supply curve in the following vertical section, there will be a unique equilibrium and likely multiple equilibrium prices. In either case, farmers in the United States will not produce cotton.

21. The logic behind the first claim is that the firm chooses not to charge the full price of one of the inputs, the rent. The logic for the second claim is that since it is charged a lower price for one of the inputs, the output price is also lower.

22. In either case, marginal cost is unaffected. The only difference is the magnitude of the upward shift in average cost. If the tax is collected every year instead of only once but the total amounts are equal, the average cost curve is shifted up by more due to the increase in the tax. Long-run supply is also shifted upward due to the increase in the minimum point of the average cost.

23. In the short run, since there is no change in marginal cost, there will be no change in the equilibrium output level or price. Profits will be reduced by the amount of the tax. The only exception is if the firms were close enough to the shutdown point such that payment of the tax increases losses beyond fixed costs (assuming payment of the tax is not required if the firm shuts down). In this case, with identical firms, equilibrium quantity drops to zero.

24. Such a tax will not affect the marginal cost. However, the tax incidence will be shared by the grocers and the consumers. The amount of tax passed on to consumers will be determined by the demand elasticity of grocery bags.

25. The shutdown notice reduces the firm's flexibility, which matters in an uncertain market. If conditions suddenly change, the firm may have to operate at a loss for six months before it can shut down. This potential extra expense of shutting down may discourage some firms from entering the market initially.

26. See Figure 8.13. In this case the firm is producing more than the long-run profit-maximizing output level of 110. Profits are currently equal to area *abcd* but would be increased to area *ebfg* with the optimal plant size.

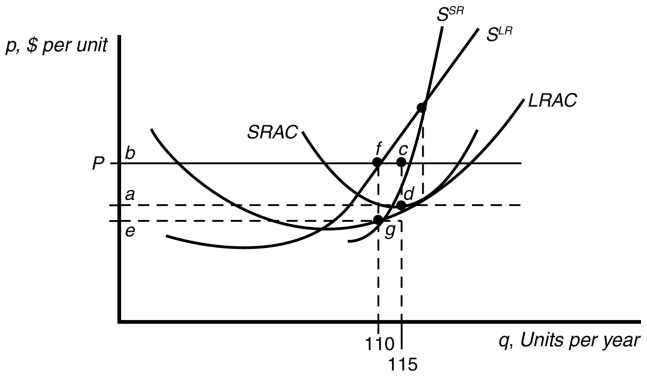

Figure 8.14

27. No. Although horizontal factor supply curves would generate a horizontal firm supply curve, it could also be that one input increases in cost at the same rate and that another decreases in cost. In either case, as firm and industry output expands, average cost will remain unchanged and the industry long-run supply curve will be horizontal.

28. If Arizona starts collecting a specific tax (a) on its firms, then they may be driven from the market. Assuming that firms in California and Arizona have initial costs to start, a specific tax on Arizona oranges could have two possible effects. If there is unlimited entry by California firms, the long-run supply curve will be unaffected and all Arizona firms will be driven from the market due to their cost disadvantage. If entry in California is limited, then the long-run supply curve becomes a step function, as shown in Figure 8.15. All output up to Q_C would be supplied by California firms, after which costs (and so the supply curve) shift upward by the amount of the tax for output supplied by Arizona firms.

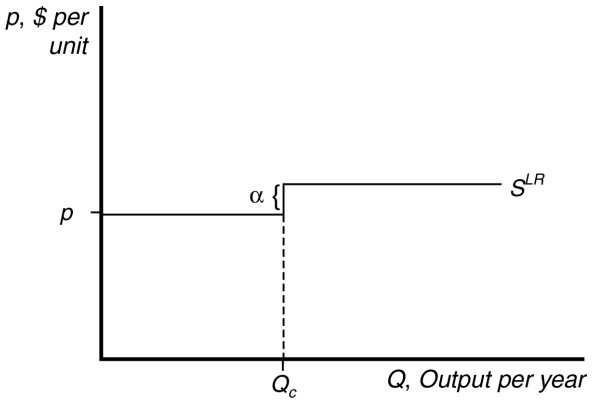

Figure 8.15

29. See Figure 8.16. In panel (b), a decrease in the demand for real trees caused by the increase in artificial tree sales shifts the demand curve to the left. The supply curve shifts to the left due to the decreased number of tree growers. The result is an increase in price to $26.50, and a decrease in quantity to 33 million. In panel (a), each retail tree seller purchases trees at an average cost of $20, and sells for the market price of $26.50.

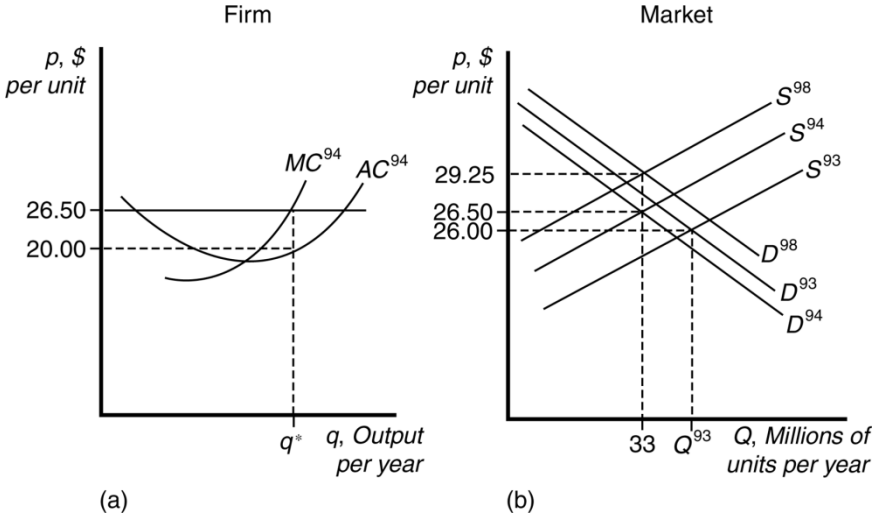

Figure 8.16

30. When the bribes lose their tax-deductible status, the cost of making a bribe increases. The supply curve shifts to the left, just as it would if a tax were enacted (similar to Figure 8.10). The increase in the price of bribes reduces the equilibrium quantity. In the product market, if we view the bribes as part of the cost of doing business, an increase in the cost of bribing foreign officials would shift the marginal cost curve upward in the product markets, reducing the supply.

31. If importers were allowed to bring gas to California at a 15-cent surcharge, it would not alter the normal equilibrium, as shown as p^*, G^* in Figure 8.17. However, a large leftward shift of the supply curve would prevent prices from rising above $p^* + 0.15$. In the graph, the horizontal portion of the supply curve represents imported gas at the surcharge price. As a result of these imports, prices rise only to $p^* + 0.15$ and quantity is G^I, instead of a price increase to p' and a drop to the "no import" level G^{NI}.

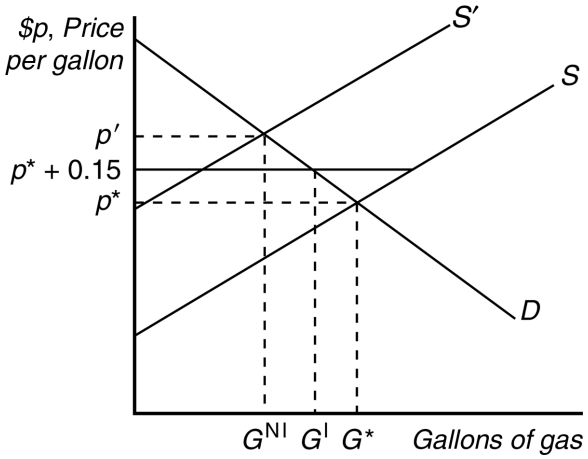

Figure 8.17

32. Marginal cost is computed by taking the derivative dC/dq. Profits are maximized by setting $MC = MR = p$. For the function given, $MC = 10 - 2q + q^2$. Thus profits are maximized when $p = 10 - 2q + q^2$. The supply curve is $p = 10 - 2q + q^2$ for $P > 9.25$.

33. The competitive firm's marginal cost function is found by differentiating its cost function with respect to quantity: $MC(q) = \mathrm{d}C(q)/\mathrm{d}q = b + 2cq + 3dq^2$. The firm's necessary profit-maximizing condition is $p = MC = b + 2cq + 3dq^2$. The firm solves this equation for q for a specific price to determine its profit-maximizing output.

34. In the long run, price equals marginal cost, and profits are zero. Thus given that industry output $Q = nq$, the following will be true in long-run equilibrium, $p = 24 - nq$. Therefore,

$$24 - nq = 2q$$
$$(24 - nq)q = 16 + q^2.$$

Solving these equations for q, n, Q, and p yields

$$q = 4$$
$$n = 4$$
$$Q = 16$$
$$p = 8.$$

35. Because the clinics are operating at minimum average cost, a lump-sum tax that causes the minimum average cost to rise by 10% would cause the market price of abortions to rise by 10%. Based on the estimated price elasticity of between –0.70 and –0.99, the number of abortions would fall to between 7% and 10%. A lump-sum tax shifts upward the average cost curve but does not affect the marginal cost curve. Consequently, the market supply curve, which is horizontal and the minimum of the average cost curve, shifts up in parallel.

36. To derive the expression for the elasticity of the residual or excess supply curve in Equation 8.17, we differentiate the residual supply curve, Equation 8.16, $S^r(p) = S(p) - D^o(p)$, with respect to p to obtain

$$\frac{dS^r}{dp} = \frac{dS}{dp} - \frac{dD^o}{dp}.$$

Let $Q_r = S^r(p)$, $Q = S(p)$, and $Q_o = D(p)$. We multiply both sides of the differentiated expression by p/Q_r, and for convenience, we also multiply the second term by $Q/Q = 1$ and the last term by $Q_o/Q_o = 1$:

$$\frac{dS^r}{dp}\frac{p}{Q_r} = \frac{dS}{dp}\frac{p}{Q_r}\frac{Q}{Q} - \frac{dD^o}{dp}\frac{p}{Q_r}\frac{Q_o}{Q_o}.$$

We can rewrite this expression as Equation 8.17 by noting that $\eta_r = (dS^r/dp)(p/Q_r)$ is the residual supply elasticity, $\eta = (dS/dp)(p/Q)$ is the market supply elasticity, $\varepsilon_o = (dD^o/dp)(p/Q_o)$ is the demand elasticity of the other countries, and $\theta = Q_r/Q$ is the residual country's share of the world's output (hence $1 - \theta = Q_o/Q$ is the share of the rest of the world). If there are n countries with equal outputs, then $1/\theta = n$, so this equation can be rewritten as $\eta_r = n\eta - (n-1)\varepsilon_o$.

37. See the text for details:
    a. The incidence of the federal specific tax is shared equally between consumers and firms, whereas firms bear virtually none of the incidence of the state tax (they pass the tax on to consumers).
    b. From Chapter 2, we know that the incidence of a tax that falls on consumers in a competitive market is approximately $\eta/(\eta - \varepsilon)$. Although the national elasticity of supply may be a relatively small number, the residual supply elasticity facing a particular state is very large. Using the analysis about residual supply curves, we can infer that the supply curve to a particular state is likely to be nearly horizontal—nearly perfectly elastic. For example, if the price rises even slightly in Maine relative to Vermont, suppliers in Vermont will be willing to shift up to their entire supply to Maine. Thus we expect the incidence on consumers to be nearly one from a state tax but less from a federal tax, consistent with the empirical evidence.
    c. If all 50 states were identical, we could write the residual elasticity of supply, Equation 8.17, as $\eta_r = 50\eta - 49\varepsilon_o$. Given this equation, the residual supply elasticity to one state is at least 50 times larger than the national elasticity of supply, $\eta_r \geq 50\eta$, because $\varepsilon_o < 0$, so the $-49\varepsilon_o$ term is positive and increases the residual supply elasticity.

38. Each competitive firm wants to choose its output q to maximize its after-tax profit: $\pi = pq - C(q) - \mathcal{L}$. Its necessary condition to maximize profit is that price equals marginal cost: $p - \mathrm{d}C(q)/\mathrm{d}q = 0$. Industry supply is determined by entry, which occurs until profits are driven to zero (we ignore the problem of fractional firms and treat the number of firms, n, as a continuous variable): $pq - [C(q) + \mathcal{L}] = 0$. In equilibrium, each firm produces the same output, q, so market output is $Q = nq$, and the market inverse demand function is $p = p(Q) = p(nq)$. By substituting the market inverse demand function into the necessary and sufficient condition, we determine the market equilibrium (n^*, q^*) by the two conditions:

$$p(n^*q^*) - dC(q^*)/dq = 0,$$
$$p(n^*q^*)q^* - [C(q^*) + \mathcal{L}] = 0.$$

For notational simplicity, we henceforth leave off the asterisks. To determine how the equilibrium is affected by an increase in the lump-sum tax, we evaluate the comparative statics at $\mathcal{L} = 0$. We totally differentiate our two equilibrium equations with respect to the two endogenous variables, n and q, and the exogenous variable, $\mathcal{L}$:

$$dq(n[dp(nq)/dQ] - d^2C(q)/dq^2) + dn(q[dp(nq)/dQ]) + d\mathcal{L}\,(0) = 0,$$
$$dq(n[qdp(nq)/dQ] + p(nq) - dC/dq) + dn(q^2[dp(nq)/dQ]) - d\mathcal{L} = 0.$$

We can write these equations in matrix form (noting that $p - dC/dq = 0$ from the necessary condition) as

$$\begin{bmatrix} n\dfrac{dp}{dQ} - \dfrac{d^2C}{dq^2} & q\dfrac{dp}{dQ} \\ nq\dfrac{dp}{dQ} & q^2\dfrac{dp}{dQ} \end{bmatrix} \begin{bmatrix} dq \\ dn \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} d\mathcal{L}.$$

There are several ways to solve these equations. One is to use Cramer's rule. Define

$$\begin{aligned} D &= \begin{vmatrix} n\dfrac{dp}{dQ} - \dfrac{d^2C}{dq^2} & q\dfrac{dp}{dQ} \\ nq\dfrac{dp}{dQ} & q^2\dfrac{dp}{dQ} \end{vmatrix} \\ &= \left(n\frac{dp}{dQ} - \frac{d^2C}{dq^2}\right)q^2\frac{dp}{dQ} - q\frac{dp}{dQ}\left(nq\frac{dp}{dQ}\right) \\ &= -\frac{d^2C}{dq^2}q^2\frac{dp}{dQ} > 0, \end{aligned}$$

where the inequality follows from each firm's sufficient condition. Using Cramer's rule:

$$\frac{dq}{d\mathcal{L}} = \frac{\begin{vmatrix} 0 & q\dfrac{dp}{dQ} \\ 1 & q^2\dfrac{dp}{dQ} \end{vmatrix}}{D} = \frac{-q\dfrac{dp}{dQ}}{D} > 0, \quad \text{and}$$

$$\begin{aligned} \frac{dn}{d\mathcal{L}} &= \frac{\begin{vmatrix} n\dfrac{dp}{dQ} - \dfrac{d^2C}{dq^2} & 0 \\ nq\dfrac{dp}{dQ} & 1 \end{vmatrix}}{D} \\ &= \frac{n\dfrac{dp}{dQ} - \dfrac{d^2C}{dq^2}}{D} < 0. \end{aligned}$$

The change in price is

$$\frac{dp(nq)}{d\mathcal{L}} = \frac{dp}{dQ}\left[q\frac{dn}{d\mathcal{L}} + n\frac{dq}{d\mathcal{L}}\right]$$
$$= \frac{dp}{dQ}\left[\frac{\left(n\frac{dp}{dQ} - \frac{d^2C}{dq^2}\right)q}{D} - \frac{nq\frac{dp}{dQ}}{D}\right]$$
$$= \frac{dp}{dQ}\left(\frac{-\frac{d^2C}{dq^2}q}{D}\right) > 0.$$

39. After-tax profit is $\overline{\pi} = (1-\alpha)pq - C(q)$ and the profit-maximizing output after the tax is imposed is:

$$\frac{\partial \overline{\pi}(q)}{\partial q} = (1-\alpha)p - \frac{\partial C(q)}{\partial q} = 0 \quad \text{or} \quad p - MC(q)(1-\alpha)^{-1} = 0$$

the first order condition. Differentiating this with respect to the ad valorem tax rate α yields:

$$-\frac{\partial MC}{\partial q}\frac{\partial q}{\partial \alpha}(1-\alpha)^{-1} - MC(q)(1-\alpha)^{-2} = 0$$

and rearranging:

$$\frac{\partial q}{\partial \alpha} = -\frac{MC(q)}{\frac{\partial MC}{\partial q}(1-\alpha).} < 0$$

40. Solution provided in Jim Dearden's audio presentation.

a. The total cost function is:

$$\boldsymbol{C(q)} = 6860 + \left(\boldsymbol{p_T} + \boldsymbol{t} + \frac{7}{12}\right)\boldsymbol{q} + \frac{37}{27{,}000{,}000}\boldsymbol{q}^3 = 6860 + \frac{169}{12}\boldsymbol{q} + \frac{37}{27{,}000{,}000}\boldsymbol{q}^3,$$

then the marginal cost function is:

$$\boldsymbol{MC(q)} = \frac{\partial \boldsymbol{C(q)}}{\partial \boldsymbol{q}} = \frac{169}{12} + \frac{37}{9{,}000{,}000}\boldsymbol{q}^2$$

b. The average variable cost function is:

$$\boldsymbol{AVC(q)} = \frac{\boldsymbol{VC(q)}}{\boldsymbol{q}} = \left(\boldsymbol{p_T} + \boldsymbol{t} + \frac{7}{12}\right) + \frac{37}{27{,}000{,}000}\boldsymbol{q}^2 = \frac{169}{12} + \frac{37}{27{,}000{,}000}\boldsymbol{q}^2.$$

Therefore, the shutdown price $= \min_{q} \boldsymbol{AVC(q)} = \min_{q} \frac{169}{12} + \frac{37}{27{,}000{,}000}\boldsymbol{q}^2 = \frac{169}{12}.$

c. Since the short-run supply function is the segment of the marginal cost function above the average variable cost function, and since

$$\boldsymbol{MC}(\boldsymbol{q}) = \frac{169}{12} + \frac{37}{9{,}000{,}000}\boldsymbol{q}^2 \geq \frac{169}{12} + \frac{37}{27{,}000{,}000}\boldsymbol{q}^2 = \boldsymbol{AVC}(\boldsymbol{q}),$$

the marginal cost curve is always above the average variable cost curve. Thus the short-run supply function is just the solution q^* to: $\boldsymbol{p} = \boldsymbol{MC}(\boldsymbol{q})$. Solving this equation, we can obtain the short-run supply function:

$$\boldsymbol{S}(\boldsymbol{p}) = \boldsymbol{q}^* = 300\left(\frac{\boldsymbol{p} - \frac{169}{12}}{37}\right)^{\frac{1}{2}} = 300\left(\frac{\boldsymbol{p} - (\boldsymbol{p}_T + \boldsymbol{t} + \frac{7}{12})}{37}\right)^{\frac{1}{2}}$$

d. $$\frac{\partial \boldsymbol{S}(\boldsymbol{p},\boldsymbol{t})}{\partial \boldsymbol{t}} = -\frac{150}{37}\left(\frac{\boldsymbol{p} - (\boldsymbol{p}_T + \boldsymbol{t} + \frac{7}{12})}{37}\right)^{-\frac{1}{2}} < 0$$

$$\left.\frac{\partial \boldsymbol{S}(\boldsymbol{p},\boldsymbol{t})}{\partial \boldsymbol{t}}\right|_{\boldsymbol{p}_T = 11.5,\, \boldsymbol{t}=2} = -\frac{150}{37}\left(\frac{\boldsymbol{p} - (\boldsymbol{p}_T + \boldsymbol{t} + \frac{7}{12})}{37}\right)^{-\frac{1}{2}}\Bigg|_{\boldsymbol{p}_T = 11.5,\, \boldsymbol{t}=2}$$

$$= -\frac{150}{37}\left(\frac{\boldsymbol{p} - \frac{169}{12}}{37}\right)^{-\frac{1}{2}} = -\frac{150}{37}\left(\frac{\boldsymbol{p} - \frac{169}{12}}{37}\right)^{-\frac{1}{2}}$$

$$= -\frac{300\sqrt{3}}{\sqrt{444\boldsymbol{p} - 6253}} < 0$$

41. Solution provided in Jim Dearden's audio presentation.

a. 8-year-old Joe's total cost function is: $\boldsymbol{C}(\boldsymbol{q}) = 180 + 0.15\boldsymbol{q}$.

His marginal cost function is: $\boldsymbol{MC}(\boldsymbol{q}) = \dfrac{\boldsymbol{dC}(\boldsymbol{q})}{\boldsymbol{dq}} = 0.15.$

His average variable cost function is: $\boldsymbol{AVC}(\boldsymbol{q}) = \dfrac{\boldsymbol{VC}(\boldsymbol{q})}{\boldsymbol{q}} = 0.15.$

Therefore his shutdown price = 0.15.

b. 17-year-old Joe's total cost function is:

$$\boldsymbol{C}(\boldsymbol{q}) = \begin{cases} 180 + 0.15\boldsymbol{q} + 6 \cdot \dfrac{\boldsymbol{q}}{5} = 180 + 1.35\boldsymbol{q}, & \text{if } \boldsymbol{q} \leq 6 * 5 = 30 \\ 180 + 36 + 0.15\boldsymbol{q} + 6 \cdot \dfrac{(\boldsymbol{q} - 30)}{5} + \left(\dfrac{\boldsymbol{q} - 30}{5}\right)^2 = 216 - 1.05\boldsymbol{q} + 0.04\boldsymbol{q}^2, & \text{if } \boldsymbol{q} > 30. \end{cases}$$

Then his marginal cost function is:

$$\boldsymbol{MC}(\boldsymbol{q}) = \frac{\boldsymbol{dC}(\boldsymbol{q})}{\boldsymbol{dq}} = \begin{cases} 1.35, & \text{if } \boldsymbol{q} \le 30 \\ -1.05 + 0.08\boldsymbol{q}, & \text{if } \boldsymbol{q} > 30. \end{cases}$$

Since his average variable cost function is:

$$\boldsymbol{AVC}(\boldsymbol{q}) = \frac{\boldsymbol{VC}(\boldsymbol{q})}{\boldsymbol{q}} = \begin{cases} 1.35, & \text{if } \boldsymbol{q} \le 30 \\ 0.15 + 6 \cdot \dfrac{(\boldsymbol{q} - 30)}{5\boldsymbol{q}} + \dfrac{\left[(\boldsymbol{q} - 30)/5\right]^2}{\boldsymbol{q}} = \dfrac{\boldsymbol{q}}{25} - 1.05, & \text{if } \boldsymbol{q} > 30, \end{cases}$$

Therefore the shutdown price = 1.35.

c. The shutdown prices of 8-year-old Joe and 17-year-old Joe are different. Since 17-year old Joe's costs are higher, his shutdown price is also higher.