Chapter 14
Oligopoly and Monopolistic Competition

■ Chapter Outline

14.7 Bertrand Oligopoly Model
- Bertrand Equilibrium with Identical Products
  - Best-Response Curves
  - Bertrand Versus Cournot
- Nash-Bertrand Equilibrium with Differentiated Products
  - General Demand Functions
  - Cola Market
  - Product Differentiation and Welfare

14.8 Monopolistic Competition
- Monopolistically Competitive Equilibrium
- Fixed Costs and the Number of Firms

■ Teaching Tips

Chapter 14 begins with a general description of market structures that lie between perfect competition and monopoly in the competitive spectrum. Table 14.1 in the text provides a good summary of eight characteristics of various market structures, plus an example of each. It would be well worth the time to begin this section by discussing this table with the class and asking the students to come up with additional examples of each market structure.

There are a number of models presented in this chapter and the next, and you may not have time to cover all of them. If they are presented too quickly in succession, students are more likely to get confused between the models and their outcomes. You might consider introducing game theory as the primary method of analysis, and discuss other approaches (e.g., the graphical approach to the Cournot and Stackelberg models) in the context of game theory.

When presenting game theory, consider dividing the class into small groups before making any formal presentation of types of equilibria and strategic rules. Give each group three or four games to solve, including a simple zero-sum game, a dominant strategy equilibrium where players follow a given strategy no matter what the other does, and a Nash equilibrium where the payoffs create a prisoners' dilemma. (The Additional Questions and Problems section in this chapter includes sample payoff matrices.) You can ask the groups to simply play the games at first, under the following rules. First, assume that each player must move simultaneously, and that no cooperation is allowed. Second, allow collusion between players, and third, assume that one player gets to move first. Finally, you could ask the groups to try to write down general decision-making rules for players, and note if they need to modify those rules when the game is played repeatedly. If you try this, you may find that students are quite good at identifying strategic decision-making rules once they understand the games. By asking students to play the games first, you can then go back through the various outcomes and identify them as Cournot, cartel, and so on. One of the great advantages of game theory is that by simply changing the rules, the same payoff matrix can be evaluated more than once, with different outcomes. You can return to this discussion when covering the final section of the chapter on the comparison of output, price, and welfare effects for the various models, which can also be related back to the game theory examples in Chapter 13.

The text contains a large number of examples in the cartel section that illustrate the inefficiencies caused by cartels if they succeed, and the difficulties that they face that often lead them to fail. One point to stress is that this is the only model in which firms are asked to produce where marginal cost is not equal to marginal revenue, and make note of the incentive to cheat that is created by this divergence. In addition to the examples in the text, one of the great examples of the punishment not fitting the crime for a cartel was the United

States Football League successful antitrust suit against the NFL in which they were awarded a judgment of $3. Despite winning the case, the lack of any significant award helped to end the USFL's effort to form a competing league. Since that decision, no serious effort to launch another competing league has been attempted.

If you cover the Cournot and Stackelberg models using algebra and graphs, you may want to keep the functions as simple as possible in order to maintain the focus on reaction functions and residual demand. With all models of oligopoly, the behavior of the firms at a conceptual level is a prerequisite to understanding the mechanics of solutions. Once the class gets going, they can often think of many examples of rival firms that coincide with these models. In cases where they appear to find contradictions, it is often a misunderstanding of the assumptions of the model.

The model of monopolistic competition can be covered fairly quickly through a description of Figure 14.8 in the text. Students should be able to think of many examples in this industry among the consumer products they routinely buy such as clothing. As part of the minimum efficient scale discussion, you might note the trade-off between the efficiency of perfect competition and utility derived from nonhomogeneity of product.

■ Additional Applications

Combining Soft Drinks[1]

In 1986, Coke, the largest producer of carbonated soft drinks (38.6% market share), tried to buy the third largest firm, Dr. Pepper (7.1% share). Also, Pepsi (27.4% share) tried to acquire the fourth largest firm, Seven-Up Co. (6.3% share). Had these proposed mergers taken place, Coke's market share would have risen to 45.7% and Pepsi's to 33.7%. Their combined share would have gone from 66% to 79.4%.

The mergers were not consummated. The Federal Trade Commission (FTC) opposed these mergers on the grounds that they would increase the market shares of these firms, make entry more difficult, and "ease collusion among the participants in the relevant markets."

Later in 1986, after Coke's and Pepsi's proposed mergers were blocked, both Dr. Pepper and Seven-Up were sold. Dr. Pepper Co. was sold for $416 million to an investor group, and Seven-Up Co. was sold for $240 million to another investment group. Coke had offered $470 million for Dr. Pepper Co., which means that owners of Dr. Pepper got $54 million less than they would have had they sold to Coke for $470 million. Similarly, the owners of Seven-Up, Philip Morris Co., got $140 million less than Pepsi's bid of $380 million. That Dr. Pepper and Seven-Up had lower value to others than to Coke and Pepsi is consistent with the FTC's view that Coke and Pepsi would have gained market power through these mergers. (This result may also be consistent, however, with the view that the larger firms could have more efficiently marketed the other firm's brands.)

Eventually, Dr. Pepper and Seven-Up merged. By 1995, Dr. Pepper/Seven-Up had 11.5% of the carbonated beverage market and Cadbury had 5.5%, with its Schweppes, Canada Dry, Crush, Sunkist, and A&W brands. In 1995, Cadbury bought Dr. Pepper/Seven-Up. The new firm's market share was 17% of the carbonated drink market and 50% of the noncola market. Coke's share was 41% and Pepsi's 32% of the carbonated drink market.

[1]Oswald Johnston, "Coke and Pepsi Proposals Face Close Scrutiny," *Los Angeles Times,* February 24, 1986: Part 4, p.1; Jube, Shiver Jr. "RC Takes Fight on Coke, Pepsi Deals to Public," *Los Angeles Times,* June 12, 1986; Nathaniel C. Nash, "Seven-Up Sale to Pepsico Canceled," *New York Times,* August 21, 1986:D1; "Soft Drinks and Other Trusts," *New York Times,* June 27, 1986:A34; Jube Shiver Jr. "Forstman, Little, Will Sell Dr. Pepper for $416 Million," *Los Angeles Times,* August 21, 1986: Part IV, 1–2; Glen Collins, "Cadbury Purchases Dr. Pepper," *New York Times,* January 27, 1995:C1 and C5.

Thus mergers have increased the share of the industry controlled by the top three firms. The FTC's actions, however, have limited the share controlled by the top two firms. As Jesse Meyers, publisher of *Beverage Digest*, an industry newsletter, observed, "(W)orld-wide, Coca-Cola is the gorilla, Pepsi is the younger gorilla in several markets, and now Cadbury will definitely be a gorilla-ette to be contended with in the world market."

1. Do you think the original proposed mergers might have been accepted in today's market, with the emergence of iced teas as popular soft drinks, even though they are noncarbonated?

2. What do you believe are important sources of scale economies in soft drink marketing?

Are Universities Cartels?[2]

Gordon K. Davies, the former executive officer of the Virginia State Council of Higher Education, believes that the state university systems in the United States have historically functioned as cartels. Could it be that these institutions will go the way of so many cartels before—failing in the face of competitive force? Davies thinks so. Because they are unable to prevent entry to the education market by more agile, technologically efficient, for-profit universities such as the University of Phoenix and the Graduate School of America, state universities' market position is severely threatened.

At the core of the problem for state university systems are fundamental changes in demand and supply that have eroded their traditional entry barriers. On the demand side, accreditation and recognition by external constituents (both students and employers) are now driven by the highly vocational focus of today's students and their focus on employment as the desired outcome of an education. "We will see a market for education that leads directly and immediately to employment," Davies says. In addition, firms are now looking to private universities, unburdened by the traditional constraints, to solve their training needs. According to Davies, "AT&T has contracted with the University of Phoenix for employee training, for example, citing the institution's responsiveness." Davies believes that if accreditation bodies do not become more flexible, they risk replacement by entities similar to *Consumer Reports.*

On the supply side, changes in technology now allow for the delivery of courses to students without the need for students to sit in a traditional classroom. The ability to offer courses electronically means that geographic market edges may be blurred, if not gone altogether, and that education can be customized to fit the needs of the student and/or employer at very low cost. "(E)ntry into the market of large-scale, national providers of electronic courses changes everything," remarks Davies. He recommends that state university systems form alliances similar to athletic conferences to collaborate on the delivery of electronic education.

1. What do you predict will happen to the price of education as more firms enter the market? Are there quality issues that must be considered?

2. How are the definitions of the product and units of output important to the study of the education market?

3. Is competition in the education market a good thing?

[2]Gordon K. Davies, "Point of View: Higher Education Systems as Cartels: The End Is Near," *The Chronicle of Higher Education,* October 3, 1997:A68.

DeBeers Pleads to Price Fixing to Reenter U.S. Market[3]

DeBeers SA, the huge diamond company, pleaded guilty recently to price fixing and agreed to pay $10 million to settle a 10-year-old indictment. This action will allow the company to start doing business directly with the American market.

Based in London and South Africa, DeBeers controls 60% of all rough, uncut diamonds sold worldwide. It already reaches U.S. consumers through intermediaries, including diamond distributors and marketing firms. So this action may have little impact on diamond prices and market share here. But the settlement will give DeBeers a bigger marketing presence and greater legitimacy with U.S. consumers.

DeBeers is the biggest diamond mining operation in the world, but its dominance of the world's diamond market has been declining in recent years as new mines have opened in Russia, Canada, and Australia and as new varieties of synthetic diamonds—both industrial and gem quality—are being created.

Industry experts say the company may have settled because it was too risky to stay away from the U.S. market when so many new sources of diamonds are emerging.

DeBeers's competitors said they were expecting such a settlement, though. "DeBeers may recognize that market dynamics are going to change with the introduction of cultured diamonds," said Robert C. Linares, chairman of Apollo Diamond Inc., one of the few makers of new, high-quality synthetic diamonds for both the jewelry and technology markets. Linares added, "It does . . . seem coincidental that their settlement comes at the same time that Apollo Diamond is entering the market with cultured diamonds."

1. What do you think is the major economic reason for DeBeers to change its strategy and plead to price fixing?
2. What would be the possible impact of Apollo Diamond's new product on DeBeers' market power?

■ Discussion Questions

1. Which types of markets are more likely to have cartels and which are less likely? Why?
2. In a prisoners' dilemma game, will prisoners confess to a crime even if they are not guilty? What are the implications of this analysis for our legal system?
3. Should we pass laws to prevent firms offering to "meet or beat" other firm's prices?
4. Should the government engage in strategic trade policies? Why or why not?
5. Some political leaders argue that we should do away with certain antitrust laws to facilitate cooperation between firms in their competition with foreign rivals. Explain or attack this reasoning using the models discussed in the chapter.
6. Should your government subsidize domestic firms to enable them to compete more successfully with foreign rivals?
7. Will the creation of the Euro currency facilitate collusion among EU countries?

[3] Margaret Webb Pressler, "DeBeers Pleads to Price Fixing," *Washington Post,* July 14, 2004, Page E01.

■ Additional Questions and Problems

1. The following game is called a zero-sum game, because the winnings of one player are always taken directly from the other player (such as a market share battle between two firms). In the payoff matrix shown below, payoffs shown are for player *A* (*B* gets minus one times what *A* receives). What strategy would each player select? Does it matter which player gets to choose first? Can you determine a general rule for strategies when the game is zero-sum? Would collusion alter the outcome? Why or why not?

		B	
		B_1	B_2
A	A_1	4	–1
	A_2	2	1

2. In each payoff matrix shown below, determine the strategy of each player assuming they must play simultaneously. Would collusion alter the outcome? Why or why not? Payoffs shown are *A*, *B*.

a.

		B	
		B_1	B_2
A	A_1	4, 2	1, 1
	A_2	2, 1	0, 0

b.

		B		
		B_1	B_2	
A	*A*1	–1, –2	1, –3	
	A_2	2, 3		2, 2

c.

		B	
		B_1	B_2
A	A_1	3, 3	7, 2
	A_2	1, 7	6, 6

3. What types of industries or firms would a local government be most likely to subsidize? Why?

4. Describe, using game theory, the recent rash of professional sports teams receiving generous deals for new stadiums from state and local governments.

5. Suppose the market demand function facing three firms is $Q = 500 - 2p$. Each firm has a marginal cost of \$5 per unit. What is the cartel solution? Suppose instead that one of the firms could supply up to 100 units at $MC = 4$, and the other two firms had a marginal cost of \$5. How would this alter the final output, price, and profit? Does this complicate the division of profits? How?

6. In an industry where any firm can enter the industry and produce according to the cost function $C = 50 + 5q$, what is the optimal number of firms? Does your answer change if there are no fixed costs?

7. True, false, or uncertain; explain your answer. "If all firms charge the same price, they must be colluding." Does your answer create difficulties for those charged with enforcing industrial policy?

8. In a Cournot duopoly, each firm has marginal cost $MC = 20$, and market demand is $Q = 100 - 1/2p$. What are the best response functions of each firm? What is the best output level for each? How does the total output level compare to the cartel output level?

9. Assume that the payoffs in the matrix below are profits from various output choices, based on a non-cooperative game, with *A* as the leader. Because of product tie-ins, the firms must choose to produce either 60 units or 30. No other output levels are possible. Re-write the payoffs in extended "tree" form similar to Figure 13.5 in the text. Payoffs shown are *A*, *B*. What is the equilibrium? How would your answer change if *B* was the leader?

		Player A's Output	
		60	30
Player B's Output	60	3, 3	4, 8
	30	8, 4	6, 6

10. Suppose in Question 9 that movement was simultaneous rather than sequential. Is there a unique equilibrium? If so, what is it? Instead, suppose movement was simultaneous, but collusion were permitted. Would the outcome change?

11. How do a Bertrand equilibrium output and price compare to those of competitive equilibrium?

■ Answers to Additional Questions and Problems

1. In the payoff matrix, player *A*'s highest payoff is in the upper left (A_1, B_1), but *B* regards this as the least preferred. Since *B* will not select B_1, *A* can assure that they will not lose by selecting strategy A_2. This is referred to as a maximin strategy—choosing the strategy with the highest minimum payoff. Player *B* will choose Strategy 2, in an attempt to minimize *A*'s payoff (which also maximizes their own payoff). This is referred to as a minimax strategy. This solution would be the outcome regardless of which player goes first. Collusion would never alter the outcome of a zero-sum game because what is better for one player is, by definition, worse for the other.

2. a. Dominant strategies are A_1, B_1. Collusion would not alter the outcome because there is no other combination in which both players are at least as well off.
   b. Dominant strategies are A_2, B_1. Collusion would not alter the outcome because there is no other combination in which both players are at least as well off.
   c. Prisoners' dilemma. Dominant strategies are A_1, B_1. If the players could collude they would choose A_2, B_2, which has a higher payoff for both.

3. Local governments are most likely to subsidize firms that will bring in large quantities of tax revenue (once the subsidies expire) and employment opportunities. All else equal, a firm that promises to generate the greatest total payroll is likely to receive the highest subsidy offer. Not only does the creation of jobs increase political officials' chances of re-election, but increases in employment in the local economy raise taxes indirectly through real estate, sales, and occupational privilege taxes.

4. Because the teams have the ability to make a credible threat that they will leave and move to another city, they are able to force the current host city into a prisoners' dilemma game against other potential sites. Cities that currently have teams with old stadiums or buildings that lack revenue-enhancing features such as superboxes are aware that other teams in similar circumstances have been lured away by other cities with promises of new buildings and favorable treatment. Thus the cities end up in a battle trying to outbid each other for the right to host a team. This has resulted in numerous heavily debated proposals to issue municipal bonds to construct new stadiums.

5. In a cartel solution, the firms set a monopoly price using $MC = MR$.

$$MR = 250 - Q$$
$$MC = 5$$
$$Q^* = 245$$
$$p^* = 127.5$$

If one firm can supply the first 100 units at $MC = 4$, price and quantity remain unchanged but profits are increased by \$100. This complicates the division of profits because the firms must now agree on how the profits are to be divided, given that they are not generated by equal contributions of each firm.

6. With only one firm, average cost will fall continuously as the \$50 fixed cost is spread across increasing quantities of output. Thus the optimal number of firms from a cost standpoint is one. If there are no fixed costs, there is neither an advantage nor a disadvantage to adding additional firms, as any firm can produce at the same marginal cost.

7. Uncertain. If all firms in an industry have the same cost function, they will naturally end up charging the same price without collusion. The difficulty that this creates for the Federal Trade Commission and the Justice Department is that it complicates the process of proving collusive behavior.

8. First, calculate the residual demand function.

$$q_1 = 100 - 1/2\, p - q_2$$
$$p = 200 - 2q_1 - 2q_2$$

Then, to derive the best-response function, set $MC = MR$ for each firm.

$$MR_1 = 200 - 4q_1 - 2q_2 = 20 \qquad MR_2 = 200 - 2q_1 - 4q_2 = 20$$
$$q_1 = 45 - 1/2\, q_2 \qquad q_2 = 45 - 1/2\, q_1$$

The equilibrium output level for each firm is

$$q_1 = 45 - 1/2\,(45 - 1/2\, q_1) = 30$$
$$q_2 = 45 - 1/2\,(45 - 1/2\, q_2) = 30.$$

The cartel output level is 45 (obtained by setting market MR equal to MC). Thus the Cournot output level is 1/3 greater than that of the cartel.

9. See Figure 14.1. Firm A as the leader will choose to produce 60, knowing that B's best response is to produce 30. Because the matrix is symmetric, the game players would end up with the same total output but would produce 60, and A would produce 30.

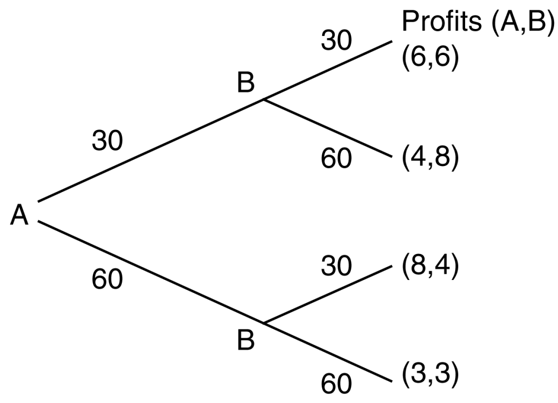

Figure 14.1

10. If movement were simultaneous, there is no unique equilibrium because neither player has a dominant strategy. There is no combination of choices that results in a payout that both players will choose to keep even if the other player commits to not changing, and neither can make a credible threat to try to force a favorable outcome. If collusion were allowed, both players should realize the lack of equilibrium and agree to each produce 30 units.

11. The Bertrand equilibrium has the same output and price as the competitive equilibrium.

■ Answers to Questions and Problems in the Text

1. See Figure 14.1 in the text. Each cartel member has incentive to cheat, reasoning that one country increasing the output will not change the price much. At the same time, since the marginal revenue is above marginal cost, by producing more oil than the agreed-upon amount, it can make additional profit.

2. The monopoly will make more profit than the duopoly will, so the monopoly is willing to pay the college more rent. Although granting monopoly rights may be attractive to the college in terms of higher rent, students will suffer (lose consumer surplus) because of the higher textbook prices.

3. Assume that markets with multiple bail-bond firms (n firms) are oligopolistic, produce a homogenous good, face a linear inverse market demand of $p = a - bQ$, and have constant marginal costs of m per unit. Also assume that the market outcome is a Cournot-Nash equilibrium.

   Firm 1's profit function is

$$\pi_1 = q_1(a - b(q_1 + q_2 + ... + q_n)) - mq_1.$$

   Firm 1 maximizes profit by first taking the derivative of their profit function with respect their output (q_1):

$$\frac{d\pi_1}{dq_1} = a - b(2q_1 + q_2 + ... + q_n) - m.$$

If all n firms are identical, then in equilibrium $q_1 = q_2 = \ldots = qn = q$. Therefore, setting the first order condition equal to zero and solving for q,

$$q = \frac{a - m}{(n+1)b}.$$

Total market supply is

$$Q = \frac{n(a - m)}{(n+1)b}.$$

Substituting this back into the inverse demand function and solve for p to find the market price the price consumers pay before the tax is

$$p = \left(\frac{a + mn}{n+1}\right).$$

If markets with one or two firms charge prices (fees) that are essentially equal to the maximum, then the state maximum must be no more than $(\frac{a+2m}{3})$, which is the optimal price with n equal to 2, but if markets with more than two firms charge prices (fees) that are less than the maximum, then the state maximum must be greater than $(\frac{a+3m}{4})$, which is the optimal price with n equal to 3.

4. With only one firm, the deadweight loss is equal to the deadweight loss of a monopoly; that is, (243 − 147) × (192 − 96)/2 = (243 − 147) × (243 − 147)/2 = 4608 (see Figure 14.2(a) in the text). With three firms, the deadweight loss is (195 − 147) × (195 − 147)/2 = 1152, decreasing by 75%.

5. See Figure 14.2. The graph shows response curves for the two airlines. The airline with the lower marginal cost produces more: Southwest transports Q_1 passengers and US Airways transports Q_2 passengers. This result is shown algebraically in Solved Problem 14.1.

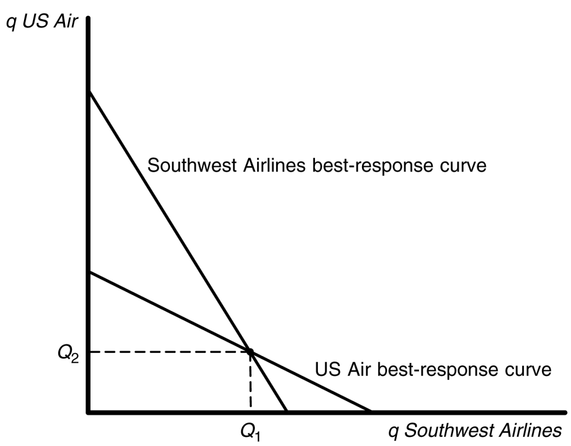

Figure 14.2

6. The increase in price after the exit of one firm is consistent with a Cournot equilibrium, where the equilibrium price is decreasing in the number of firms. We have to assume that the painkillers are homogeneous for this model to work.

7. The best response function of Firm 2 is

$$q_2 = \frac{a - m_2 - bq_1}{2b}.$$

Figure 14.3 shows best-response functions for Firm 1 and Firm 2. If marginal costs of the two firms are equal, then Nash-Cournot outputs of the firms are also equal (equilibrium e_1). Increasing marginal cost of the second firm shifts its best-response function inward, which leads to lower output of Firm 2 (equilibrium e_2).

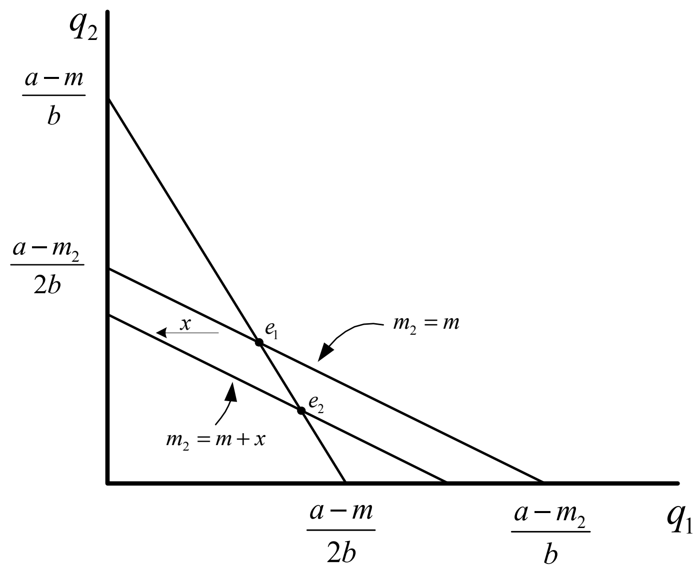

Figure 14.3

8. Governmental subsidy that reduces fixed cost of each firm in an industry would shift each firm's best-response curve rightward, resulting in higher output and lower price in a Cournot monopolistic equilibrium.

9. If there are no fixed costs, $MC = AC$. The two conditions that must hold for a monopolistically competitive equilibrium $MC = MR$, and $p = AC$, cannot hold simultaneously. When $MC = MR$, firms earn positive profits, which violates $p = AC$. The solution is indeterminate.

10. Because firms must bear part of the burden of the tax, profits are reduced. With each firm earning smaller profits, beginning from a point where all firm profits are zero, some firms must exit the industry to restore equilibrium.

11. No. As with the monopolist, there is no unique relationship between price and output. A change in demand may produce a change in price but no change in output, a change in output but not price, or a change in both.

12. In Figure 14.11 in the text, a specific tax increases marginal cost by the amount of the tax. Coke's best-response function shifts upward, and Pepsi's best-response function shifts to the right. The result is that both firms charge higher prices.

13. If the firms are price setters, then we can assume that they are currently in a Bertrand equilibrium. We can evaluate the increase in cost using a figure similar to Figure 14.11 in the text. The increase in marginal cost of between \$70 and \$270 per vehicle will shift the best-response functions outward on their respective axes. The new equilibrium will result in higher prices, but those price increases will not be on the order of \$7000, and will not likely be much different than the increase in marginal cost.

14. If output is homogeneous, the market inverse demand function is $p(Q)$, where Q, the total market output, is the sum of the output of each of the n firms $Q = q_1 + q_2 + \ldots + q_n$. Each of the n identical firms has the same cost function, $C(q_i)$. Firm 1's profit function is

$$\pi_1 = q_1 p(q_1 + q_2 + ... + q_n) - C(q_1).$$

Firm 1 maximizes profit by first taking the derivative of their profit function with respect their output (q_1):

$$\frac{d\pi_1}{dq_1} = p(Q) + q_1 \frac{dp(Q)}{dQ}\frac{dQ}{dq_1} - \frac{dC(q_1)}{dq_1}.$$

If all n firms are identical, then in equilibrium $q_1 = q_2 = \ldots = q_n$. Therefore, setting the first order condition equal to zero and solving for q,

$$\frac{d\pi_1}{dq_1} = p[1 + \frac{q}{p}\frac{dp}{dQ}] - \frac{dC(q_1)}{dq_1}.$$

Multiplying and dividing the last term in parentheses by n, noting that $Q = nq$ (given that all firms are identical), and substituting in the market elasticity of demand, ε, we can rewrite the first-order condition as

$$p\left(1 + \frac{1}{n\varepsilon}\right) = \frac{dC(q)}{dq}$$

or

$$p = \frac{MC}{1 + \frac{1}{n\varepsilon}},$$

where $$MC = \frac{dC(q)}{dq}.$$

Therefore, the optimal price depends on marginal costs but not fixed costs. Furthermore, the effect of an increase in marginal cost (MC) is

$$\frac{dp}{dMC} = \frac{1}{1 + \frac{1}{n\varepsilon}}.$$

If consumers are price sensitive (if consumer demand is not perfectly inelastic), then ε does not equal 0 and $\frac{dp}{dMC}$ does not equal 1. That is, if ε does not equal zero, then prices will not increase proportionally with marginal costs.

15. In the Bertrand equilibrium, the price is equal to the competitive price for homogeneous good when there are at least two firms. Hence increasing the number of firms beyond two will not affect the market price.

16. Given that the duopolies produce identical goods, the equilibrium price is lower if the duopolies set price rather than quantity. If the goods are heterogeneous, we cannot answer this question definitively.

17. By differentiating its product, a firm makes the residual demand curve it faces less elastic everywhere. For example, no consumer will buy from that firm if its rival charges less and the goods are homogeneous. In contrast, some consumers who prefer this firm's product to that of its rival will still buy from this firm even if its rival charges less. As the chapter shows, a firm sets a higher price the lower the elasticity of demand at the equilibrium.

18. The best-response curve of the praised firm shifts out, while the best-response curve of the other firm does not shift. This is the result of an outward shift of the demand curve for the praised firm but not the other. The prices of both firms increase, but the price of the praised firm increases by more. See Figure 14.4 below.

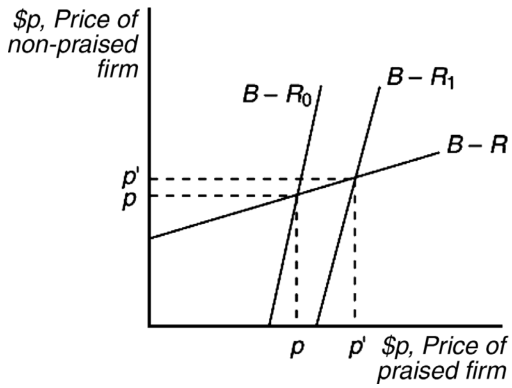

Figure 14.4

19. Beginning with Equation 14.4 in the text and substituting the new marginal cost levels, the best-response functions and output levels become

$$q_U = 119.5 - 1/2\ q_A$$
$$q_A = 69.5 - 1/2\ q_U$$
$$q_U = 113$$
$$q_A = 13.$$

20. Because the profit-maximizing output level is determined by equating residual marginal revenue to marginal cost, the addition of a fixed cost for both firms does not shift the response functions. However, each response function is truncated at the point where output is too low for the firm to cover variable cost (the shutdown point). Thus as long as profits are greater than $-FC$, the output decisions are unchanged.

21. a. If there is a collusion, Firm 1 should produce all output due to its lower marginal cost. The monopoly price and output levels are determined by

$$MR = 120 - 2Q$$
$$MC = 20$$
$$120 - 2Q = 20$$
$$Q^* = 50$$
$$p^* = 70.$$

b. To calculate the Cournot equilibrium, derive the response function and solve each by setting it equal to the appropriate marginal cost for each firm. Then, solve the response functions simultaneously to determine output.

$$p = 120 - q_1 - q_2$$
$$MR_1^r = 120 - 2q_1 - q_2$$
$$MR_2^r = 120 - q_1 - 2q_2$$
$$120 - 2q_1 - q_2 = 20$$
$$q_1 = 50 - 1/2\, q_2$$
$$120 - q_1 - 2q_2 = 40$$
$$q_2 = 40 - 1/2\, q_1$$
$$q_1^* = 40$$
$$q_2^* = 20$$
$$Q^* = 60$$
$$p^* = 60$$

22. The inverse demand curve is $p = 1 - 0.001Q$. The first firm's profit is $\pi_1 = [1 - 0.001(q_1 + q_2)]q_1 - 0.28q_1$. Its first-order condition is $d\pi_1/dq_1 = 1 - 0.001(2q_1 + q_2) - 0.28 = 0$. If we rearrange the terms, the first firm's best-response function is $q_1 = 360 - \frac{1}{2}q_2$. Similarly, the second firm's best-response function is $q_2 = 360 - \frac{1}{2}q_1$. By substituting one of these best-response functions into the other, we learn that the Nash-Cournot equilibrium occurs at $q_1 = q_2 = 240$, so the equilibrium price is 52¢.

23. The response functions and output levels with the subsidy are

$$q_U = 120 - 1/2q_A$$
$$q_A = 120 - 1/2q_U$$
$$q_U = q_A = 80.$$

24. Given that the firm's after-tax marginal cost is $m + \tau$, the Nash-Cournot equilibrium price is $p = (a + n[m + \tau])/(n + 1)$, using Equation 14.17. Thus, the consumer incidence of the tax is $dp/d\tau = n/(n + 1) < 1$ (= 100%).

25. See Solved Problem 14.2. The equilibrium quantities are $q_1 = (a - 2m_1 + m_2)/3b = (90 + 30)/6 = 20$ and $q_2 = (90 - 60)/6 = 5$. As a result, the equilibrium price is $p = 90 - 20 - 5 = 65$.

26. Consider a Cournot equilibrium where each of n firms faces a constant marginal cost of m and the market demand curve is

$$p = a - bQ.$$

Firm 1's profit function is

$$\pi_1 = q_1(a - b(q_1 + q_2 + ... + q_n)) - mq_1.$$

Firm 1 maximizes profit by first taking the derivative of their profit function with respect their output (q_1):

$$\frac{d\pi_1}{dq_1} = a - b(2q_1 + q_2 + ... + q_n) - m.$$

If all n firms are identical, then in equilibrium $q_1 = q_2 = \ldots = q_n = q$. Therefore, setting the first order condition equal to zero and solving for q,

$$q = \frac{a-m}{(n+1)b}.$$

Total market supply is

$$Q = \frac{n(a-m)}{(n+1)b}.$$

Substituting this back into the inverse demand function and solve for p to find the market price., the price consumers pay before the tax is

$$p = \left(\frac{a+mn}{n+1}\right).$$

The effect of a shift in demand on price is

$$\frac{dp}{da} = \frac{1}{n+1}, \text{ which is positive.}$$

The effect of an increase in marginal cost on price is

$$\frac{dp}{dm} = \frac{n}{n+1}, \text{ which is positive.}$$

The effect of an increase in the number of firms on price is

$$\frac{dp}{dn} = \frac{m-a}{n+1}, \text{ which is negative.}$$

In sum, a leftward shift in demand cannot explain a price increase, but market price would increase if demand shifts to the right, marginal costs increase, or the number of firms decreases.

27. When there are multiple followers instead of one, the response function of the followers becomes

$$q_i = (a - m)/nb - q_1/n.$$

The leader maximizes profits, taking the best-response functions as given. The output of the leader is the same as the one follower example.

$$q_1 = (a - m)/2b$$

Industry output is $Q = [(a - m)/2b][(2n - 1)/n]$.

28. Firm 1 wants to maximize its profit:

$$\pi_1 = (p_1 - 10)q_1 = (p_1 - 10)(100 - 2p_1 + p_2).$$

Its first-order condition is $d\pi_1/dp_1 = 100 - 4p_1 + p_2 + 20 = 0$, so its best-response function is $p_1 = 30 + \frac{1}{4}p_2$. Similarly, Firm 2's best-response function is $p_2 = 30 + \frac{1}{4}p_1$. Solving, the Nash-Bertrand equilibrium prices are $p_1 = p_2 = 40$. Each firm produces 60 units.

29. If marginal cost is equal to zero, we can use the same methodology described above to solve for the new prices. In this case, the response functions are

$$p_1 = 25 + 0.25p_2$$
$$p_2 = 25 + 0.25p_1$$

and the new equilibrium prices are $p_1 = 33.33$, $p_2 = 33.33$.

30. This problem is solved using the same methodology as in the previous two problems, except that now, the response functions are asymmetric due to the difference in marginal cost. The best-response functions are

$$p_1 = 40 + 0.25p_2$$
$$p_2 = 30 + 0.25p_1$$

and the new equilibrium prices are $p_1 = 50.67$, $p_2 = 42.67$.

31. One approach is to show that a rise in marginal cost or a fall in the number of firms tends to cause the price to rise. Solved Problem 14.4 shows the effect of a decrease in marginal cost due to a subsidy (the opposite effect). The section titled "The Cournot Equilibrium with Two or More Firms" shows that as the number of firms falls, market power increases and the markup of price over marginal cost increases. The two effects reinforce each other. Suppose that the market demand curve has a constant elasticity of ε. We can rewrite Equation 14.10 as $p = m/[1 + 1/(n\varepsilon)] = m\mu$, where $\mu = 1/[1 + 1/(n\varepsilon)]$ is the markup factor. Suppose that marginal cost increases to $(1 + \alpha)m$ and that the drop in the number of firms causes the markup factor to rise to $(1 + \beta)\mu$; then the change in price is $[(1 + \alpha)m \times (1 + \beta)\mu] - m\mu = (\alpha + \beta + \alpha\beta)m\mu$. That is, price increases by the fractional increase in the marginal cost, α, plus the fractional increase in the markup factor, β, plus the interaction of the two, $\alpha\beta$.

32. Audio-PowerPoint answer by James Dearden is also available (14A Computer Chips).
    a. Suppose that there is a positive fixed and sunk cost F. At the Bertrand equilibrium

$$P_A^* = P_B^* = 0 \quad \text{and} \quad p_A^* = p_B^* = -F.$$

    b. No. With product differentiation, the firms can raise their price above marginal cost, but still their profit can be "razor thin."
    c. In what follows we assume $F = 0$. We have:

$$p_V = (\alpha - \beta P_V + \gamma P_A)(P_V - m)$$

and

$$p_A = (\alpha - \beta P_A + \gamma P_V)(P_A - m).$$

Taking the derivative of the profit function with respect to P_V and P_A and putting it equal to zero, we get:

$$-\beta(P_V - m) + \alpha - \beta P_V + \gamma P_A = 0$$

and

$$-\beta(P_A - m) + \alpha - \beta P_A + \gamma P_V = 0.$$

Solving the equations we get:

$$P_V = P_A = (\beta m + \alpha)/(2\beta - \gamma)$$

and

$$\pi_V = \pi_A = [\beta(\alpha - \beta m + m\gamma)]^2/(2\beta - \gamma)^2.$$

We see if:

$$\alpha = m(\beta - \gamma)$$

then

$$P_V = P_A = m \quad \text{and} \quad \pi_V = \pi_A = 0.$$

Thus even though the products are differentiated, we see that under certain conditions the profits can be zero.

33. Solution is also provided in Jim Dearden's audio presentation.

a. Wawa's profit function is: $\pi_W = (p_W - 2)(680 - 500p_W + 400p_S)$.

Sunoco's profit function is: $\pi_S = (p_S - 2)(680 - 500p_S + 400p_W)$.

The F.O.C. for Wawa is:

$$\frac{\partial \pi_W}{\partial p_W} = 680 - 500p_W + 400p_S - 500(p_W - 2) = 400p_S - 1000p_W + 1680 = 0. \quad (1)$$

The F.O.C. for Sunoco is:

$$\frac{\partial \pi_S}{\partial p_S} = 680 - 500p_S + 400p_W - 500(p_S - 2) = 400p_W - 1000p_S + 1680 = 0. \quad (2)$$

Solving equations (1) and (2) simultaneously, we can obtain the Nash equilibrium prices:

$$\begin{cases} p_W^* = 2.8 \\ p_S^* = 2.8. \end{cases}$$

b. With the salty snacks, Wawa's profit function is:

$$\pi_W = (p_W + 0.25 - 2)(680 - 500p_W + 400p_S).$$

Sunoco's profit function is still: $\pi_S = (p_S - 2)(680 - 500p_S + 400p_W)$.

The F.O.C. for Wawa is now:

$$\frac{\partial \pi_W}{\partial p_W} = 680 - 500p_W + 400p_S - 500(p_W - 1.75) = 400p_S - 1000p_W + 1555 = 0. \quad (3)$$

The F.O.C. for Sunoco is still equation (2).
Solving equations (2) and (3) simultaneously, we can obtain the new Nash equilibrium prices:

$$\begin{cases} p_W^* = 2.65 \\ p_S^* = 2.74. \end{cases}$$

34. Solution is also provided in Jim Dearden's audio presentation.

Farmer *A*'s market profit function is: $\pi_{Am} = [10 - 0.1(q_{Am} + q_{Bm} + q_{Cm})]q_{Am}$.

Farmer *A*'s home profit function is: $\pi_{Ah} = (5 - 0.1q_{Ah})q_{Ah}$.

Farmer *A*'s total profit function is:

$$\begin{aligned}\pi_A = \pi_{Am} + \pi_{Ah} &= [10 - 0.1(q_{Am} + q_{Bm} + q_{Cm})]q_{Am} + (5 - 0.1q_{Ah})q_{Ah} \\ &= [10 - 0.1(q_{Am} + q_{Bm} + q_{Cm})]q_{Am} + [5 - 0.1(50 - q_{Am})](50 - q_{Am}).\end{aligned}$$

The F.O.C. for farmer *A* is:

$$\begin{aligned}\frac{\partial \pi_A}{\partial q_{Am}} &= -0.1q_{Am} + 10 - 0.1(q_{Am} + q_{Bm} + q_{Cm}) + 0.1(50 - q_{Am}) - [5 - 0.1(50 - q_{Am})] \\ &= 15 - 0.4q_{Am} - 0.1(q_{Bm} + q_{Cm}) = 0. \qquad (1)\end{aligned}$$

Since farmers *A*, *B*, and *C* are symmetric, then: $q_{Am} = q_{Bm} = q_{Cm}$. Substitute this relationship into equation (1): $15 - 0.4q_{Am} - 0.1(q_{Am} + q_{Am}) = 0 \quad \Rightarrow \quad q^*_{Am} = 25$.

Therefore the Nash-Cournot equilibrium quantities are: $q^*_{Am} = q^*_{Bm} = q^*_{Cm} = 25$.

The market price is $p^*_m = 10 - 0.1(q^*_{Am} + q^*_{Bm} + q^*_{Cm}) = 2.5$, and the roadside stand prices for farmer *A*, *B*, and *C* are all: $p^*_{Ah} = p^*_{Bh} = p^*_{Ch} = 5 - 0.1q^*_{Am} = 2.5$.

35. Audio-PowerPoint answer by James Dearden is also available (14C Warranties).
   a. $\pi_i = R_i - C_i = 32{,}000w_i/(w_A + w_B) - 2000w_i$.
   b. The Nash equilibrium is for both to offer four years warranty.
   c. If they collude, they will provide one-year warranties.

36. Solution is also provided in Jim Dearden's audio presentation.
   a. The sum of the profits of auction houses Sotheby's (S) and Christie's (C) are:

$$\pi_S + \pi_C = rp\left[D_S(r) + D_C(r)\right] - \left[2F + v\left(D_S(r) + D_C(r)\right)\right] = rpD(r) - \left[2F + vD(r)\right].$$

   where: $D(r)$ is the market demand = $D_S(r) + D_C(r)$.

   b. The F.O.C. for maximizing the sum of profits is:

$$\frac{\partial(\pi_S + \pi_C)}{\partial r} = pD(r) + rp\frac{\partial D(r)}{\partial r} - v\frac{\partial D(r)}{\partial r} = pD(r) + (rp - v)\frac{\partial D(r)}{\partial r} = 0.$$

   In terms of the monopoly's Lerner Index and price elasticity of market demand:

$$(rp - v)\frac{\partial D}{\partial r} = -pD \quad \Rightarrow \quad \frac{rp - v}{rp} = -\frac{D}{r}\frac{1}{\frac{\partial D}{\partial r}} = -\frac{1}{\frac{\partial D}{\partial r}\frac{r}{D}} = -\frac{1}{\varepsilon_r}.$$

   where: ε_r is the price elasticity of market demand.

c. If they jointly set the commission rate, the F.O.C. for the profit-maximizing problem is:

$$\frac{rp-v}{rp}=-\frac{1}{\varepsilon_r}.$$

If Christie's cheats on their agreement, the F.O.C. for Christie's profit-maximizing problem is:

$$\frac{\partial \pi_C}{\partial r}=pD_C(r,r_C)+(r_C p-v)\frac{\partial D_C(r,r_C)}{\partial r_C}=0 \quad \Rightarrow \quad \frac{r_C p-v}{r_C p}=-\frac{1}{\varepsilon_{r_C}}.$$

where: ε_{r_C} is the price elasticity of demand for Christie's.

Since the market demand is less price elastic than the demand for Christie's, then:

$$\varepsilon_r > \varepsilon_{r_C} \;\Rightarrow\; -\frac{1}{\varepsilon_r} > -\frac{1}{\varepsilon_{r_C}} \;\Rightarrow\; r_C < r;$$

i.e., Christie's has incentives to cheat on their agreement by lowering its own commission, and gets greater profit. People will then substitute away from Sotheby's toward Christie's; hence Sotheby's will be worse off if it continues to charge *r*.

37. a. The profits of Highland Park Hospital and Evanston Northwestern Hospital are:

$$\begin{aligned}p_H &= (P_H-2000)(50-0.01P_H+0.005P_N)\\ &= 70P_H-0.01P_H^2+0.005P_HP_N-10P_N-100{,}000.\end{aligned}$$

$$\begin{aligned}p_N &= (P_N-2000)(500-0.01P_N+0.005P_H)\\ &= 520P_N-0.01P_N^2+0.005P_HP_N-10P_H-1000{,}000.\end{aligned}$$

Taking the derivative of P_H with respect to P_H and P_N with respect to P_N and putting equal to zero we get:

$$4P_H - P_N = 14{,}000 \quad \text{and} \quad 4P_N - P_H = 104{,}000.$$

Solving the two equations we get the Bertrand equilibrium prices:

$$P_H^* = 10666.67 \quad \text{and} \quad P_N^* = 28666.67.$$

b. After the merger, the new entity maximizes the following profit function:

$$\begin{aligned}p &= p_H + p_N\\ &= 60p_H-0.01p_H^2+0.01p_Hp_N+510p_N-0.01p_N^2-1{,}100{,}000.\end{aligned}$$

Taking the derivative with respect to P_H and P_N and putting equal to zero we get the following two equations:

$$2P_H - P_N = 6000 \quad \text{and} \quad 2P_N - P_H = 51000.$$

Solving the two equations we get the prices after the merger:

$$P_H^* = 21000 \quad \text{and} \quad P_N^* = 36000.$$

The effect of change in P_N on P_H is $= 0.005P_H - 10 = 0.005 \times 21000 - 10 = 95$.

The effect of change in P_H on P_N is $= 0.005P_N - 10 = 0.005 \times 36000 - 10 = 170$.

c. The prices charged after the merger are higher than before the merger.

38. You can solve this problem using calculus or the formulas for the linear demand and constant marginal cost Cournot model from the chapter.

    a. For the duopoly, $q_1 = (15 - 2 + 2)/3 = 5$, $q_2 = (15 - 4 + 1)/3 = 4$, $p_d = 6$, $\pi_1 = (6 - 1)5 = 25$, $\pi_2 = (6 - 2)4 = 16$. Total output is $Q_d = 5 + 4 = 9$. Total profit is $\pi_d = 25 + 16 = 41$. Consumer surplus is $CS_d = 1/2(15-6)9 = 81/2 = 40.5$. At the efficient price (equal to marginal cost of 1), the output is 14. The deadweight loss is $DWL_d = 1/2(6-1)(14-9) = 25/2 = 12.5$.
    b. A monopoly equates its marginal revenue and marginal cost: $MR = 15 - 2Q_m = 1 = MC$. Thus $Q_m = 7$, $p_m = 8$, $\pi_m = (8 - 1)7 = 49$. Consumer surplus is $CS_m = 1/2(15-8)7 = 49/2 = 24.5$. The deadweight loss is $DWL_m = 1/2(8-1)(14-7) = 49/2 = 24.5$.
    c. The average cost of production for the duopoly is $[(5 \times 1) + (4 \times 2)]/(5 + 4) = 1.44$, whereas the average cost of production for the monopoly is 1. The increase in market power effect swamps the efficiency gain, so consumer surplus falls while deadweight loss nearly doubles.

39. The answers are:

    a. In the Cournot equilibrium, $q_i = (a - m)/(3b) = (150 - 60)/3 = 30$, $Q = 60$, $p = 90$.
    b. In the Stackelberg equilibrium in which Firm 1 moves first, $q_1 = (a - m)/(2b) = 50 - 60)/2 = 45$, $q_2 = (a - m)/(4b) = (150 - 60)/4 = 22.5$, $Q = 67.5$, and $p = 82.5$.

40. The answers are:

    a. The Cournot equilibrium in the absence of government intervention is $q_1 = 30$, $q_2 = 40$, $p = 50$, $\pi_1 = 900$, and $\pi_2 = 1{,}600$.
    b. The Cournot equilibrium is now $q_1 = 33.3$, $q_2 = 33.3$, $p = 53.3$, $\pi_1 = 1108.9$, and $\pi_2 = 1108.9$.
    c. Because Firm 2's profit was 1,600 in part (a), a fixed cost slightly greater than 1600 will prevent entry.

41. Firm 1 earns revenue $R_1 = pq_1 = (1 - q_1 - q_2)q_1 = q_1 - q_1^2 - q_1 q_2$, which corresponds to the marginal revenue of

$$MR_1 = \frac{\partial R_1}{\partial q_1} = 1 - 2q_1 - q_2.$$

Firm 1 maximizes its profit by satisfying the first order condition (*FOC*) $MR_1 = MC_1$. Due to the government subsidy, the firm faces marginal cost $MC_1 = m - s$. Hence, the *FOC* is $1 - 2q_1 - q_2 = m - s$. The corresponding response curve is

$$q_1 = \frac{1 - q_2 - m}{2} + \frac{1}{2}s. \tag{1}$$

Similarly, Firm 2 maximizes its profit by equating its marginal revenue to its marginal cost. Since Firm 2 receives no subsidy, $MC_2 = m$. Then for Firm 2 we have:

$$\begin{aligned} R_2 &= pq_2 = (1 - q_1 - q_2)q_2 = q_2 - q_2^2 - q_1 q_2 \\ MR_2 &= 1 - 2q_2 - q_1 \\ MR_2 &= MC_2 \\ 1 - 2q_2 - q_1 &= m. \end{aligned}$$

The reaction function of Firm 2 is

$$q_2 = \frac{1 - q_1 - m}{2}. \tag{2}$$

Solving Equations (1) and (2) simultaneously, we obtain equilibrium values:

$$\begin{aligned} q_1^* &= \frac{1-m}{3} + \frac{2}{3}s \\ q_2^* &= \frac{1-m}{3} - \frac{1}{3}s. \end{aligned} \tag{3}$$

The net national income of Government 1 is:

$$\begin{aligned} NNI &= \pi_1 - sq_1 \\ &= (pq_1 - mq_1 + sq_1) - sq_1 \\ &= pq_1 - mq_1 \\ &= (1 - q_1 - q_2)q_1 - mq_1. \end{aligned} \tag{4}$$

After substituting Equations (3) into (4) and completing some algebra, we find that

$$NNI = \frac{1 - m + 2s}{3}\frac{1 - s - m}{3}.$$

Government 1 maximizes its *NNI* by solving the *FOC*:

$$\begin{aligned} \frac{\partial}{\partial s} NNI &= \frac{\partial}{\partial s}\left[\frac{1 - m + 2s}{3}\frac{1 - s - m}{3}\right] \\ &= \frac{1 - 4s - m}{9} = 0. \end{aligned}$$

which suggests that the optimal subsidy is

$$s^* = \frac{1-m}{4}. \tag{5}$$

Substituting Equation (5) into Equation (3) gives

$$\begin{aligned} q_1^* &= \frac{1-m}{2} \\ q_2^* &= \frac{1-m}{4}. \end{aligned}$$

which are the outputs of the Stackelberg leader and follower respectively.

42. In the Cournot model of Solved Problem 14.4, a subsidy causes the best-response function of Firm 1 to shift outward.

43. Solution is also provided in Jim Dearden's audio presentation.

Each firm i's profit function is:

$$\pi_i = \left[a - b\left(q_i + \sum_{j \neq i} q_j\right)\right] q_i - \left[\beta q_i + \left(\frac{\gamma}{2}\right) q_i^2\right].$$

The F.O.C. is:

$$\frac{\partial \pi_i}{\partial q_i} = a - 2bq_i - b\sum_{j \neq i} q_j - \beta - \gamma q_i = a - \beta - (2b + \gamma)q_i - b\sum_{j \neq i} q_j = 0.$$

By the symmetry among all the firms, we have: $q_j = q_i, \ \forall j \neq i.$ Substitute this relationship into the F.O.C. above, we can solve for each firm's Nash equilibrium output:

$$a - \beta - (2b + \gamma)q_i - b(n-1)q_i = 0 \quad \Rightarrow \quad q_i^* = \frac{a - \beta}{b(n+1) + \gamma} \qquad \forall i.$$

Each firm's equilibrium profit is:

$$\pi_i^* = \left[a - b\left(q_i^* + \sum_{j \neq i} q_j^*\right)\right] q_i^* - \left[\beta q_i^* + \left(\frac{\gamma}{2}\right)(q_i^*)^2\right] = \frac{(a-\beta)^2(2b+\gamma)}{2\left[b(n+1)+\gamma\right]^2}.$$

The equilibrium price is:

$$p^* = a - b\left(q_i^* + \sum_{j \neq i} q_j^*\right) = \frac{a\gamma + b(a + n\beta)}{b(n+1) + \gamma}.$$

Since $\lim_{n \to \infty} \pi_i^* = \lim_{n \to \infty} \frac{(a-\beta)^2(2b+\gamma)}{2[b(n+1)+\gamma]^2} = 0,$ then each firm's equilibrium profit approaches zero as n approaches infinity. The Cournot oligopoly market approaches a competitive market as the number of firms goes to infinity if each firm produces identical products.