ANALYZING MANAGERIAL DECISIONS: *Pricing and Investment Decisions*

You work for a drug manufacturing company that holds a patent on Hair Grow, the world's most effective drug for restoring hair. Your job is to analyze the pricing and investment decisions facing the firm. Your marketing group estimates that Hair Grow has the following demand curve:

$$P = 101 - .00002Q$$

1. Your marginal cost for producing a Hair Grow pill is \$1. What is the profit-maximizing price and quantity? What is your profit?
2. Suppose that your production facility can only produce 1,000,000 pills. What is your optimal price and quantity given the production constraint? What are your profits?
3. Suppose that you could increase the capacity of your plant to 3,000,000 pills within a two-year period for a cost of \$30,000,000. Should you undertake the investment (for simplicity, assume you can borrow the funds for the expansion at a 0 percent interest rate)?

less than \$105. The firm does not lower the price to sell to these consumers because it does not want to lower the price for other customers (recall that in this chapter we presume the firm charges the same price to all customers). From the firm's standpoint, any gain from selling to additional customers would be more than offset by the loss from lowering its price to all its customers.[8]

Monopolistic Competition

As the name implies, *monopolistic competition* is a market structure that is a hybrid between competition and monopoly. In this market structure, there are multiple firms that produce similar products. There is free exit from and entry into the industry. Yet competition does not eliminate market power because the firms sell differentiated products. Examples of such industries include toothpaste, golf balls, skis, tennis rackets, shampoo, and deodorant. For instance, although Colgate and Crest compete directly, many customers do not view these brands of toothpaste as perfect substitutes. These companies thus have some market power. New toothpaste firms are likely to enter the industry if the existing firms report large profits—there are no significant barriers to entry.

Monopolistic competition is similar to monopoly in that firms under both market structures face downward-sloping demand curves: A toothpaste company can raise its price without losing all sales. Given that the firms face downward-sloping demand curves, each strives to select the price-quantity combination that maximizes its profits. The output decision is based on the same analysis as for the pure monopolist—choose that output where MC = MR.

[8]Economists frequently refer to these lost gains from trade as a *dead-weight loss.* This inefficiency (or *social cost*) is one reason why governments might pass regulations like antitrust laws to restrict the formation of monopolies. But these regulations also can be motivated by concerns about the higher prices that consumers pay when they face monopolistic suppliers. Although government regulation has the potential to reduce inefficiencies and wealth transfers from consumers to firms, it is important to keep in mind that government regulation is not costless. There are salaries for regulators and court costs, for instance. From a societal viewpoint, the costs of government regulation should be weighed against the benefits. These issues are discussed in greater detail in Chapter 21.

MANAGERIAL APPLICATIONS

Monopolistic Competition in Golf Balls

There are many brands of golf balls. Some golfers view the balls as perfect substitutes and simply purchase the lowest-priced brand. Other golfers prefer one brand to another. For instance, they might believe one brand of ball flies farther or provides greater control than competing brands. These golfers are willing to pay a higher price for their favorite ball than for competing balls. However, they often will substitute if the price difference is more than a few dollars a dozen. Also, if a company develops some popular feature, like a larger number of dimples on the ball, the feature is typically copied by other companies within a short time period. Since a golf equipment company has a *monopoly* in producing its own brand, it has some market power. However, this power is limited given the *competition* in the industry.

The difference between monopoly and monopolistic competition is that in monopolistic competition, economic profits invite entry. If a toothpaste with a new whitening formula is a hot seller, other companies will imitate the product. This entry will shift the original firm's demand curve to the left and reduce profits. Zero economic profits exist when the demand curve is shifted to the point where average cost equals price. Figure 6.6 (page 192) shows this condition.

Entry will tend to force profits to zero. Yet some brands continue to be more distinctive than others. Also, costs can vary because of differences in production techniques and inputs. It is possible for some firms to earn economic profits in monopolistic competition.[9]

Oligopoly

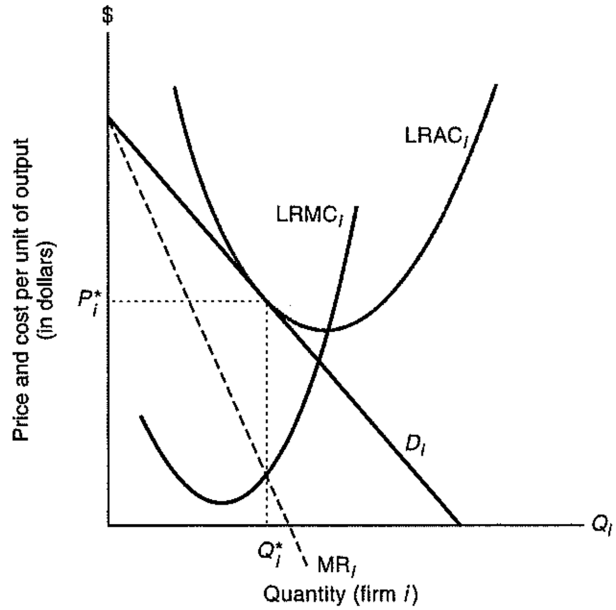
Within *oligopolistic markets,* only a few firms produce most of the output. Examples of oligopolistic industries include automobiles and steel during the 1950s. These industries had important scale economies and other substantial entry barriers. In 1995, the top four cereal makers in the United States produced about 90 percent of industry output, while the top eight accounted for virtually all production. Products may or may not be differentiated. Firms can earn substantial profits. These profits are not reduced through new entry because of effective entry barriers. Yet as we shall see, economic profits sometimes can be eliminated in oligopolistic industries through competition among the existing firms.

In our analysis of other market structures, we assume that firms take the prices of their competitors as given. A firm was not expected to respond to announcements of changes in prices by rival firms. This assumption certainly is reasonable in the case of competitive markets with many small firms, as well as in the case of monopoly with only one large firm. But this assumption rarely is valid within oligopolistic industries. For instance, when American Airlines considers lowering its prices on particular routes, it obviously must be concerned about whether United Airlines and its other competitors will follow suit. In fact, firms in oligopolistic industries ordinarily will be quite concerned about how their rivals will react to most major policy decisions, be they advertising campaigns or product design decisions. Decision making within these industries requires *strategic thinking.* Decision makers must realize that competitors are rational parties operating in

[9]Monopolistic competition does not exhaust all gains from trade for two reasons. First, as in monopoly, the firms do not sell to all consumers who value the product at above marginal cost. Second, firms do not operate at the bottom of their average cost curves (see Figure 6.6). Lower average cost would be obtained with fewer firms, each producing more output. Nonetheless, regulation to address these inefficiencies is unlikely to be effective. Consumers value product differentiation and are arguably better off with more variety at slightly higher average cost than with lower variety produced at lower average cost. Second, with few entry barriers, the market power of firms is unlikely to be great.

Figure 6.6 Monopolistic Competition

In monopolistic competition, firms sell differentiated products. This figure shows the demand curve for firm *i* in such an industry. The curve is downward-sloping. Similar to monopoly pricing, the firm selects the output where marginal revenue equals marginal cost. Monopolistic competition differs from monopoly in that abnormal profits will invite entry. Entry shifts the demand curve for the firm to the left (as some of the customers buy from the new firms). The firm makes no economic profits when price is equal to average cost. This condition occurs at price P_i^* and quantity Q_i^*.



their own self-interest. Thus, it is important for decision makers to place themselves in their rivals' positions and consider how they might react. (This basic principle, which we now examine briefly, is developed more completely in Chapter 9.[10])

Nash Equilibrium

To analyze oligopolies, we need an underlying principle to define an equilibrium when rival firms make decisions that explicitly take each other's behavior into account. Previously, we used the concept that a market is in equilibrium when firms are doing the best they can given their circumstances and have no reason to change price or output. For example, in a competitive equilibrium, there is no reason for entry or exit (existing firms are making "normal" profits). No existing firm has any reason to change its output level (all are producing where MC = MR = P^* and inventories are stable at their desired levels).

We can apply this same basic idea to oligopolistic markets with minor modification. In the following analysis, a firm does the best it can, given what its rivals are doing. In doing so, the firm anticipates that other firms will respond to any action it takes by doing the best they can as well. Actions are *noncooperative* in that each firm makes decisions that maximize its profits, given the actions of the other firms. The firms do not collude to maximize joint profits. An equilibrium exists when each firm is doing the best it can, given the actions of its rivals. Economists call this a *Nash equilibrium* for Nobel laureate John Nash who first developed these general concepts.

To illustrate this approach, assume a simple setting: There are two firms in an industry—a *duopoly*. Each independently chooses a price for an identical product. The firms choose

[10]This chapter presents a basic introduction to game theory. The material provides sufficient background for the game theory applications found in subsequent parts of the book (these are in the appendices of several chapters). Chapter 9 extends this introduction of game theory and discusses in more detail how managers might use this theory as a tool in decision making. Readers interested in a more detailed treatment of game theory should read Chapter 9.

Figure 6.7 Nash Equilibrium

In this example, there are two firms in an industry—WonCo and TuInc. Each independently chooses a price for an identical product. The firms choose either a high price or a low price. The payoffs are given in the table (the upper-left entry in a cell displays the profits for WonCo, the lower right shows the profits for TuInc). The equilibrium is for WonCo to charge a high price and TuInc to charge a low price—the shaded cell. Any other combination is unstable: That is, given the action of one of the firms, the other firm has the incentive to deviate. This equilibrium is called a *Nash equilibrium*.

	TuInc—Low price	TuInc—High price
WonCo—Low price	$20 / $40	$40 / $0
WonCo—High price	$200 / $250	$400 / $200

either a high price or a low price. The payoffs are given in Figure 6.7. (The entry on the upper left in each cell is for WonCo, while the entry on the lower right is for TuInc.) For example, if both firms charge a high price, WonCo's profits are $400 and TuInc's profits are $200.[11]

The equilibrium is for WonCo to charge a high price and TuInc to charge a low price. Any other combination is unstable: Given the action of one of the firms, the other firm has the incentive to change its price. For instance, if both firms charge a high price, it is in the interests of TuInc to lower its price—its profits go from $200 to $250. The other combinations of WonCo charging a low price and TuInc a high price and both firms charging a low price are similarly unstable: Each firm has an incentive to alter its price given the other firm's choice. A Nash equilibrium is self-enforcing. If WonCo charges a high price, it is optimal for TuInc to charge a low price. Similarly, if TuInc charges a low price, it is optimal for WonCo to charge a high price. Given the choice of one firm, there is no reason for the other to alter its strategy.

In this example, the Nash equilibrium is not the outcome that maximizes the joint profits of the two companies. Combined profits would be higher if both firms charged a high price. Conceptually, the combined profits under this pricing policy could be split in a manner that would make both firms better off than in the Nash equilibrium. For instance, the combined profits of $600 could be split, with each firm receiving $300. As this example illustrates, noncooperative equilibria do not necessarily maximize the joint value of the firms. (Since the potential gains from trade are not exhausted, it is often the case that one or more firms can be made better off, without making other firms worse off, by changing the joint decisions.)

Output Competition

The first major analysis of oligopoly was published by Augustine Cournot in 1838. To illustrate his model, suppose again that there are only two firms in the industry and that

[11]The profits differ due to differences in the underlying production costs.

they produce identical products. In the *Cournot model,* each firm treats the *output* level of its competitor as fixed and then decides how much to produce. In equilibrium, neither firm has an incentive to change its output level, given the other firm's choice. (Thus, this is a Nash equilibrium.)

Suppose the duopolists face the following total industry demand:

$$P = 100 - Q \tag{6.5}$$

where $Q = Q_A + Q_B$. For simplicity, assume that both firms have marginal costs of zero: $MC_A = MC_B = 0$. Each firm takes the other firm's output as fixed. Thus, the anticipated demand curve for firm i (i = A or B) is

$$P_i = (100 - \overline{Q}_j) - Q_i \tag{6.6}$$

where $\overline{Q}_j$ = expected output of the other firm. The marginal revenue for firm i is[12]

$$MR_i = (100 - \overline{Q}_j) - 2Q_i \tag{6.7}$$

Firm i's profits are maximized by setting marginal revenue equal to marginal cost (in this case, zero). Doing so, and rearranging the expression, yields the following *reaction curve:*

$$Q_i = 50 - 0.5Q_j \tag{6.8}$$

The reaction curve indicates firm i's optimal output given the output choice of firm j. Both firms have the same reaction curve in this example, except that the subscripts are reversed.

Equilibrium occurs where the two curves cross. At these output levels, each firm is maximizing profit given the other firm's output choice. Neither firm has an incentive to alter its output. The equilibrium is pictured in Figure 6.8. In equilibrium, each firm produces 33 units for a total output of 66 units; the price is \$33.34. This output level is lower than in a competitive market. With competition, total output would be 100 units and the price would be zero (where $P^* = MC$). In the Cournot equilibrium, firms make economic profits: Price is \$33.34; average costs are zero. Each firm thus reports profits of \$1,110.89. This profit is lower than the two firms could obtain if they directly colluded and jointly produced the monopolistic output of 50 units (for example, 25 units per firm). With effective collusion, joint profits would be \$2,500 rather than \$2,221.78. Figure 6.9 displays the three price-quantity outcomes using the original industry demand curve. (This model can be extended readily to more than two firms. The same general results hold: As the number of firms grows, outcomes approach those of a competitive market.)

Price Competition

In the Cournot model, firms focus on choosing output levels. An alternative possibility is that firms might focus on choosing product price.[13] Here, the Nash equilibrium is for both firms to choose a price equal to marginal cost—the competitive outcome. To see

[12] Recall that marginal revenue for a linear demand curve is a line with the same intercept, but twice the negative slope.

[13] This situation often is referred to as the Bertrand model. Bertrand was a French economist who wrote a short note almost 50 years after Cournot's work was published arguing that in some markets, producers set prices rather than quantities.

Empirical Evidence

There are various economic models of oligopoly. We have presented but two of them simply to illustrate that economic theory does not make unambiguous predictions about what to expect within such industries. Some models yield outcomes close to pure competition—firms sell at marginal cost and make no economic profits. Other models yield outcomes closer to pure monopoly. What actually occurs in specific oligopolistic markets is an empirical issue. Available evidence suggests that oligopolies typically result in less output than competitive markets and that firms earn economic profits—at least in some industries.[14] Firms sometimes compete on price, to each other's detriment, and normally earn less in aggregate than a monopolist could.

Cooperation and the Prisoners' Dilemma

As we have discussed, in oligopolistic industries it is in the private interests of firms to find ways to cooperate and capture more profits than through competition. In principle, firms are most profitable if they effectively collude and act as a monopolist in jointly setting price and output for the industry. Collusion maximizes joint profits, which then can be divided among the firms in the industry. Many governments understand these incentives and have passed a variety of antitrust laws to limit firms' ability to engage in fixing prices. These laws are designed to lower the prices consumers pay for products. Some of the more restrictive of these laws have been adopted in the United States. Internationally, firms tend to have more latitude in forming cooperative agreements in attempting to increase profits—for example, consider the OPEC cartel.[15]

Prisoners' Dilemma

Even when free to cooperate, firms find that cooperation is not always easy to achieve. Individual firms have incentives to "cheat" and not adhere to output and price agreements. This incentive can be illustrated by the well-known *prisoners' dilemma*. In the original prisoners' dilemma, there are two suspects; hence, suppose the SEC has been investigating an insider trading scheme and their investigation is focused on two securities brokers, Avi Wasserman and Bea Haefner, who are arrested and charged with a crime. Police have insufficient evidence to convict them for insider trading violations unless one of them confesses. The police place Avi and Bea in separate rooms and try to get them to confess. If neither confesses, they are convicted of less serious crimes associated with their trading activities and are sentenced to only 2 months in jail. If both confess, they spend 12 months in jail. However, if one confesses but the other does not, the confessor is released under a plea bargain in return for testifying while the other is sentenced to 18 months in jail—12 for the crime and 6 for obstructing justice. The payoffs in terms of jail time faced by each individual are displayed in Figure 6.10 (page 198).

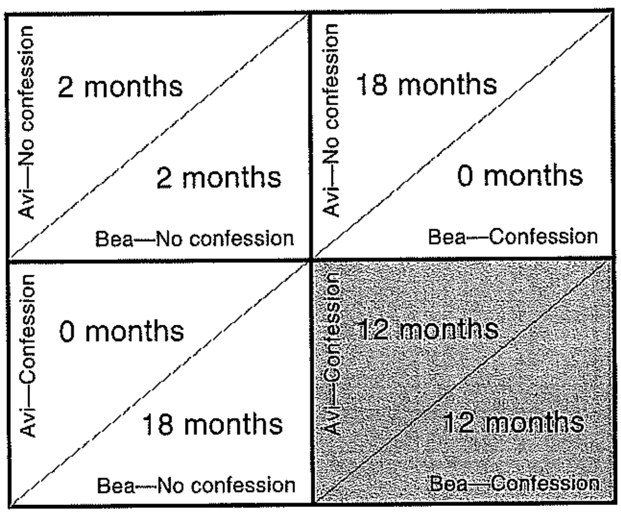
The Nash equilibrium is for both suspects to confess. Given these payoffs, it is always in the *individual interests* of each suspect to confess, taking the action of the other party as given. If Avi does not confess, Bea is set free by confessing. Alternatively, if Avi

[14] D. Carlton and J. Perloff (1990), *Modern Industrial Organization* (HarperCollins: New York), Chapter 10, discusses some of the relevant empirical literature.

[15] In smaller countries, much of the local production of key products is exported. In this case, it can be in the countries' interests to allow the formation of cartels. Ultimately, consumers pay higher prices and there are inefficiencies. However, many of these costs are imposed on people in other countries.

Figure 6.10 Prisoners' Dilemma

In the prisoners' dilemma, there are two suspects: Suppose the SEC has been investigating an insider trading scheme and their investigation is focused on two securities brokers, Avi Wasserman and Bea Haefner, who are arrested and charged with a crime. The police do not have sufficient evidence to convict them for insider trading unless one of them confesses. The police place the suspects in separate rooms and ask them to confess. If neither confesses, they are convicted of minor violations uncovered by the investigation of their trading activities and are sentenced to 2 months. If both confess, they spend 12 months in jail. However, if one confesses and the other does not, the confessor is released under a plea bargain in return for testifying but the other is sentenced to 18 months in jail—12 for the crime and 6 for obstructing justice. The payoffs in terms of jail time faced by each individual are displayed. Each entry in the table lists the jail sentences for Avi and Bea, respectively. The Nash equilibrium is for both suspects to confess—the shaded cell. Given the payoffs, it is always in the *individual interests* of each suspect to confess (taking the action of the other party as given).



confesses, Bea reduces her jail sentence from 18 to 12 months by also confessing. Either way, it is in Bea's interests to confess—confessing is a *dominant strategy.* Since the payoffs are symmetrical, it also is optimal for Avi to confess. Although it is in the individual interests of each party to confess, it is clearly in their *joint interests* not to confess. By not confessing, each only serves 2 months in jail, compared to 12 months if both confess. The prisoners' dilemma suggests that any agreement for neither to confess is likely to break down when they make their individual choices unless there is some mechanism to enforce their joint commitment not to confess. (For particular crimes one such mechanism might be the Mob: Both suspects have incentives not to confess if they expect to be executed for providing evidence to the police.)

Cartels

Cartels consist of formal agreements to cooperate in setting price and output levels. (These activities are generally illegal in the United States.) Firms trying to maintain cartels can face a problem like the prisoners' dilemma—we might call it the *cartel's dilemma.* Members can agree to restrict output to increase joint profits. However, individual firms have incentives to cheat. If all other firms restrict output, prices will not be affected

Figure 6.11 Cartel's Dilemma

Two firms, AVInc and BeaCo, attempt to form a cartel. If both firms restrict output, prices are high and each firm's profit is \$500. If both cheat on the cartel and increase output, price will be low and each firm's profit is \$200. If one firm expands output while the other restricts output, the market price will be at an intermediate level; the firm with the high output will make \$600 (because of the increased sales), but the other firm will only make \$150 (because of the lower price). These payoffs are displayed. The Nash equilibrium is for both firms to increase output—the shaded cell. Given the payoffs, it is always in the interest of each firm to increase output (taking the output of the other firm as given).

	BeaCo—Low output	BeaCo—High output
AVInc—Low output	\$500 / \$500	\$150 / \$600
AVInc—High output	\$600 / \$150	\$200 / \$200

significantly by the extra output of one firm. However, that firm's profits will increase from selling additional output at the cartel-maintained high price. But if all firms react to these incentives by increasing output, the cartel breaks down. Actual cartels often unravel because of such incentives. This outcome is pictured in Figure 6.11, which displays the payoffs for two firms attempting to form a cartel. It is in their joint interests to restrict output. Yet, as in the prisoners' dilemma, both firms have individual incentives to renege and increase output. The Nash equilibrium is for each to increase output.

A cartel can persist if it can impose sufficient penalties on cheaters. But for these penalties to be effective, cartel members must be able to observe (or reliably infer) that a firm has cheated. To the extent that cartel members expect to interact on a *repeated basis,* there are greater incentives to cooperate. Repeated interaction also increases incentives to invest in developing effective enforcement mechanisms to limit cheating. Potentially, these incentives can be strong enough to resolve the cartel's dilemma. In general, cooperation is easier to enforce if the number of firms in the industry is small: It is easier to identify and punish cheaters.

Even when firms are not permitted to form cartels, there may be ways of cooperating to increase profits. For example, over time, a firm might become known as a price leader. Such a firm changes prices in the face of new demand or cost conditions in a way that approximates what a cartel would do. Other firms follow the price changes, thus acting like members of a cartel. Individually, firms still can have short-run incentives to cheat (for example, reducing price to get more sales). However, firms might resist this short-run temptation to foster cooperation in the long run and hence obtain higher long-run profits.[16]

Another potential mechanism to foster cooperation is the structure of contracts with buyers employed by firms in the industry. *Most-favored-nation clauses* provide buyers

[16]Indeed, economists have shown that within any long-term relationship, with no specified ending date, cooperation is a *possible equilibrium*—the parties need not succumb to the cartel's dilemma. We discuss this issue in more detail in Chapter 9 and in the appendix to Chapter 10.

MANAGERIAL APPLICATIONS

Collusion in the Lysine Industry

Mark Whitacre was a high-ranking executive at Archer Daniels Midland Corporation (ADM). He has accused his former employer of engaging in price fixing. Lysine is an amino acid derived from corn used in swine and poultry feed to promote growth. ADM entered the lysine market in 1991. Prior to that time, the market had been dominated by two Japanese companies. ADM quickly gained market share. However, with the competition, the price of lysine fell from about $1.30 per pound to $.60 per pound. According to Whitacre, ADM executives began discussions in 1992 with their Japanese competitors about how it would be in their mutual self-interest to collude and fix prices. Collectively, the competitors were forgoing millions of dollars of profit per month because of the competition among the three companies. Whitacre indicates that a favorite saying at ADM is: "*The competitor is our friend, and the customer is our enemy.*"

In 1996, ADM pleaded guilty to price fixing and paid a $100 million fine. In 1999 Whitacre was sentenced to two-and-a-half years in prison.

Source: M. Whitacre, as told to R. Henkoff (1995), "My Life as a Corporate Mole for the FBI," *Fortune Magazine* (September 4), 52–62; K. Eichenwald (1999), "Three Sentenced in Archer Daniels Midland Case," *New York Times* (July 10), C1.

with guarantees that the seller will not sell to another buyer at a lower price. These clauses reduce incentives of sellers to lower the price for one buyer because that same price concession would have to be offered to other buyers as well. *Meeting-the-competition clauses* guarantee that a seller will meet the price of a competitor. Such a clause makes it difficult for firms to cheat on an agreement not to lower price since price concessions are more likely to be brought to each other's attention by customers.

Our discussion of these strategic interactions among rivals in output markets is meant only to provide a basic introduction to these issues. A more extensive analysis is provided in Chapter 9.

Summary

A *market* consists of all firms and individuals who are willing and able to buy or sell a particular product. These parties include those currently engaged in buying and selling the product, as well as *potential entrants*. *Market structure* refers to the basic characteristics of the market environment, including (1) the number and size of buyers, sellers, and potential entrants; (2) the degree of product differentiation; (3) the amount and cost of information about product price and quality; and (4) the conditions for entry and exit.

Competitive markets are characterized by four basic conditions: A large number of potential buyers and sellers; product homogeneity; rapid, low-cost dissemination of information; and free entry into and exit from the market. In competitive markets, individual buyers and sellers take the market price of the product as given: They have no control over price. Firms thus view their demand curves as horizontal. The firm's short-run supply curve is that portion of its short-run marginal cost curve above short-run average variable cost. The long-run supply curve is that portion of its long-run marginal cost curve above long-run average cost. In a competitive equilibrium, firms make no economic profits. Production is efficient in that firms produce at their minimum long-run average cost. Firms in competitive industries must move rapidly to take advantage of transitory opportunities. They also must strive for efficient production in order to terrorist attacks. This was recognized in Morgan Stanley's August 12, 2002, research report on Boeing. It suggests "an already tough pricing environment gets tougher if Airbus needs to fill slots available."

Many of the world's markets are like the commercial aircraft industry in that there are a few large firms who are the major players. Examples include soft drinks (Coke and Pepsi), U.S. domestic airlines (American, United, and Delta), copy machines (Canon and Xerox), candy (Hershey and Mars), and film (Kodak and Fuji). Even small firms often compete with an identifiable set of rivals and can act as the major players within a given market area. Consider two competing gasoline stations at an expressway interchange.

In this type of market, it generally is important for managers to consider rivals' responses when making major decisions. For example, part of Airbus's marketing plan in the late 1990s was to be overtly negative toward Boeing. One Airbus brochure depicted the Boeing 777 as an aging stretch limousine painted like a yellow taxicab, while the Airbus craft was pictured as a Mercedes luxury sedan. In another ad, Airbus pointed out that the Boeing 737 entered service in 1968, the same year Richard Nixon first was elected president of the United States. Perhaps not surprisingly, Boeing produced negative advertisements of its own. In choosing its advertising policy, Airbus presumably had to consider whether a negative campaign would be value-maximizing given Boeing's likely response. Similarly, Boeing had to consider Airbus's response in choosing its actions.

Game theory provides a useful set of tools for managers to use when considering rival responses in decision making. We briefly introduced these tools in Chapter 6. This chapter extends this introduction by presenting a more detailed discussion of the basic theory and by showing how managers might use these tools in strategic decision making. This analysis also provides managers with a richer understanding of competition within different market settings. For example, it provides insights into why there is fierce competition in some concentrated industries (such as commercial aircraft), whereas in others the competition is more benign. Although we focus primarily on interactions among rival firms in product markets, these concepts also are useful to managers when dealing with other parties, such as suppliers, employees, or government officials.

Game Theory

Game theory is concerned with the general analysis of strategic interaction.[2] It focuses on optimal decision making when all decision agents are presumed to be rational, with each attempting to anticipate the likely actions and reactions of its rivals.[3] Although it

[2] The terms *strategy* and *strategic* are used in at least three related yet slightly different ways in the economics literature. In all three contexts, the decision maker is assumed to interact with others in the environment. Thus the optimal decision is affected by the actions of others. The focus of the analysis, however, varies among the three uses. First, as in Chapter 8, the terms are employed to refer to the general policies that managers use to generate profits. The traditional strategy literature tends to use the terms within this context (for example, what businesses should the firm be in and how should they compete?). Even though rival responses are in the background in this literature, they are not explicitly treated in the analysis. Second, the terms are used to refer more specifically to decision-making contexts where it is essential for managers to consider the behavior of identifiable rivals in choosing their policies (for example, in setting prices in an industry with a few large firms). This is the primary use in this chapter. Third, they also are used in a more formal sense in game theory to describe the players' actions in a given game (for example, to describe a player's "strategy" in playing a game). We introduce this usage and related concepts in this chapter.

[3] Game theory is divided into two branches. In *cooperative games*, players can negotiate binding contracts that allow them to plan and implement joint strategies. In this chapter, we focus on *noncooperative games*, where negotiation and enforcement of binding contracts is not possible. This type of game theory generally is more useful for analyzing managerial decision making.

ACADEMIC APPLICATIONS

Game Theorists Win the Nobel Prize

The Nobel Prize for Economics (or, more precisely, The Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel) is the world's most prestigious award for contributions to the field of economics. It is awarded annually by the Royal Swedish Academy of Sciences. The prize consists of a gold medal, a diploma bearing a citation, and a sum of money—U.S. $1.3 million in recent years. It represents the ultimate recognition by one's peers.

In 1994, John Harsanyi, John Nash, and Reinhard Selten won the prize "for their pioneering analysis of the theory of non-cooperative games." And again in 2005, game theorists Robert Aumann and Thomas Schelling received the prize. Their contributions have had an important impact not only on theoretical economics, but on business practice as well. Firms hire game theorists as consultants in formulating strategic decisions (for example, in government auctions, corporate takeovers, pricing, labor negotiations, and competitive positioning). Several best-selling business books have illustrated how game theory can be used in everyday business decisions. Game theory now is being taught within most major business schools. And for those who do not want to take a course or read a book, the movie *A Beautiful Mind*—based on Sylvia Nasser's award-winning biography of John Nash—won three Oscars in 2001, including Best Picture. (Note, however, that the movie's illustration of a Nash equilibrium is fundamentally flawed.)

began as a set of methods to analyze parlor games, this theory has evolved to the point where it is applied to study a wide variety of strategic interactions ranging from politics to competitive strategy. In this chapter, we introduce its basic elements and apply them in the context of managerial decision making.

Sound managerial decision making often requires "putting yourself behind your rivals' desk." Assuming rivals are rational and acting in their self-interest, what decisions are they likely to make and how are they likely to respond to your actions? A complicating factor is that rivals' optimal choices typically will depend on their expectations of what you will do; their expectations, in turn, depend on their assessments of your expectations about them. This type of circularity or recursive thinking might appear to make the overall problem completely intractable. Yet, this situation is precisely where game theory is most useful.

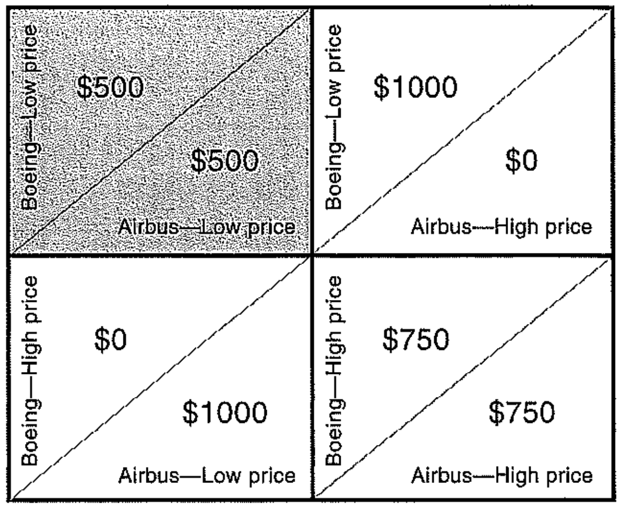
Strategic interactions can take a variety of forms and involve many players who choose among a variety of potential actions. In this chapter, we limit ourselves to simple two-player, two-action cases. This limitation allows us to depict strategic problems using convenient diagrams. The fundamental intuition and concepts developed in these basic cases readily extend to multiple players and multiple actions. Some problems involve simultaneous decisions by rivals, whereas others involve sequential choices. We begin by examining strategic problems involving simultaneous choices. Later, we consider sequential problems. In some cases, interaction is expected to be repeated; in others, it is not. Throughout most of this chapter, we focus on problems where the interaction is not expected to be repeated. Toward the end of the chapter—and in the appendix—we consider implications of repeated interaction.

Simultaneous-Move, Nonrepeated Interaction

In strategic problems that involve *simultaneous moves,* rivals must make decisions without knowledge of the decisions made by their competitors. *Nonrepeated* means that the interaction is presumed to occur only once. As an example, suppose that Boeing and Airbus are asked to submit sealed bids on the price of 10 jet airliners to a foreign national airline. Both companies doubt that they will compete in similar ways in the future. Both

Figure 9.1 Strategic Form

In this case, Boeing and Airbus individually choose and simultaneously submit a bid price for 10 planes. They can submit either a high price or a low price. If one company bids high and the other bids low, the order goes to the low bidder; if both companies submit the same bid, they split the order. This diagram presents the possible profits from the interaction in strategic form (normal form). Each cell presents the payoffs (in millions of dollars) of a pair of decisions. The entry on the lower right of each cell is the payoff for Airbus, whereas the entry on the upper left is for Boeing. Both firms have a dominant strategy (shaded cell)—choose a low price.



companies can select either a high price or a low price. If one company bids high and the other bids low, the order goes to the low bidder; if both companies submit the same bid, they split the order. Each firm has the capacity to build all 10 airplanes.

Analyzing the Payoffs

Both companies privately choose their bids at the same time. The resulting payoffs (profits expressed in millions of dollars) depend on both firms' choices; they are displayed in Figure 9.1. This type of diagram was first introduced in Chapter 6 and presents the potential payoffs from the interaction in what is called *strategic form* (also called *normal form*). Each cell presents the payoffs in millions of dollars for a pair of decisions. The entry on the lower right of each cell is the profit for Airbus, and the entry on the upper left is for Boeing.[4]

Dominant Strategies

A *dominant strategy* exists when it is optimal for a firm to choose that strategy no matter what its rival does. In Figure 9.1, both firms have a dominant strategy—choose the low price. To illustrate, consider Boeing's position. If Airbus chooses a high price (the right column), Boeing captures the entire order by submitting a low price. The resulting payoff of $1 billion is higher than the payoff of $750 million if both firms price high and split the order. If Airbus chooses a low price (the left column), Boeing is clearly better off to price low

[4]This diagram has two primary columns and two rows. Boeing is the row firm in the sense that its strategies vary between the two rows. Airbus is the column firm in that its strategies vary across columns. We place the payoff to the row firm at the upper left of the cell and the payoff to the column firm in the lower right. An alternative way to picture the payoffs is a simpler 2 × 2 table with each row representing one of Boeing's potential actions and each column representing one of Airbus's potential actions. The entries in each cell of the table would list the payoff to Boeing and to Airbus, respectively (for example, 100, 0). Although this alternative is more common (possibly because it is easier to type), students seem to find diagrams like 9.1 easier to read. Both diagrams display the same information.

MANAGERIAL APPLICATIONS

Stocklifting—A Dominant Strategy?

In the spring of 1998, Midwest Quality Gloves, Inc., paid about $700,000 to Lowe's Home Improvement Stores (the number-two home-center chain behind Home Depot) for 225,000 pairs of gloves produced by a competing firm, Wells Lamont. Midwest then sold the gloves for about $280,000 to a firm that specializes in liquidating closed-out merchandise. The motivation for this transaction was to clear shelf space, allowing Lowe's to restock the shelves with Midwest's gloves.

This practice, known as "stocklifting," is increasing in popularity. Makers of everything from bicycle chains to party napkins are lifting truckloads of competitors' products from large retail chains such as Kmart and Revco drugstores. Other stocklifting examples include cellular phones, power adapters, leather cases, pet toys, humidifiers, flashlights, faucets, and glue. The stocklifted merchandise is subsequently "dumped" for resale by faraway (sometimes foreign) retailers. The purpose in each case is to clear shelf space for the stocklifter's products. To quote one executive involved in this practice, "buybacks are a necessary evil in gaining market share."

From the standpoint of the manufacturer this costly practice is a potentially dominant strategy. To quote one product manager, "It costs a ton of money; however, if you want to land a major retail account, you're going to have to do it."

When competing manufacturers jointly engage in this practice, they can find themselves in a "rivals' dilemma" such as in our Boeing/Airbus example: They would each be better off if no one stocklifted. Given the private incentives of each firm, however, stocklifting is difficult to avoid. For instance, after purchasing stocklifted products from a company, one major liquidator makes "courtesy calls" to the victims, encouraging them to "return the favor" by working with his company.

Source: Y. Ono (1998), "Where Are the Gloves? They Were Stocklifted by a Rival Producer," *The Wall Street Journal* (May 15), A1.

and split the order. Its alternative is to price high and sell no planes. The same logic holds for Airbus. Given these strong incentives, the likely outcome is for both firms to submit a low price. Note that the firms would be better off if they jointly were to submit high prices. But this outcome is unlikely without repeated interactions. This problem has the same structure as the *prisoners' dilemma* introduced in Chapter 6—we might call it the *rivals' dilemma*. As we shall see, a "cooperative" outcome where both firms submit high prices without explicit collusion is more likely if their interaction is expected to be repeated.

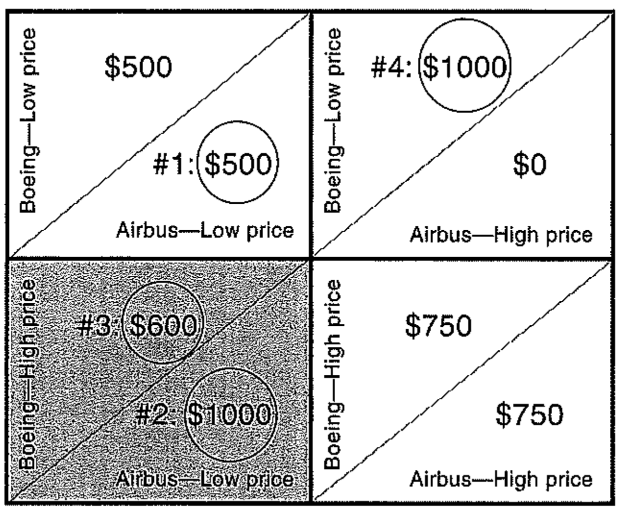
This logic helps explain why Boeing and Airbus frequently compete aggressively on price. Airline orders frequently are measured in billions of dollars, so each sale is important. Further, customers (normally commercial airline companies) have economic incentives to deal with a single major supplier of aircraft since this policy reduces the required inventory of spare parts, technician training (maintenance personnel work only on one make of plane), and so on.[5] Thus if Boeing or Airbus lose an order, it implies the loss of potential future orders as well. Just as in Figure 9.1 the companies have strong economic incentives to submit low bids to capture orders.

Boeing and Airbus have particularly strong incentives to compete on price because each firm has the capacity to sell higher output. Boeing has stated that it wants to win two-thirds of all new orders (substantially above its current level), whereas Airbus wants to win about 50 percent (approximately equal to its current level). These conflicting goals promote price competition as each firm tries to take orders from the other. If the rivals faced tighter capacity constraints, it is likely that there would be less price competition. For instance in our simplified example, a firm clearly would not want to lower the price to capture the full order if it lacked the capacity to produce all 10 planes.

[5]Given these considerations, our assumption that if the bids are the same, the order is split between Boeing and Airbus should be questioned. Yet, if the buyer flips a coin and gives all the order to the lucky bidder whenever the bids are equal, then the *expected* payoffs are the same as in Figure 9.1.

Figure 9.2 Nash Equilibrium

Boeing and Airbus individually submit prices for 10 planes. They can choose either a high price or a low price. If one company bids high and the other bids low, the order goes to the low bidder; if both companies make the same bid, they split the order. If Boeing loses the bid, it sells four planes at the high price through a side deal. The circle technique provides a simple way to identify a Nash equilibrium. Start by assuming that Boeing will submit a low price (the top row). Circle the maximum payoff (in millions of dollars) that Airbus can achieve. This payoff (labeled #1) is in the cell where Airbus submits a low price (if the same payoff occurs regardless of whether Airbus submits a high or low price, circle both cells). Second, move to the bottom row and assume that Boeing submits a high price; circle Airbus's highest payoff (#2). Third, assume Airbus will charge a low price (left column) and circle Boeing's highest payoff (#3). Fourth, move to the right column and assume Airbus submits a high price; circle Boeing's highest payoff (#4). If a Nash equilibrium exists, the payoffs in both halves of the cell will be circled. In this game, the Nash equilibrium is where Boeing submits a high price and Airbus submits a low price—shaded cell. (Note: Airbus has a dominant strategy—submit a low price—the low-price strategy is circled in both rows.)



Nash Equilibrium Revisited

Firms do not always have dominant strategies. For instance, suppose in our example that the United States government places pressure on the foreign country to have its national airline purchase planes from Boeing (governments sometimes do this for their domestic producers). The airline still splits the order when the bids are the same and awards Boeing the entire order if Boeing is the low bidder. But due to this political pressure, if Boeing bids high and loses the bid, the airline will buy four planes from Boeing at the high price on a side deal after purchasing the 10 planes from Airbus at the low price. Figure 9.2 presents this new payoff structure. Choosing a low price is still a dominant strategy for Airbus. Boeing, however, does not have a dominant strategy. If Airbus prices high, it is optimal for Boeing to price low to capture the entire order, whereas if Airbus prices low, it is better for Boeing to price high and make the side deal.

ACADEMIC APPLICATIONS

Are Nash Equilibria Likely?

Researchers have conducted many laboratory experiments on how people act in strategic situations. One particular question of interest is, *Do they choose Nash equilibria?* The evidence suggests that the concept works relatively well in predicting behavior in simple single-move situations—especially if the individuals have prior experience interacting in similar ways with different partners in the past. It appears to work less well in more complex situations (for example, situations that involve sophisticated mathematical calculations) and in repeated situations (we discuss implications of repetition later in this chapter). Also it often fails where coordination is required and there are multiple equilibria, unless there is a natural focal point.

Source: D. Davis and C. Holt (1993), *Experimental Economics* (Princeton University Press: Princeton, NJ).

Nash Equilibrium

When dominant strategies do not exist, the concept of a *Nash equilibrium* is useful in predicting the outcome. As defined in Chapter 6, a Nash equilibrium is a set of strategies (or actions) in which each firm is doing the best it can, given the actions of its rival. In Figure 9.2, the combination of a low Airbus price and a high Boeing price is a Nash equilibrium. Neither firm would want to change its price given the price submitted by the other firm.

A particular problem might have multiple Nash equilibria. Nash equilibria are not necessarily the outcomes that maximize the joint payoff of the players. For instance, in Figure 9.1 the outcome where both firms submit low prices is a Nash equilibrium. Yet both firms would be better off if they jointly submitted high prices.

Identifying a Nash Equilibrium

The *circle technique* provides a simple way to identify a Nash equilibrium in such a problem. Consider the case in Figure 9.2. Start by assuming that Boeing will charge a low price (this is in the top row). Circle the maximum payoff that Airbus can achieve. This payoff (labeled #1) is in the cell where Airbus submits a low price (if the same payoff were to occur regardless of whether Airbus submits a high or low price, circle *both cells*). Second, move to the bottom row and assume that Boeing submits a high price; again circle Airbus's higher payoff (#2). Third, assume Airbus submits a low price (left column) and circle Boeing's higher payoff (#3). Finally, move to the right column and assume Airbus submits a high price; circle Boeing's higher payoff (#4). If a Nash equilibrium exists, the payoffs in both halves of the cell will be circled. In this problem, the Nash equilibrium is the shaded cell where Boeing submits a high price and Airbus submits a low price.

Dominant strategies also can be identified by this technique. If the firm has a dominant strategy, the strategy will be circled for all actions by the rival firm. In this example, submitting a low price is a dominant strategy for Airbus: For each of Boeing's possible actions submitting a low price is circled.

Management Implications

The power of a Nash equilibrium to predict the outcome in strategic situations stems from the fact that Nash equilibria are self-enforcing: They are stable outcomes. For instance, if Boeing can forecast Airbus's choice (perhaps because it understands that Airbus has a

ANALYZING MANAGERIAL DECISIONS: *Favoring a Government Ban on Advertising*

Cigarette manufacturers were among the first companies to advertise extensively on television. Older people today can still hum the heavily televised jingle, "Winston tastes good like a cigarette should," and recall the Old Gold Dancing Cigarette Pack—an oversized dancing cigarette package with shapely female legs. They can also remember beautiful women with black eyes as they testified that "Tareyton smokers would rather fight than switch." John Wayne and other movie stars appeared in commercials to endorse cigarettes. Cigarette companies were the major sponsors for many popular television shows. The companies also paid to have cigarettes included in the actual programs. In 1962 the cartoon characters Fred and Wilma Flintstone were shown smoking Winston cigarettes.

The U.S. federal Government banned television advertising of cigarettes starting in 1971. Interestingly the ban was supported by the leading cigarette manufacturing companies even though they had advertised heavily on television since the 1940s.

1. Design a simple two-company game that illustrates why it might have been in the economic interests of the cigarette companies to support the ban. In designing the game, assume that there is no regulation and that the two firms simultaneously choose between advertising and not advertising. Display your hypothetical payoffs in strategic form (see Figure 9.1) and highlight the Nash equilibrium. Explain the intuition for why the firms in your example would favor regulation to ban advertising.
2. Can you conclude from your example that all firms in all industries will favor bans on television advertising? Explain. Can you ever envision a situation where one firm might favor the ban and a competing firm might be against it? Discuss.

dominant strategy), it is optimal for Boeing to choose its equilibrium action, a high price. And Airbus has no incentive to avoid its equilibrium choice, a low price. Thus, even if both firms can forecast the outcome, neither firm has an incentive to choose any other action.

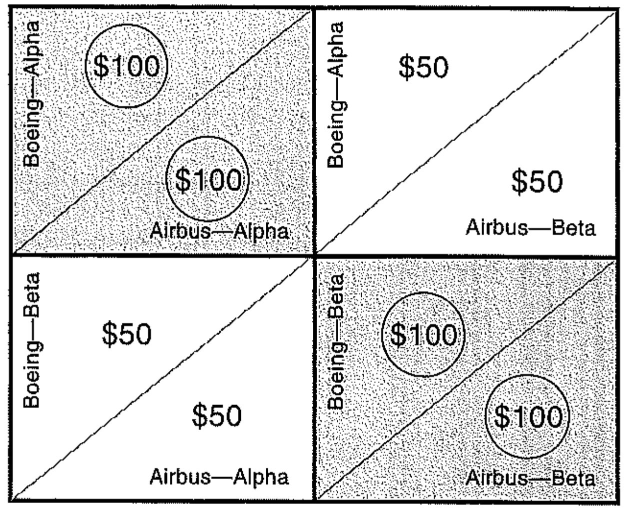
Although the idea of a Nash equilibrium is quite useful, it is not as powerful in predicting the outcomes of strategic interactions as is the concept of a dominant strategy. When dominant strategies exist, there are strong private incentives to choose them, regardless of what the other player does. Thus, it is quite predictable that rivals will choose dominant strategies. With a Nash equilibrium, your best choice generally is contingent on what you expect your rival to do.

In many cases it is reasonable to expect that a Nash equilibrium will occur. This is more likely to be true when the rivals have more experience in similar strategic problems, have better information about each other, or when the Nash equilibrium is what is called a natural focal point.[6] For example, consider the problem in Figure 9.2. If

[6] A focal point exists when there is a reasonable and obvious way to behave. To illustrate how a Nash equilibrium could be a focal point, consider a game where two strangers are asked to raise a hand. Both players receive a large payoff if they stick up the same hand (both left hands or both right hands) and nothing if they raise opposite hands. Two Nash equilibria exist: (1) both raising left hands, (2) both raising right hands. Nonequilibrium outcomes occur when the players raise opposite hands. The Nash equilibrium of both raising right hands is potentially a focal point. Most people are right-handed. If one player expects that the other is likely to raise his right hand because he is right-handed, she will have the incentive to raise her right hand as well. Reciprocally, it is reasonable for the other player to follow the same logic. Thus this outcome is potentially much more likely than either the nonequilibrium outcomes or the Nash equilibrium of two left hands.

Figure 9.3 Coordination Game

Boeing and Airbus make simultaneous choices of new communication systems for their planes. Two technologies exist: Alpha and Beta (payoffs in millions of dollars). Both firms benefit if they choose the same technology. Applying the circle technique, we can see that there are two Nash equilibria: Alpha/Alpha and Beta/Beta (shaded cells).



Boeing has reasonable information about potential payoffs and Airbus's lack of political power within the specific country (it understands that there is a close working relationship between the local and U.S. governments), it will realize that Airbus has a dominant strategy to submit a low price. Boeing correspondingly will choose a high price—the Nash equilibrium. When rivals know little about the game or each other and when there is not a natural focal point, outcomes other than Nash equilibria (nonequilibrium outcomes) are more likely to occur.

Competition versus Coordination

To this point, we have analyzed competitive interaction. In each case, at least one of the firms has an incentive to bid low to take sales from the other and garner additional profits. This potential gain comes at the expense of the other firm. Many strategic situations, however, involve coordination rather than competition.

Consider the problem in Figure 9.3, in which Boeing and Airbus make simultaneous choices of new communication systems for their planes.[7] Two technologies exist: Alpha and Beta. Both firms benefit if they choose the same technology. A common technology standard allows producers to exploit scale economies and increases the likelihood that other companies will invest to develop new enhancements for the system because they can sell to both companies. Similarly, companies are more likely to develop service capabilities and stock larger inventories of spare parts. The overall demand for planes also might be higher because airlines would have lower costs in learning a single system.

[7]For example, suppose each company is working to introduce a new intermediate-capacity plane at next year's Paris Air Show and each views its choice of communication technology as a critical selling point for its model. Each will have to commit to a technology at the design phase, and each might be reluctant to discuss such features with its rival before the new model is unveiled.

MANAGERIAL APPLICATIONS

Coordination Problems with HDTV

High-definition televisions are digital and capable of displaying images at very high resolution. When combined with a good sound system, HDTV can provide a theater-like experience. The introduction of HDTV into the marketplace was slowed by coordination problems between television networks and manufacturers. Both groups thought that they would benefit by the development of this product. However, neither wanted to be the first to commit. Network executives were quoted as saying that they were reluctant to move forward with plans for new programming until the television manufacturers committed themselves to producing enough affordable sets to receive it. Yet manufacturers did not want to commit until the networks indicated that there would be enough digital programming for consumers to want to buy the sets. The situation was summed up in 1997 by a senior executive at CBS, "The networks are waiting to see what the TV makers are going to do, and the TV makers are waiting to see what the networks are going to do." In this situation, there are two Nash equilibria: Manufacturers and broadcasters both invest or neither invests. Due to coordination problems, firms may "get stuck" in the second equilibrium, even though both groups prefer the first. Although development of HDTV was slowed by coordination problems, it became a commercial reality by 1999. Manufacturers were selling the sets and broadcasting companies were providing more and more HDTV programming (the first equilibrium). Nonetheless, for HDTV to become a widely adopted product, available programming had to increase and set prices had to decline. Their initial prices for the sets ranged from about $5,000 to $10,000.

The coordination problems illustrated in this example arise frequently with new technologies. The overall value of a technology is usually higher when there are many users (there are network effects) and there is a common standard (for example, consider how much less valuable DVDs would be if there were several different incompatible formats and only a small number of users of any one type). Adopting a uniform standard can be difficult when there are numerous players with somewhat conflicting interests. Sometimes governments, joint ventures among firms, and industry trade groups play a constructive role in promoting common standards, thereby helping to realize a preferred equilibrium. For example, in December 1996 the Federal Communications Commission set a timetable for stations and manufacturers converting to digital technology and, in October 2005, the Senate Commerce Committee set April 7, 2009, as the last date at which U.S. television stations can broadcast analog signals.

Source: J. Brinkley (1997), "Networks and Set Makers in Standoff over HDTV," *New York Times* (August 29), 5; and J. Kerr (2005), "Senate Looks to Spend $3B on Digital TV," WashingtonPost.com (October 20).

Applying the circle technique, we can see that there are two Nash equilibria: Alpha/Alpha and Beta/Beta. If precommitment communication is possible, it is quite likely that one of these equilibria will be reached. For instance, if both firms announce that they will choose Alpha, there is no private incentive to deviate from this choice. Coordination can prove more difficult in cases where precommitment communication is costly and/or there are many players.

Some strategic interactions involve elements of both competition and coordination. In the interactions problem in Figure 9.4, Boeing and Airbus benefit from choosing the same technology; again, there are two equilibria. But the companies are not indifferent between the two. Boeing prefers the Alpha technology, whereas Airbus prefers the Beta technology (the technologies are better matches for their particular aircraft design). Coordination in this setting can be more difficult than in pure coordination problems, since the firms want different outcomes. Nonetheless, if one of the firms is convinced of the choice the other firm is going to make, it has an economic incentive to follow suit and choose the same technology. Below we discuss ways that firms might be able to make credible statements regarding their upcoming choices.