CHAPTER 13

Game Theory and Competitive Strategy

*U*nlike a pure monopoly or a perfectly competitive firm, most firms must consider the likely responses of competitors when they make strategic decisions about price, advertising expenditure, investment in new capital, and other variables. Although we began to explore some of these strategic decisions in the last chapter, there are many questions about market structure and firm behavior that we have not yet addressed. For example, why do firms tend to collude *in* some markets and compete aggressively in others? How do some firms manage to deter entry by potential competitors? And how should firms make pricing decisions when demand or cost conditions are changing, or new competitors are entering the market?

To answer these questions, we will use game theory to extend our analysis of strategic decision making by firms. The application of game theory has been an important development in microeconomics. This chapter explains some of this theory and shows how it can be used to understand how markets evolve and operate, and how managers should think about the strategic decisions they continually face. We will see, for example, what happens when oligopolistic firms must set and adjust prices strategically over time, so that the Prisoners' Dilemma, which we discussed in Chapter 12, is repeated over and over. We will discuss how firms can make strategic moves that give them an advantage over their competitors or the edge in a bargaining situation. And we will see *how* firms can use threats, promises, or more concrete actions to deter entry by potential competitors.

13.1 *Gaming arid Strategic Decisions*

First, we should clarify what gaming and strategic decision making are all about. In essence, we are concerned with the following question: *If I believe that my competitors are rational and act to maximize their own profits, how should I take their behavior into account when making my own profit-maximizing decisions?*

As we will see, this question can be difficult to answer, even under conditions of complete symmetry and perfect information (i.e., my competitors and I have the same cost structure and are fully informed about each others' costs, about demand, etc.). Moreover, we will be concerned with more complex situations in which firms have different costs, different types of information, and various degrees and forms of competitive "advantage" and "disadvantage."

Noncooperative versus Cooperative Games

The economic games that firms play can be either *cooperative or noncooperative.* A game is *cooperative* if the players can negotiate binding contracts that allow them to plan joint strategies. A game is *noncooperative* if negotiation and enforcement of a binding contract are not possible.

An example of a cooperative game is the bargaining between a buyer and a seller over the price of a rug. If the rug costs $100 to produce and the buyer values the rug at $200, a cooperative solution to the game is possible because an agreement to sell the rug at any price between $101 and $199 will maximize the gum of the *buyer's* consumer surplus and the seller's profit, while making both parties better off. Another cooperative game would involve two firms in an industry, which negotiate a joint investment to develop a new technology (where neither firm would have enough know-how to succeed on its own). If the firms can sign a binding contract to divide the profits from their joint investment, a cooperative outcome that makes both parties better off is possible.[1] An example of a noncooperative game is a situation in which two competing firms take each other's likely behavior into account and independently determine a pricing or advertising strategy to win market share.

Note that the fundamental difference between cooperative and noncooperative games lies in the contracting possibilities. In cooperative games binding contracts are possible; in noncooperative games they are not.

We will be concerned mostly with noncooperative games. In any game, however, the most important aspect of strategy design is *understanding your*

[1] Bargaining over a rug is called a *constant sum* game because no matter what the selling price, the sum of consumer surplus and profit will be the same. Negotiating over a joint venture is a *nonconstant sum* game: the total profit that results from the venture will depend on the outcome of the negotiations, e.g., the resources that each firm devotes to the venture.

opponent's point of view, and (assuming your opponent is rational) deducing how he or she is likely to respond to your actions. This may seem obvious-of course, one must understand an opponent's point of view. Yet even in simple gaming situations, people often ignore or misjudge their opponents' positions and the rational responses those positions imply.

An example of this is the following game devised by Martin Shubik.[2] A dollar bill is auctioned, but in an unusual way. The highest bidder receives the dollar in return for the amount bid. However, the second-highest bidder must also hand over the amount he or she bid-and get nothing in return. *If you were playing this game, how much would you bid for the dollar bill?*

Classroom experience shows that students often end up bidding more than a dollar for the dollar. In a typical scenario, one player bids 20 cents, and another 30 cents. The lower bidder now stands to lose 20 cents, but figures he can earn a dollar by raising his bid, and so bids 40 cents. The escalation continues until two players carry the bidding to a dollar against 90 cents. Now the 90-cent bidder has to choose between bidding $1.10 for the dollar, or paying 90 cents to get nothing. Most often, he raises his bid, and the bidding escalates further. In some experiments, the "winning" student has ended up paying more than $3 for the dollar!

How could intelligent students put themselves in this position? By failing to think through the likely response of the other players, and the sequence of events it implies. How much would you bid for the dollar? We hope nothing.

In the rest of this chapter, we will examine Simple games that involve pricing, advertising, and investment decisions. The games are simple in that, *given some behavioral assumption,* we can determine the best strategy for each firm. But even for these simple games, we will find that the correct behavioral assumptions are not always easy to make, and will depend on how the game is played (e.g., how long the firms stay in business, their reputations, etc.). Therefore, when reading this chapter, you should try to understand the basic issues involved in making strategic decisions. You should also keep in mind the importance of carefully assessing your opponent's position and rational response to your actions, as Example 13.1 illustrates.

EXAMPLE 13.1 ACQUIRING A COMPANY

You represent Company A (the acquirer), which is considering acquiring Company T (the target).[3] You plan to offer cash for all of Company T's shares, but you are unsure what price to offer. The complication is this: The value of Company T, indeed, its viability, depends on the outcome of a major oil exploration project that it is currently undertaking. If the'project fails. Company T under current management will be worth nothing. But if it succeeds. Company

[2] Martin Shubik, *Game Theory in the Social Sciences* (Cambridge, Mass.: MIT Press, 1982).

[3] This is a revised version of an example designed by Max Bazerman for a course at MIT.

T's value under current management could be as high as $100/share. All share values between $0 and $100 are considered equally likely-

It is well known, however, that Company T will be worth much more under the progressive management of Company A than under current management. In fact, whatever the ultimate value under current management. *Company T will be worth 50 percent more under the management of Company A.* If the project fails. Company T is worth $0/share under either management. If the exploration project generates a $50/share value under current management, the value under Company A will be $75/share. Similarly, a $100/share value under Company T implies a $150/share value under Company A, and so on.

You must determine what price Company A should offer for Company T's shares. This offer must be made *now, before* the outcome of the exploration project is known. From all indications. Company T would be happy to be acquired by Company A, *for the right price.* You expect Company T to delay a decision on your bid until the exploration results are in and then accept or reject your offer before news of the drilling results reaches the press.

Thus, *you (Company A) will 'not know the results of the exploration project when submitting your price offer, but Company T will know the results when deciding whether to accept your offer. Also, Company T will accept any offer by Company A that is greater than the (per share) value of the company under current management.* As the representative of Company A, you are considering price offers in the range $0/share (i.e., making no offer at all) to $150/share. *What price per share should you offer for Company T's stock?*

Note: The typical response-to offer between $50 and $75 per share-is wrong. The correct answer to this problem appears at the end of this chapter, but we urge you to try to answer it on your own.

13.2 *Dominant Strateqies*

How can we decide on the best strategy for playing a game? How can we determine a gamers likely outcome? We need something to help us determine how the rational behavior of each player will lead to an equilibrium solution. Some strategies may be successful if competitors make certain choices, but will fail if they make other choices.Other strategies,however, may be successful whatever competitors choose to do. We begin with the concept of a *dominant strategy-one that is optimal for a player no matter what an opponent does.*

The following example illustrates this in a duopoly setting. Suppose Firms A and *B* sell competing products and are deciding whether to undertake advertising campaigns. Each firm, however, will be affected by its competitor's decision. The possible outcomes of the game are illustrated by the payoff matrix in Table 13.1. (Recall that the payoff matrix summarizes the possible

TABLE 13.1 Payoff Matrix for Advertising Game

		Firm B	
		Advertise	Don't Advertise
Firm A	Advertise	10, 5	15, 0
	Don't Advertise	6, 8	10, 2

outcomes of the game; the first number in each cell is the payoff to *A* and the second is the payoff to *B*.) Observe from this payoff matrix that if both firms decide to advertise. Firm *A* will make a profit of 10, and Firm B will make a profit of 5. If Firm *A* advertises and Firm *B* doesn't. Firm *A* will earn 15, and Firm *B* will earn zero. And similarly for the other two possibilities.

What strategy should each firm choose? First, consider Firm *A*. It should clearly advertise because no matter what Firm B does. Firm A does best by advertising. (If Firm *B* advertises, *A* earns a profit of 10 if it advertises, but only 6 if it doesn't. And if *B* does not advertise, *A* earns 15 if it advertises, but only. 10 if it doesn't.) Thus, advertising is a dominant strategy for Firm *A*. The same is true for Firm *B*; no matter what Firm *A* does. Firm *B* does best by advertising. Therefore, assuming that both firms are rational, we know that the outcome for this game is that *bothfirms will advertise.* This 'outcome is easy to determine because both firms have dominant strategies.

However, not every game has a dominant strategy for each player. To see this, let's change our advertising example slightly. The payoff matrix in Table 13.2 is the same as in Table 13.1, except for the bottom right-hand corner-if neither firm advertises. Firm B will again earn a profit of 2, but Firm *A* will earn a profit of 20 (perhaps because Firm *A*'s ads are largely defensive, designed to refute Firm *B*'s claims, and expensive; so by not advertising. Firm *A* can reduce its expenses considerably).

Now Firm *A* has no dominant strategy. *Its optimal decision depends on what Firm B does.* If Firm *B* advertises, then Firm *A* does best by advertising; but if Firm B does not advertise. Firm *A* also does best by not advertising. Now

TABLE 13.2 Modified Advertising Game

		Firm B	
		Advertise	Don't Advertise
Firm A	Advertise	10, 5	15, 0
	Don't Advertise	6, 8	20, 2

suppose both firms must make their decisions at the same time. What should Firm *A* do?

To answer this. Firm *A* must put itself in Firm *B*'s shoes. What decision is best from Firm *B*'s point of view, and what is Firm *B* likely to do? The answer is clear: Firm *B* has a dominant strategy-advertise, no matter what Firm *A* does. (If Firm *A* advertises, *B* earns 5 by advertising and 0 by not advertising. If *A* doesn't advertise, *B* earns 8 if it advertises and 2 if it doesn't.) Therefore, Firm *A* can conclude that Firm *B* will advertise. This means that Firm *A* should itself advertise (and thereby earn 10 instead of 6). The equilibrium is that both firms will advertise. If is the logical outcome of the game because Firm *A* is doing the best it can, given Firm *B's* decision; and Firm B is doing the best it can, given Firm *A*'s decision.

13.3 *The Nash Equilibrium Revisited*

To determine the likely outcome of a game, we have been seeking "self-enforcing," or "stable," strategies. Dominant strategies are stable, but in many games, one or more players do not have a dominant strategy. We therefore need a more general equilibrium concept. In Chapter 12 we introduced the concept of a *Nash equilibrium* and saw that it is widely applicable and intuitively appealing.[4]

Recall that a Nash equilibrium is a set of strategies (or actions) such that *each player is doing the best it can given the actions of its opponents. Since* each player has no incentive to deviate from its Nash strategy, the strategies are stable. In the example shown in Table 13.2, the Nash equilibrium is that both firms advertise. It is a Nash equilibrium because, given the decision of its competitor, each firm is satisfied that it has made the best decision possible, and has no incentive to change its decision.

In Chapter 12 we used the Nash equilibrium to study output and pricing by oligopolistic firms. In the Cournot model, for example, each firm sets its own output while taking the outputs of its competitors as fixed. We saw that in a Cournot equilibrium, no firm has an incentive to change its output unilaterally because each firm is doing the best it can given the decisions of its competitors. Hence a Cournot equilibrium is a Nash equilibrium.[5] We also examined models in which firms choose price, taking the prices of their com-

[4] Our discussion of the Nash equilibrium, and of game theory in general, is at an introductory level. For a more in-depth discussion of game theory and its applications, see James W. Friedman, *Game Theory with Applications to Economics* (New York: Oxford University Press, 1990); David Kreps, *A Course in Microeconomic Theory* (Princeton, N.J.: Princeton University Press, 1990); and Drew Fudenberg and Jean Tirole, *Game Theory* (Cambridge, Mass.: MIT Press, 1991).

[5] A Stackelberg equilibrium is also a Nash equilibrium. In the Stackelberg model, the rules of the game are different: One firm makes its output decision before its competitor does. Under these rules, each firm is doing the best it can given the decision of its competitor.

petitors as fixed. Again, in the Nash equilibrium, each firm is earning the largest profit it can given the prices of its competitors, and thus has no incentive to change its price.

It is helpful to compare the concept of a Nash equilibrium with that of an equilibrium in dominant strategies:

Dominant Strategies:	I'm doing the best I can no *matter what you* do. You're doing the best you can no *matter what I do.*
Hash. Equilibrium:	I'm doing the best I can *giuen what you are doing.* You're doing the best you can *giuen what I am doinq.*

Note that a dominant strategy equilibrium is a special case of a Nash equilibrium.

In the advertising game of Table 13.2 there is a single Nash equilibrium-both firms advertise. In general, a game does not have to have a single Nash equilibrium. Sometimes there is no Nash equilibrium, and sometimes there are several (i.e., several sets of strategies are stable and self-enforcing). A few more examples will help to clarify this.[6]

Consider the following "product choice" problem. Two breakfast cereal companies face a market in which two new variations of cereal can be successfully introduced-provided each variation is introduced by only one firm. There is a market for a new "crispy" cereal and for a new "sweet" cereal, but each firm has the resources to introduce only one new product. Then the payoff matrix for the two firms might look like the one in Table 13.3.

In this game each firm is indifferent about which product it produces, so long as it does not introduce the same product as its competitor. If coordination were possible, the firms would probably agree to divide the market. But what will happen if the firms must behave *noncooperatively*? Suppose that somehow-perhaps through a news releas-Firm 1 indicates it is about to introduce the sweet cereal, and Firm 2 (after hearing this) indicates it will introduce the crispy one. Now, given the action it believes its opponent is taking, neither firm has an incentive to deviate from its proposed action. If it

TABLE 13.3 Product Choice Problem

		Firm 2	
		Crispy	Sweet
Firm 1	Crispy	−5, −5	10, 10
	Sweet	10, 10	−5, −5

6 Several of-these examples were developed by Garth Saloner.

takes the proposed action, its payoff is 10, but if it deviates-given that its opponent's action remains unchanged-its payoff will be -5. Therefore, the strategy set given by the bottom left-hand corner of the payoff matrix is stable and constitutes a Nash equilibrium: Given the strategy of its opponent, each firm is doing the best it can and has no incentive to deviate.

Note that the upper right-hand corner of the payoff matrix is also a Nash equilibrium, which might occur if Firm 1 indicated it was about to produce the crispy cereal. Each Nash equilibrium is stable because *once the strategies are chosen,* no player will unilaterally deviate from them. However, without more information, we have no way of knowing which equilibrium (crispy/sweet vs. sweet/crispy) is likely to result-or if *either* will result. Of course, both firms have a strong incentive to reach *one* of the two Nash equilibria-if they both introduce the same type of cereal, they will both lose money. The fact that the two firms are not allowed to collude does not mean that they will not reach a Nash equilibrium. As an industry develops, understandings often evolve as firms "signal" each other about the paths the industry is to take.

Maximin Strategies

The concept of a Nash equilibrium relies heavily on individual rationality. Each player's choice of strategy depends not only on its own rationality, but also on that of its opponent. This can be a limitation, as the example in Table 13.4 shows.

In this game, playing "right" is a dominant strategy for Player 2 because by' using this strategy. Player 2 will do better (earning 1 rather than 0), no matter what Player 1 does. Thus, Player 1 should expect Player 2 to play the "right" strategy. In this case Player 1 would do better by playing "bottom" (and earning 2) than by playing "top" (and earning 1). Clearly the outcome (bottom, right) is a Nash equilibrium for this game, and you can verify that it is the only Nash equilibrium. But note that Player 1 had better be sure that Player 2 understands the game and is rational. If Player 2 should happen to make a mistake and play "left," it would be extremely costly to Player 1.

If you were Player I, what would you do? If you tend to be cautious, and you are concerned that Player 2 might not be fully informed or rational, you

TABLE 13.4 Maximin Strategy

		Player 2 Left	Player 2 Right
Player 1	Top	1, 0	1, 1
	Bottom	−1000, 0	2, 1

TABLE 13.5 Prisoners' Dilemma

		Prisoner B: Confess	Prisoner B: Don't Confess
Prisoner A	Confess	−5, −5	−1, −10
	Don't Confess	−10, −1	−2, −2

might choose to play "top," in which case you will be assured of earning 1, and you will have no chance of losing 1000. Such a strategy is called a *maximin strategy* because *it maximizes the minimum gain that can be earned.* If both players used maximin strategies, the outcome would be (top, right). A maximin strategy is conservative, but not profit maximizing (since Player 1 earns a profit of 1 rather than 2). Note that if Player 1 *knew for certain* that Player 2 was using a maximin strategy, it would prefer to play "bottom" (and earn 2), instead of following the maximin strategy of playing "top."

What is the Nash equilibrium for the Prisoners' Dilemma discussed in Chapter 12? Table 13.5 shows the payoff matrix for the Prisoners7 Dilemma. For the two prisoners, the ideal outcome is one in which neither confessed, so that they both get two years in prison. However, confessing is *adominant'strategy* for each prisoner-it yields a higher payoff regardless of the strategy of the other prisoner. Dominant strategies are also maximin strategies. Therefore, the outcome in which both prisoners confess is both a Nash equilibrium and a maximin solution. Thus, in a very strong sense, it is rational for each prisoner to confess.

*Mixed Strategies

In all of the games that we examined so far, we have considered strategies in which players make a specific choice or take a specific action: advertise or don't advertise, set a price of $4 or a price of $6, and so on. Strategies of this kind are called *pure strategies.* There are games, however, in which pure strategies are not the best way to play.

An example is the game of "Matching Pennies." In this game, each player chooses heads or .tails, and the two players reveal their coins at the same time. If the coins match (i.e., both are heads or both are tails). Player *A* wins and receives a dollar from Player *B*. If the coins do not match. Player *B* wins and receives a dollar from Player *A*. The payoff matrix is shown in Table 13.6.

Note that there is no Nash equilibrium in pure strategies for this game. Suppose, for example, that Player *A* chose the strategy of playing heads. Then Player *B* would want to play tails. But if Player *B* plays tails. Player *A* would also want to play tails. No combination of heads or tails leaves both players satisfied, so that neither would want to change strategies.

TABLE 13.6 Matching Pennies-

		Player B	
		Heads	Tails
Player A	Heads	1, −1	−1, 1
	Tails	−1, 1	1, −1

Although there is no Nash equilibrium in pure strategies, there is a Nash equilibrium in *mixed strategies.* A *mixed strategy is a strategy in which the player makes a random choice among two or more possible actions, based on a set of chosen probabilities.* In this game, for example. Player A might simply flip the coin, thereby playing heads with probability ½ and playing tails with probability ½. In fact, if Player *A* follows this strategy and Player *B* does the same, we will have a Nash equilibrium; both players will be doing the best they can given what the opponent is doing. Note that the outcome of the game is random, but the *expected payoff* is 0 for each player.

It may seem strange to play a game by choosing actions randomly But put yourself in the position of Player *A* and think what would happen if you followed a strategy *other* than just flipping the coin. Suppose, for example, you decided to play heads. If Player *B* knows this, she would play tails, and you would lose. Even if Player B didn't know your strategy, if the game were played over and over again, she could eventually discern your pattern of play and choose a strategy that countered it. Of course, you would then want to change your strategy-which is why this would not be a Nash equilibrium. Only if you and your opponent both choose heads or tails randomly with probability V2, would neither of you have any incentive to change strategies.[7]

One reason to consider mixed strategies is that some games (such as "Matching Pennies") do not have any Nash equilibria in pure strategies. It can be shown, however, that *every* game has at least one Nash equilibrium, once we allow for mixed strategies.[8] Hence, mixed strategies provide solutions to games when pure strategies fail. Of course, whether solutions involving mixed strategies are reasonable will depend on the particular game and players. Mixed strategies are likely to be very reasonable for "Matching Pennies," poker, and other such games. A firm, on the other hand, might not find it reasonable to believe that its competitor will set its price randomly.

Some games have Nash equilibria both in pure strategies and in mixed strategies. An example is "The Battle of the Sexes," a game that you might

[7] You can check that the use of different probabilities, say ¾ for heads and ¼ for tails, does not generate a Nash equilibrium.

[8] More precisely, every game with a finite number of players and a finite number of actions has at least one Nash equilibrium. For a proof, see David M. Kreps, *A Course in Microeconomic Theory* (Princeton, N.J-: Princeton University Press, 1990), p. 409.

TABLE 13.7 The Battle of the Sexes

		Joan	
		Wrestling	Opera
Jim	Wrestling	2, 1	0, 0
	Opera	0, 0	1, 2

find familiar. It goes like this. Jim and Joan would like to spend Saturday night together, but have different tastes in entertainment. Joan would like to go to the opera, but Jim prefers mud wrestling. (Feel free to reverse these preferences.) As the payoff matrix in Table 13.7 shows, Joan would most prefer to go to the opera with Jim, but prefers watching mud wrestling with Jim to going to the opera alone, and similarly for Jim.

First, note that there are two Nash equilibria in pure strategies for this game-the one in which Jim and Joan both watch mud wrestling, and the one in which they both go to the opera. Jim, of course, would prefer the first of these outconies and Joan the second, but both outcomes are equilibria-neither Jim nor Joan would want to change his or her decision, given the decision of the other.

This game also has an equilibrium in mixed strategies: Jim chooses wrestling; with probability ⅔ and opera with probability ⅓, and Joan chooses wrestling with probability ⅓ and opera with probability ⅔. You can check that if Joan uses this strategy, Jim cannot do better with any other strategy; and vice versa. The outcome is random, and Jim and Joan will each have an expected payoff of ⅔.

Should we expect Jim and Joan to use these mixed strategies? Unless they're very risk loving or in some other way a strange couple, probably not. By agreeins; to either form of entertainment, each will have a payoff of at least 1, which exceeds the expected payoff of ⅔ from randomizing. In this game as in many others, mixed strategies provide another solution, but not a very realistic one. Hence for the remainder of this chapter we will focus on pure strategies.

13.4 *Repeated Games*

We saw in Chapter 12 that in oligopolistic markets, firms often find themselves in a Prisoners7 Dilemma when making output or pricing decisions. Can firms

[9] Suppose Jim randomizes, letting p be the probability of wrestling, and $(1 - p)$ the probability of opera. Since Joan is using probabilities of for opera, the probability that both will for wrestling and choose wrestling is $(1/3)p$, and the probability that both will choose opera is $(2/3)(1 - p)$. Hence Jim's expected payoff is $2(1/3)p + 1(2/3)(1 - p) = (2/3)p + 2/3 - (2/3)p = 2/3$. This is independent of p, so Jim cannot do better in terms of expected payoff no matter what he chooses.

find a way out of this dilemma, so that oligopolistic coordination and cooperation (whether explicit or implicit) could prevail?

To answer this question, we must recognize that the Prisoners' Dilemma, as we have described it so far, is static and thus limited. Although some prisoners may have only one opportunity in life to confess or not, most firms set output and price over and over again. In real life, firms play a *repeated game.* With each repetition of the Prisoners' Dilemma, firms can develop reputations about their behavior, and study the behavior of their competitors.

How does repetition change the likely outcome of the game? Suppose you are Firm 1 in the Prisoners' Dilemma illustrated by the payoff matrix in Table 13.8. If you and your competitor both charge a high price, you will both make a higher profit than if you both charged a low price.However, you are afraid to charge a high price because if your competitor charges a low price, you will lose money and, to add insult to injury, your competitor will get rich. But suppose this game is repeated over and over again-for example, you and your competitor simultaneously announce your prices on the first day of every month. Should you then play the game differently, perhaps changing your price over time in response to your competitor's behavior?

In an interesting study, Robert Axelrod asked game theorists to come up with the best strategy they could think of to play this game in a repeated manner.[10] (A possible strategy might be: "I'll start off with a high price, then lower my price, but then if my competitor lowers its price, Fll raise mine for a while before lowering it again, etc.") Then, in a computer simulation, Axelrod played these strategies off against one another to see which worked best.

As you would expect, any given strategy would work better against some strategies than it would against others. The objective, however, was to find the strategy that was most robust, i.e., would work best on average against *all,* or almost all, other strategies- The result was surprising. The strategy that worked best was extremely simple-it was a *"tit-for-tat" strategy*: I start out with a high price, which I maintain so long as you continue to "cooperate" and also charge a high price. As soon as you lower your price, however, I follow suit and lower mine. If you later decide to cooperate and raise your price again, I'll immediately raise my price as well.

TABLE 13.8 Pricing Problem

		firm 2	
		Low Price	High Price
Firm *1*	Low Price	10, 10	100, −50
	High Price	−50, 100	50, 50

[10] See Robert Axelrod, *The Evolution of Cooperation* (New York: Basic Books, 1984).

Why does this tit-for-tat strategy work best? In particular, can I expect that using the tit-for-tat strategy will induce my competitor to behave cooperatively (and charge a high price)?

Suppose the game is *infinitely repeated.* In other words, my competitor and I repeatedly set price month after month, *forever.* Cooperative behavior (i.e., charging a high price) is then the rational response to a tit-for-tat strategy. (This assumes that my competitor knows, or can figure out, that I am using a tit-for-tat strategy.) To see why, suppose that in one month my competitor sets a low price and undercuts me. In that month it will make a large profit. But the competitor knows that the following month I will set a low price, so that its profit will fall, and will remain low as long as we both continue to charge a low price. Since the game is infinitely repeated, the cumulative loss of profits that results must outweigh any short-term gain that accrued during the first month of undercutting. Thus, it is not rational to undercut.

In fact, with an infinitely repeated game, my competitor does not even have to be sure that I am playing tit-for-tat to make cooperation the rational strategy for it to follow. Even if the competitor believes there is only some chance that I am playing tit-for-tat, it will still be rational for it to start by charging a high price, and maintain the high price as long as I do. The reason is that with infinite repetition of the game, the *expected* gains from cooperation will outweigh those from undercutting. This will be true even if the probability that I am playing tit-for-tat (and so will continue cooperating) is small.

Now suppose the game is repeated a *finite* number of times-say N months. (*N* can be large as long as it is finite.) If my competitor (Firm 2) is rational, *and believes that I am rational,* it would reason as follows: "Because Firm 1 is playing tit-for-tat, I (Firm 2) cannot undercut-that is, *until the last month.* I *should* undercut in the last month because then I can make a large profit that month, and afterwards the game is over, so that Firm 1 cannot retaliate. Therefore," figures Firm 2,"I will charge a high price until the last month, and then I will charge a low price."

However, since I (Firm 1) have also figured this out, I also plan to charge a low price in the last month. Of course. Firm 2 can figure this out as well, and therefore *knows* I will charge a low price in the last month. But then what about the next-to-last month? Firm 2 figures that it should undercut and charge a low price in the next-to-last month, because there will be no cooperation anyway in the last month. But, of course, I have figured this out too, so I *also* plan to charge a low price in the next-to-last month. And because the same reasoning applies to each preceding month, the only rational outcome is for both of us to charge a low price every month.

Since most of us do not expect to live forever, the tit-for-tat strategy seems of little value; once again we are stuck in the Prisoners' Dilemma without a way out. However, there zs a way out if my competitor *has even a slight doubt about my "rationality."*

Suppose my competitor thinks (it need not be certain) that I am playing tit-for-tat. It also thinks that *perhaps* I am playing tit-for-tat "blindly," or with limited rationality, in the sense that I have failed to work out the logical implications of a finite time horizon as discussed above. My competitor thinks, for example, that perhaps I have not figured out that it will undercut me in the last month, so that I should also charge a low price in the last month, so that it should charge a low price in the next-to-last month, and so on. *"Perhaps,"* thinks my competitor, "Firm 1 will play tit-for-tat blindly, charging a high price as long as I charge a high price." Then (if the time horizon is long enough), it *is* rational for my competitor to maintain a high price until the last month (when it will undercut me).

Note that we have stressed the word "perhaps." My competitor need not be sure that I am playing tit-for-tat "blindly," .or even that I am playing tit-for-tat at all. Just the *possibility* of this can make cooperative behavior a good strategy (until near the end) if the time horizon is long enough. Although my competitor's conjecture about how I am playing the game might be wrong, cooperative behavior is profitable *in expected value terms*. With a long time horizon, the sum of current and future profits, weighted by the probability that the conjecture is correct, can exceed the sum of profits from warfare, even if the competitor is the first to undercut.[11]

Most managers don't know how long they and their firms will be competing with their rivals, and this also serves to make cooperative behavior a good strategy. Although the number of months that the firms compete is probably finite, managers are unlikely to know just what that number is. As a result, the unravelling argument that begins with a clear expectation of undercutting in the last month no longer applies. As with an infinitely repeated game, it will be rational to play tit-for-tat.

Thus, in a repeated game, the Prisoners' Dilemma can have a cooperative outcome. In most markets the game is, in fact, repeated over a long and uncertain length of time, and managers have doubts about how "perfectly rationally" they and their competitors operate. As a result, in some industries, particularly those in which only a few firms compete over a long period under stable demand and cost conditions, cooperation prevails, even though no contractual arrangements are made. (The water meter industry, discussed below, is an example of this.) In many other industries, however, there is little or no cooperative behavior.

Sometimes cooperation breaks down or never begins because there are too many firms. More often, the failure to cooperate is the result of rapidly shifting demand or cost conditions. Uncertainties about demand or costs make it difficult for the firms in the industry to reach an implicit understanding of what cooperation should entail. (Remember that an *explicit* understanding, arrived at through meetings and discussions, could.lead to an antitrust conviction.) Suppose, for example, that cost differences or different beliefs about demand lead one firm to conclude that cooperation means charging $50, but lead a

[11] After all, if I am wrong and my competitor charges a low price, I can shift my strategy at the cost of only one period's profit, a minor cost in light of the substantial profit that I can make if we both choose to set a high price. These results on the repeated Prisoners' Dilemma were first developed by David Kreps, Paul Milgrom, John Roberts, and Robert Wilson, "Rational Cooperation in the Finitely Repeated Prisoners' Dilemma," *Journal of Economic Theory 27* (1982): 245-252.

second firm to think it means charging $40. If the second firm charges $40, the first firm might view that as a grab for market share and respond in tit-for-tat fashion with a $35 price. A price war could then develop.

EXAMPLE 13.2 OLIGOPOLISTIC COOPERATION IN THE WATER METER INDUSTRY

For more than 30 years, almost all the water meters sold in the United States have been produced by four American companies: Rockwell International, Badger Meter, Neptune Water Meter Company, and Hersey Products. Rockwell has had about a 35 percent share of the market, and the other three firms have together had about a 50 to 55 percent share.[12]

Most buyers of water meters are municipal water utilities, who install the meters in residential and commercial establishments so that they can measure water consumption and bill consumers accordingly. Since the cost of the water meters is a small part of the total cost of providing water, the utilities are concerned mainly that the meters be accurate and reliable. The price of the meters is thus not a primary issue, and demand is very price inelastic. Demand is also very stable; every residence or commercial establishment must have a water meter,so demand grows slowly along with the population.

In addition, utilities tend to have long-standing relationships with suppliers and are reluctant to shift from one supplier to another. This creates a barrier to entry because any new entrant will find it difficult to lure customers from existing firms. Substantial economies of scale create a second barrier to entry: To capture a significant share of the market, a new entrant would have to invest in a large factory. This virtually precludes entry by new firms.

With inelastic and stable demand and little threat of entry by new firms, the existing four firms could earn substantial monopoly profits if they set prices cooperatively. If, on the other hand, they compete aggressively, with each firm cutting price to try and increase its own share of the market, profits would fall to nearly competitive levels. The firms are thus in a Prisoners' Dilemma. Can cooperation prevail?

It can and *has* prevailed since the 1960s. Remember that the same four firms have been playing a *repeated game* for decades. Demand has been stable and predictable, arid over the years the firms have been able to assess their own and each other's costs. In this situation, tit-for-tat strategies work well; it pays each firm to cooperate, as long as its competitors are cooperating.

So, the firms operate as though they were members of a country club. There is rarely an attempt to undercut price, and each firm appears satisfied with its share of the market. And while the business may appear dull, it is certainly profitable. All four firms have been earning returns on their investments that far exceed those in more competitive industries.

[12] This example is based in part on Nancy Taubenslag, "Rockwell International," Harvard Business School Case No. 9-383-019, July 1983.

EXAMPLE 13.3 COMPETITION AND COLLUSION IN THE AIRLINE INDUSTRY

In March 1983, American Airlines, whose president, Robert Crandall, had become notable for his use of the telephone (see Example 10.4), proposed that all airlines adopt a uniform fare schedule based on mileage. The rate per mile would depend on the length of the trip, with the lowest rate of 15 cents per mile for trips over 2,500 miles, higher rates for shorter trips, and the highest rate, 53 cents per mile, for trips under 250 miles. For example, a one-way coach ticket from Boston to Chicago, a distance of 932 miles, would cost $233 (based on a rate of 25 cents per mile for trips between 751 and 1,000 miles).

This proposal would do away with the many different fares (some heavily discounted) then available. The cost of a ticket from one city to another would depend only on the number of miles between those cities. As a senior vice-president of American Airlines said, 'The new streamlined fare structure will help reduce fare confusion." Most other major airlines reacted favorably to the plan and began to adopt it. A vice-president of TWA said, "It's a good move. It's very businesslike." United Airlines quickly announced that it would adopt the plan on routes where it competes with American, which includes most of its system, and TWA and Continental said that they would adopt it for all of their routes.[13]

Why did American Airlines propose this fare structure, and what made it so attractive to the other airlines? Was it really to "help reduce fare confusion"? No, the aim was to reduce price competition and achieve a collusive pricing arrangement. Prices had been driven down by competitive undercutting, as airlines competed for market share. And as Robert Crandall had learned less than a year earlier, fixing prices over the telephone is illegal. Instead, the companies would implicitly fix prices by agreeing to use the same formula for fares.

The plan failed, a victim of the Prisoners' Dilemma. Only two weeks after the plan was announced and adopted by most airlines. Pan Am, which was dissatisfied with its small share of the U.S. market, dropped its fares. American, United, and TWA, afraid of losing their own shares of the market, quickly dropped their fares to match Pan Am. The price-cutting continued, and fortunately for consumers, the plan was soon dead.

This episode exemplifies the problem of oligopolistic pricing. One economist summarized it accurately: "You can:" blame American Airlines for trying. After all, it is the American Way to try to cartelize prices with a simple formula. But it is also in the great tradition of open competition in this country to frustrate any such establishment of cartel prices by competitive chiseling."[14]

American Airlines introduced another simplified, four-tier fare structure in April 1992, which was quickly adopted by most major carriers. But it, too, soon

[13] American to Base Fares on Mileage," *New York Times,* March 15,1983; "Most Big Airlines Back American's Fare Plan," *New York Times,* March 17, 1983.

[14] Paul W. MacAvoy, "A Plan That Won't Endure Competition," *New York Times,* April 3, 1983.

fell victim to competitive discounts. In May 1992, Northwest Airlines announced a "kids fly free" program, and American responded with a summer half-price sale, which other carriers matched. As a result, the airline industry lost billions of dollars in 1992.

13.5 *Sequential Games*

In most of the games we have discussed so far, both players move at the same time. For example, in the Cournot model of duopoly, both firms set output at the same time. In *sequential games,* the players move in turn. The Stackelberg model discussed in Chapter 12 is an example of a sequential game; one firm sets output before the other does. There are many other examples: an advertising decision by one firm and the response by its competitor, entry-deterring investment by an incumbent firm and the decision whether to enter the market by a potential competitor, or a new government regulatory policy and the investment and output response of the firms being regulated.

We will look at a variety of sequential games in the remainder of this chapter. As we will see, they are often easier to analyze than games in which the players move at the same time. In a sequential game, the key is to think through the possible actions and rational reactions of each player.

As a simple example, let's return to the product choice problem first discussed in Section 13.3. This involves two companies who face a market in which two new variations of breakfast cereal can be successfully introduced/. as long as each firm introduces only one variation. This time, let's change the payoff matrix slightly. As Table 13.9 shows, the new sweet cereal will inevitably be a better seller than the new crispy cereal, earning a profit of 20 rather than 10 (perhaps because consumers prefer sweet things to crispy things). Both the new cereals will still be profitable, however, as long as each is introduced by only one firm. (Compare Table 13.9 with Table 13.3.)

TABLE 13.9 Modified Product Choice Problem

		Firm 2	
		Crispy	Sweet
Firm 1	Crispy	−5, −5	10, 20
	Sweet	20, 10	−5, −5

Suppose that both firms, in ignorance of each other's intentions, must announce their decisions independently and simultaneously. Both will then probably introduce the sweet cereal-and both will lose money.

Now suppose that Firm 1 can introduce its new cereal first. (Perhaps it can gear up its production faster.) We now have a sequential game: Firm 1 introduces a new cereal, and then Firm 2 introduces one. What will be the outcome of this game? When making its decision. Firm 1 must consider the rational response of its competitor. It knows that whichever cereal it introduces. Firm 2 will introduce the other kind. Hence it will introduce the sweet cereal, knowing that Firm 2 will respond by introducing the crispy one.

The Extensive Form of a Game

This outcome can be deduced from the payoff matrix in Table 13.9, but sometimes sequential games are easier to visualize if we represent the possible moves in the form of a decision tree. This is called the *extensive form* of the game, and is shown in Figure 13.1. The figure shows the possible choices of Firm 1 (introduce a crispy or a sweet cereal), and then the possible responses of Firm 2 for each of those choices. The resulting payoffs are given at the end of each branch. For example, if Firm 1 produces a crispy cereal and Firm 2 responds by also producing a crispy cereal, each firm will have a payoff of -5.

To find the solution to the extensive form game, work backwards from the end. For Firm 1, the best sequence of moves is the one in which it earns 20, and Firm 2 earns 10. Thus,it can deduce that it should produce the sweet cereal, because then Firm 2's best response is to produce the crispy cereal.

The Advantage of Moving First

In this product-choice game, there is a clear advantage to moving first; by introducing the sweet cereal. Firm 1 creates a fait accompli that leaves Firm 2

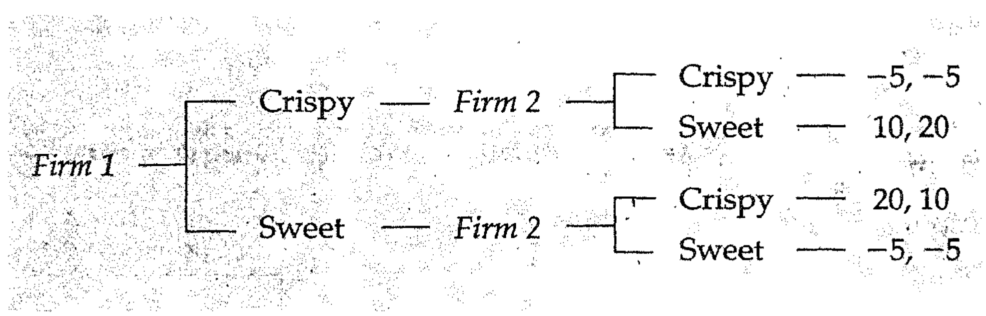

FIGURE 13.1 Product Choice Game in Extensive Form.

little choice but to introduce the crispy one. This is much like the first-mover advantage that we saw in the Stackelberg model in Chapter 12, In that model the firm that moves first can choose a large level of output, thereby giving its competitor little choice but to choose a small level of output.

To clarify the nature of this first-mover advantage, it would be useful to review the Stackelberg model and compare it to the Cournot model in which both firms choose their outputs simultaneously As in Chapter 12, we will use the example in which two duopolists face the market demand curve:

$$P = 30 - Q$$

where Q is total production, i.e., $Q = Q_1 + Q_2$. We will also assume, as before, that both firms have zero marginal cost. Recall that the Cournot equilibrium is then $Q_1 = Q_2 = 10$, so that $P = 10$, and each firm earns a profit of 100. Recall also that if the two firms colluded, they would set $Q_1 = Q_2 = 7.5$, so that $P = 15$, and each firm earns a profit of 112.50. Finally, recall from Section 12.3 that in the Stackelberg model in which Firm 1 moves first, the outcome is $Q_1 = 15$ and $Q_2 = 7.5$, so that $P = 7.50$, and the firms' profits are 112.50 and 56.25, respectively.

These and a few other possible outcomes are summarized in the payoff matrix of Table 13.10. If both firms move simultaneously, the only solution to the game is that both firms produce 10 and earn 100. In this Cournot equilibrium each firm is doing the best it can given what its competitor is doing. If Firm 1 moves first, however, it knows its decision will constrain Firm 2's choice. Observe from the payoff matrix that if Firm 1 sets $Q_1 = 7.5$, Firm 2's best response will be to set $Q_2 = 10$, which will give Firm 1 a profit of 93.75 and Firm 2 a profit of 125. If Firm 1 sets $Q_1 = 10$. Firm 2 will set $Q_2 = 10$, and both firms will earn 100. But if Firm 1 sets $Q_1 = 15$, Firm 2 will set $Q_2 = 7.5$, so that Firm 1 earns 112.50, and Firm 2 earns 56.25. Thus, the most Firm 1 can earn is 112.50, and it does this by setting $Q_1 = 15$. Compared to the Cournot outcome, when Firm 1 moves, first, it does better- and Firm 2 does much worse.

[redacted]

TABLE 13.10 Choosing Output

		Firm 2		
		7.5	10	15
	7.5	112.50, 112.50	93.75, 125	56.25, 112.50
Firm 1	10	125, 93.75	100, 100	50, 75
	15	112.50, 56.25	75, 50	0, 0

[redacted]

13.6 *Threats, Commitments, and Credibility*

The product choice problem and the Stackelberg model are two examples of how a firm that moves first can create a fait accompli that gives it an advantage over its competitor. In this section we'll-take a broader look at the advantage a firm can have by moving first, and also consider what determines *which* firm goes first. We will focus on the following question: *What actions can a firm take to gain advantage in the marketplace?* For example, how might a firm deter entry by potential competitors, or induce existing competitors to raise prices, reduce output, or leave the market altogether? Or how might a firm reach an implicit agreement with its competitors that is heavily weighted in its own favor?

An action that gives a firm this kind of advantage is called a *strategic move.* A good definition of a strategic move was given by Thomas Schelling, who first explained the concept and its implications: "A strategic move is one that influences the other person's choice in a manner favorable to one's self, by affecting the other person's expectations of how one's self will behave. One constrains the partner's choice by constraining one's own behavior."[15]

The idea of constraining your own. behavior to gain an advantage may seem paradoxical, but we'll soon see that it is not. Let's consider a few examples.

First, let's return once more to the product-choice problem shown in Table 13.9. The firm that introduces its new breakfast cereal first will do best. *But which firm will introduce its cereal first*? Even if both firms require the same amount of time to gear up production, each has an incentive to *commit itself first to the sweet cereal.* The key word is "commit." If Firm 1 simply announces it will produce the sweet cereal. Firm 2 will have little reason to believe it. After all, Firm 2, knowing the incentives, can make the same announcement louder and more vociferously. Firm 1 must constrain its own behavior-Firm 2 must be convinced that Firm 1 has *no choice* but to produce the sweet cereal. Such an action by Firm 1 might include an expensive advertising campaign describing the new sweet cereal well before its introduction, thereby putting Firm 1's reputation on the line. Firm 1 might also sign a contract for the forward delivery of a large quantity of sugar (and make the contract public, or at'least send a copy to Firm 2). The idea is for Firm 1 to *commit itself to* produce the sweet cereal. Commitment is a strategic move that will induce Firm 2 to make the decision Firm 1 wants it to make-to produce the crispy cereal.

Why can't Firm 1 simply *threaten* Firm 2, vowing to produce the sweet cereal even if Firm 2 does the same? Because Firm 2 has little reason to believe the threat and can make the same threat itself. A threat is useful only if it is credible. The following example should help make this clear.

[15] Thomas C. Schelling, *The Strategy of Conflict* (New York: Oxford University Press, 1960), p. 160. (1980 edition published by Harvard University Press.) For a general discussion of strategic moves in business planning, see Michael E. Porter, *Competitive Strategy* (New York: Free Press, 1980).

TABLE 13.11 Pricing of Computers and Word Processors

		Firm 2	
		High Price	Low Price
Firm 1	High Price	100, 80	80, 100
	Low Price	20, 0	10, 20

Empty Threats

Suppose Firm 1 produces personal computers that can be used both as word processors and to do other tasks. Firm 2 produces only dedicated word processors. As the payoff matrix in Table 13.11 shows,as long as Firm 1 charges, a high price for its computers, both firms can make a good deal of money Even if Firm 2 charges a low price for its word processors, many people will still buy Firm I's computers (because they can do so many other things), although some will be induced by the price differential to buy the dedicated word processor instead. However, if Firm 1 charges a low price for its computers, Firm 2 will also have to charge a low price (or else make zero profit), and the profit of both firms will be significantly reduced.

Firm 1 would prefer the outcome in the upper left-hand corner of the matrix. For Firm 2, however, charging a low price is clearly a dominant strategy. Thus, the outcome in the upper right-hand corner will prevail (no matter which firm sets its price first).

Firm 1 would probably be viewed as the "dominant" firm in this industry because its pricing actions will have the greatest impact on overall industry profits. Then, can't Firm 1 induce Firm 2 to charge a high price by *threatening* to charge a low price itself if Firm 2 charges a low price? No, as the payoff matrix in Table 13.11 makes clear. *Whatever* Firm 2 does. Firm 1 will be much worse off if it charges a low price. As a result, its threat is not credible.

Commitment and Credibility

Sometimes firms can make a threat credible. To see how, consider the following example. Race Car Motors, Inc., produces cars, and Far Out Engines, Ltd., produces specialty car engines. Far Out Engines sells most of its engines to Race Car Motors, and a few to a limited outside market. Nonetheless, it depends heavily on Race Car Motors, and makes its production decisions in response to the production plans of Race Car Motors.

We thus have a sequential game in'which Race Car Motors is the "leader." It will decide what kind of cars to build, and Far Out Engines will then decide

TABLE 13.12a Production Choice Problem

		Race Car Motors Small Cars	Big Cars
Far Out Engines	Small Engines	3, 6	3, 0
	Big Engines	1, 1	8, 3

what kind of engines to produce. The payoff matrix in Table 13.12a shows the possible outcomes of this game. (Profits are in millions of dollars.) Observe that Race Car Motors will do best by deciding to produce small cars. It knows that in response to this. Far Out Engines will produce small engines, most of which Race Car Motors will then buy for its new cars. As a result. Far Out Engines will make $3 million, and Race Car Motors will earn $6 million.

Far Out Engines, however, would much prefer the outcome in the lower right-hand corner of the payoff matrix. If it could produce big engines, *and* Race Car Motors produced big cars and therefore bought the big engines, it would make $8 million. (Race Car Motors, however, would make only $3 million.) Can Far Out Engines induce Race Car Motors to produce big cars instead of small ones?

Suppose Far Out Engines *threatens to* produce big engines no matter what Race Car Motors does, and no other engine producer can easily satisfy the needs of Race Car Motors. If Race Car Motors believed this, it would produce big cars, since it would have trouble finding engines for its small cars, and would earn only $1 million instead of $3 million. But the threat is not credible. Once Race Car Motors announced its intentions to produce small cars. Far Out Engines would have no incentive to carry out its threat.

Far Out Engines can make its threat credible by visibly and irreversibly reducing some of *its own* payoffs in the matrix, so that its choices become constrained. In particular. Far Out Engines must reduce its profits from small engines (the payoffs in the top row of the matrix). It might do this by *shutting down or destroying some of its small engine production capacity.* This would result in the payoff matrix shown in Table 13.12b. Now Race Car Motors *knows* that

TABLE 13.12b Modified Production Choice Problem

		Race Car Motors Small Cars	Big Cars
Far Out Engines	Small Engines	0, 6	0, 0
	Big Engines	1, 1	8, 3

whatever kind of car it produces. Far Out Engines will produce big engines. (If Race Car Motors produces the small cars. Far Out Engines will sell the big engines as best it can to other car producers, and will make only $1 million. But this is better than making no profits by producing small engines. Race Car Motors will also have to look elsewhere for its engines, so its profit will also be lower,at $1 million.) Now it is clearly in Race Car Motors' interest to produce the large cars. By making a strategic move that *seemingly puts itself at a disadvantage,* Far Out Engines has improved the outcome of the game.

Strategic commitments of this kind can be effective, but they are risky and depend heavily on the committing firm's having accurate knowledge of the payoff matrix and the industry. Suppose, for example, that Far Out Engines commits itself to producing big engines, but is surprised to find that another firm can produce small engines at a low cost. The commitment may then lead Far Out Engines to bankruptcy rather than to continued high profits.

Developing the right kind of *reputation* can also give one a strategic advantage. Again, consider Far Out Engines' desire to produce big engines for Race Car Motors' big cars.-Suppose the managers of Far Out Engines develop a reputation for being irrational-perhaps downright crazy. They threaten to produce big engines no matter what Race Car Motors does. (Refer to Table 13.12a.) Now the threat might be credible without any further action; after all, you can't be sure that an irrational manager will always make a profit-maximizing decision. In gaming situations, the party that is known (or thought) to be a little crazy can have a significant advantage. The game of "chicken" (two cars careen toward each other, and the first driver to swerve to the side is the loser) is a dramatic example of this.

Developing a reputation can be an especially important strategy in a repeated game. A firm might find it advantageous to behave irrationally for several plays of the game. This might give it a reputation that will allow it to increase its long-run profits substantially.

EXAMPLE 13.4 WAL-MART STORES' PREEMPTIVE INVESTMENT STRATEGY

Wat-Mart Stores, Inc., is an enormously successful chain of discount retail stores started by Sam Walton in 1969.[16] Its success was unusual in the industry. During the 1960s and 1970s, rapid expansion by existing firms and the entry and expansion of new firms made discount retailing increasingly competitive. During the 1970s and 1980s, industrywide profits fell; and large discount chains-including such giants as King's, Korvette's, Mammoth Mart, W.T. Grant, and Woolco-went bankrupt. Wal-Mart Stores, however,kept on growing

[16]This'example is based in part on information in Pankaj Ghemawat, "Wal-Mart Stores' Discount Operations," Harvard Business School, 1986.

TABLE 13.13 The Discount Store Preemption Game

		Company X	
		Enter	Don't Enter
Wal-Mart	Enter	−10, −10	20, 0
	Don't Enter	0, 20	0, 0

(from 153 stores in 1976 to 1009 in 1986) and became even more profitable. By the end of 1985, Sam Walton was one of the richest people in the United States.

How did Wal-Mart Stores succeed where others failed? The key is in Wal-Marfs expansion strategy. To charge less than ordinary department stores and small retail stores, discount stores rely on size, no frills, and high inventory turnover. Through the 1960s, the conventional wisdom held that a discount store could succeed only in a city with a population of 100,000 or more. Sam Walton disagreed and decided to open his stores in small Southwestern towns; by 1970 there were 30 Wal-Mart stores in small towns in Arkansas, Missouri, and Oklahoma. The stores succeeded because Wal-Mart had created. 30 "local monopolies." Discount stores that had opened in larger towns and cities were competing with other discount stores, which drove prices and profit margins down. These small towns, however, had room for only one discount operation. Wal-Mart could undercut the nondiscount retailers but never had to worry that another discount store would open and compete with it.

By the mid-1970s, other discount chains realized that Wal-Mart had a profitable strategy: Open a store in a small town that could support only one' discount store and enjoy a local monopoly. There are a lot of small towns in the United States, so the issue became who would get to each town first. Wal-Mart now found itself in a *preemption game* of the sort illustrated by the payoff matrix in Table 13.13. As the matrix shows, if Wal-Mart enters a town, but Company X doesn't, Wal-Mart would make 20, and Company X would make 0. Similarly, if Wal-Mart doesn't enter, but Company X does, Wal-Mart makes 0, and Company X makes 20. But if Wal-Mart and Company X *both* enter, *they will both lose 10.*

This game has two Nash equilibria-the lower left-hand corner and the upper right-hand corner. Which equilibrium results depends on *who moves first.* If Wal-Mart moves first, it can enter, knowing that the rational response of Company X will be not to enter, so that Wal-Mart will be assured of earning 20. *The trick is therefore to preempt*-to set up stores in other small towns quickly, before Company X (or Company Y or Z) can do so. That is exactly what Wal-Mart did. By 1986 it had 1009 stores in operation and was earning an annual profit of $450 million. And -white other discount chains were going under, Wal-Mart continued to grow; by 1993 it had over 1800 stores and was earning an annual profit of over $1.5 billion.

13.7 *Entry Deterrence*

Barriers to entry, which are an important source of monopoly power and profits, sometimes arise naturally. For example, economies of scale, patents and licenses, or access to critical inputs can create entry barriers. However, firms themselves can sometimes deter entry by potential competitors.

To deter entry, *the incumbent firm must convince any potential competitor that entry will be unprofitable.* To see how this might be done, put yourself in the position of an incumbent monopolist facing a prospective entrant. Firm X. Suppose that to enter the industry. Firm X will have to pay a (sunk) cost of $40 million to build a plant. You, of course, would like to induce Firm X to stay out of the industry. If X stays out, you can continue to charge a high price and enjoy monopoly profits. As shown in the upper right-hand corner of the payoff matrix in Table 13.14a, you would then earn $100 million in profits.

If Firm X does enter the market, you must make a decision. You can be //accommodating," maintaining a high price in the hope that X will do the same. You will then earn only $50 million in profit because you will have to share the market. The new entrant X will earn a *net* profit of $10 million: $50 million less the $40 million cost of constructing a plant. (This outcome is shown in the upper left-hand corner of the payoff matrix.) Alternatively, you can increase your production capacity, produce more, and force price down. Increasing production capacity is costly, however, and lower prices will mean lower revenues. Warfare will therefore mean lower profits for both you and Firm X. As Table 13.14a shows, your profit will fall to $30 million, and Firm X will have a net loss of $10 million: the $30 million that it earns from sales less the $40 million for the cost of its plant.

If Firm X thinks you will be accommodating and maintain a high price after entry, it will find it profitable to enter and will do so. Suppose you threaten to expand output and fight a price war to keep X out. If X believed the threat, it would not enter the market because it -would expect to lose $10 million. However, the threat is not credible. As Table 13.14a shows (and as the potential competitor knows), *once entry has occurred, it will be in your best interest to accommodate and maintain a high price.* Firm X's rational move is to enter the market; the outcome will be the upper left-hand corner of the matrix.

TABLE 13.14a Entry Possibilities

		Potential Entrant	
		Enter	Stay Out
Incumbent	High Price (Accommodation)	50, 10	100, 0
	Low Price (Warfare)	30, −10	40, 0

But what if you can make an irrevocable commitment that would alter your incentives once entry occurred-a commitment that would give you little choice but to charge a low price if entry occurred? In particular, suppose you invest *now,* rather than later, in the extra capacity needed to increase output and engage in competitive warfare should entry occur. We'll assume that this extra capacity will cost $30 million to build, maintain, and operate. Of course, if you later maintain a high price (whether or not X enters),this added cost will reduce your payoffs.

We now have a new payoff matrix, as shown in Table 13.14b. Now your threat to engage in competitive warfare if entry occurs is *completely credible,* as a result of your decision to invest in additional capacity. Because you have the additional capacity, you will do better in competitive warfare, if entry occurs, than you would by maintaining a high price. The potential competitor now knows that entry will result in warfare, so it is rational for it to stay out of the market. You can therefore maintain a high price, and earn a profit of $70 million, having deterred entry.[17]

Might an incumbent monopolist deter entry without making the costly move of installing additional production capacity? Earlier we saw that a reputation for irrationality can bestow a strategic advantage. Suppose the incumbent firm has such a reputation. Suppose also that with vicious price-cutting this firm has eventually driven out every entrant in the past, even though it incurred (rationally unwarranted) losses in doing so. Its threat might then indeed be credible. In this case the incumbent's irrationality suggests to the potential competitor that it might be better off staying away.

Of course, if the game described above were to be *indefinitely repeated,* then the incumbent might have a *rational* incentive to carry out the threat of warfare whenever entry actually occurs. The reason is that short-term losses from warfare might be outweighed by longer-term, gains from preventing entry. Furthermore, the potential competitor, making the same calculations, might find the incumbent's threat of warfare credible and decide to stay out of the market. Now the incumbent relies on its reputation for being rational-and

TABLE 13.14b Entry Deterrence

		Potential Entrant	
		Enter	Stay Out
Incumbent	Hiegh Price (Accommodation)	20, 10	70, 0
	Low Price (Warfare)	30, −10	40, 0

[17] This use of investment to deter entry is discussed in more detail in Jean Tirole, *The Theory of Industrial Organization* (Cambridge, Mass.: MIT Press, 1988), and Marvin B. Lieberman, "Strategies for Capacity Expansion," *Sloan Management Review* (Summer 1987): 19-27.

in particular for being far-sighted-to provide the credibility needed to deter entry. But whether this works depends on the time horizon and the relative gains and losses associated with accommodation and warfare.

We have seen that the attractiveness of entry depends largely on how incumbents can be expected to react. In general, incumbents cannot be expected to maintain output at the preentry level once entry has occurred. Eventually, incumbents may back off and reduce output, raising price to a new joint profit-maximizing level. Because potential entrants know this, incumbent firms must create a credible threat of warfare to deter entry. A reputation for irrationality can help do this. Indeed, this seems to be the basis for much of the entry-preventing behavior that goes on in actual markets. The potential entrant must consider that *rational* industry discipline can break down after entry occurs. By fostering an image of irrationality and belligerence, an incumbent firm might convince potential entrants that the risk of warfare is too high.[18]

Strategic Trade Policy and International Competition

We have seen how a preemptive investment can give a firm an advantage by creating a credible threat to potential competitors. In some situations a preemptive investment-subsidized or otherwise encouraged by the government-can give a *country* an advantage in international markets, and be an important instrument of trade policy.

Does this conflict with what you have learned about the benefits of free trade? In Chapter 9, for example,we saw how trade restrictions such as tariffs or quotas lead to deadweight losses. In Chapter 16 we go further and show how, in a general way, free trade between people (or between countries) is mutually beneficial. Given the virtues of free trade, how could government intervention in an international market ever be warranted? An emerging literature in international trade theory suggests that in certain situations a country can benefit by adopting policies that give its domestic industries a competitive advantage.[19]

To see how this might occur, consider an industry with substantial economies of scale, so that a few large firms can produce much more efficiently than

[18]There is an analogy here to *nuclear deterrence.* Consider the use of a nuclear threat to deter the former Soviet Union from invading Western Europe during the cold war. If they invaded, would the United States actually react with nuclear weapons, knowing that the Soviets would then respond in kind? It is not rational for the United States to react this way, so a nuclear threat might not seem credible. But this assumes that everyone is rational; there **is** a reason to fear an *irrational* response by the United States. Even if an irrational response is viewed as very improbable, it can be a deterrent, given the costliness of an error. The United States can thus gain by promoting the idea that it might act irrationally, or that events might get out of control once an invasion occurs. This is the "rationality of irrationality." See Thomas C. Schelling, *The Strategy of Conflict.*

[19] For a good overview of this literature, see Paul R. Krugman, "Is Free Trade Passe?" *Journal of Economic Perspectives 1* (Fall 1987): 131-144; and Elhanan Helpman and Paul R. Krugman, *Trade Policy and Market Structure* (Cambridge, Mass.: MIT Press, 1989).

many small ones. Suppose that by granting subsidies or tax breaks, the government can encourage domestic firms to expand faster than they would otherwise. This might prevent firms in other countries from entering the world market, so that the domestic industry can enjoy higher prices and greater sales. Such a policy would work by creating a credible threat to potential entrants; large domestic firms, taking advantage of scale economies, would be able to satisfy world demand at a low price, so that if other firms entered price would be driven below the point at which they could make a profit.

For example, consider the international market for commercial aircraft. The development and production of a new line of aircraft are subject to substantial economies of scale; it wouldn't pay to develop a new aircraft unless a firm expected to sell many of them. Suppose that Boeing and Airbus (a European consortium that includes France, West Germany, Britain, and Spain) are each considering developing a new aircraft (as indeed they were in the late 1970s and early 1980s). The ultimate payoff to each firm depends in part on what the other firm does. Suppose it is only economical for one firm to produce the new aircraft. Then the payoffs might look like those in Table 13.15a.[20]

If Boeing has a head start in the development process, the outcome of the game is the upper right-hand corner of the payoff matrix. Boeing will produce a new aircraft, and Airbus, realizing that it would lose money if it did the same, will not. Boeing will then earn a profit of 100.

European governments, of course, would prefer that Airbus produce the new aircraft Could they change the outcome of this game? Suppose they commit to subsidizing Airbus, and make this commitment before Boeing has committed itself to produce. If the European governments committed to pay a subsidy of 20 to Airbus if it produces the plane, *regardless of what Boeing does,* the payoff matrix would change to the one in Table 13.15b.

Now Airbus will make money from a new aircraft whether or not Boeing produces one. Hence, Boeing knows that even if it commits to producing, Airbus will produce as well, and Boeing will lose money. Thus, Boeing will decide not to produce, and the outcome will be the one in the lower left-hand corner. A subsidy of 20, then, changes the outcome from one in which

TABLE 13.15a Development of a New Aircraft

		Airbus Produce	*Airbus* Don't Produce
Boeing	Produce	−10, −10	100, 0
	Don't Produce	0, 100	0, 0

[20] This example is drawn from Paul Krugman, "Is Free Trade Passe?," *op. at.*

TABLE 13.15b Development of Aircraft After European Subsidy

		Airbus: Produce	Airbus: Don't Produce
Boeing	Produce	−10, 10	100, 0
	Don't Produce	0, 120	0, 0

Airbus does not produce and earns 0 to one in which it does produce and earns 120. Of this, 100 is a transfer of profit from the United States to Europe. Thus, from the European point of view, subsidizing Airbus yields a high return.

European governments *did* commit to subsidizing Airbus, and during the 1980s, Airbus successfully introduced several new airplanes. The result, however, was not quite the one in- our stylized example. Boeing also introduced new airplanes (the 757 and 767 models) that were extremely profitable. As commercial air travel grew, it became clear that both companies could profitably develop and sell a new generation of airplanes. Nonetheless, Boeing's market share would have been much larger without the European subsidies to Airbus. One study estimated that those subsidies totalled $25.9 billion during the 1980s, and found that Airbus would not have entered the market without them.[21]

The example of Boeing and Airbus shows how strategic trade policy can transfer profits from one country to another. The story, however, is not complete. A country that uses such a policy may provoke retaliation from its trading partners. If a trade war results, all countries could end up much worse off. The possibility of such an outcome must be considered before adopting a strategic trade policy.

EXAMPLE 13.5 DU PONT DETERS ENTRY IN THE TITANIUM DIOXIDE INDUSTRY

Titanium dioxide is a whitener used in paints, paper, and other products. In the early 1970s, Du Pont and National Lead each accounted for about a third of U.S. titanium dioxide sales; another seven firms produced the remainder. In 1972, Du Font was weighing whether to expand its capacity. The industry was changing, and with the right strategy, those changes might enable Du Font to capture more of the market and dominate the industry [22]

[21] "Aid to Airbus Called Unfair in U.S. Study,"*New York Times,* September 8,1990.

[22] This example is based on Pankaj Ghemawat, "Capacity Expansion in the Titanium Dioxide Industry," *Journal of Industrial Economics* 33 (Dec. 1984): 145-163; and P. Ghemawat, "Du Pont in Titanium Dioxide," Harvard Business School, Case No. 9-385-140, June 1986.

Three factors had to be considered. First, although the future demand for titanium dioxide was uncertain, it was expected to grow substantially. Second, the government had announced that new environmental regulations would be imposed. And third, the prices of raw materials used to make titanium dioxide were rising. The new regulations and the higher input prices would have a major effect on production cost, and give Du Pont a cost advantage, both because its production technology was less sensitive to the change in input prices and because its plants were in areas that made disposal of corrosive wastes much less difficult than it would be for other producers. Because of these cost changes, Du Pont anticipated that National Lead and some of the other producers would have to shut down part of their capacity. Du Pont's competitors would in effect have to "reenter" the market by building new plants. Could Du Pont deter them from doing this?

In 1972, Du Pont's Executive Committee considered the following strategy: invest nearly $400 million in increased production capacity to try to capture 64 percent of the market by 1985. The production capacity that would be put on line would be much more than what was actually needed. The idea was to *deter Du Pont's competitors from investing.* Scale economies and movement down the learning curve would give Du Pont a cost advantage. This would make it hard for other firms to compete, and would make credible the implicit threat that Du Pont would fight in the future, rather than accommodate.

The strategy was sensible, and it seemed to work for a few years. By 1975, however, things began to go awry. First, demand grew much less than expected, so that there was excess capacity industrywide. Second, the environmental regulations were only weakly enforced, so that Du Pont's competitors did not have to shut down capacity as expected. And finally, Du Pont's strategy led to antitrust action by the Federal Trade Commission in 1978. (The FTC claimed that Du Pont was attempting to monopolize the market. Du Pont won the case, but the decline in demand made its victory moot.)

EXAMPLE 13.6 DIAPER WARS

For more than a decade, the disposable diaper industry in the United States has been dominated by just two firms: Procter & Gamble, with an approximately 50-60 percent market share, and Kimberly-Clark, with another 30 percent.[23] How do these firms compete? And why haven't other firms been able to enter and take a significant share of this $4 billion per year market?

Even though there are only two major firms, competition is intense. The competition occurs mostly in the form of *cost-reducing innovation.* The key to success is to perfect the manufacturing process, so that a plant can manufac-

[23] Procter & Gamble makes Pampers, Ultra Pampers, and Luvs. Kimberly-Clark has only one major brand, Huggies.

ture diapers in high volume and at low cost. This is not as simple as it might seem. Packing cellulose fluff for absorbency, adding an elastic gatherer, and binding, folding, and packaging the diapers-at a rate of about 3000 diapers per minute and at a cost of about 6 to 8 cents per diaper-requires an innovative, carefully designed, and finely tuned process. Furthermore, small technological improvements in the manufacturing process can result in a significant competitive advantage. If a firm can shave its production cost even slightly, it can reduce price and capture market share. As a result, both firms are forced to spend heavily on research and development (R&D) in a race to reduce cost.[24]

The payoff matrix in Table 13.16 illustrates this. If both firms spend aggressively on R&D, they can expect to maintain their current market shares. P&G will then earn a profit of 40, and Kimberly (with a smaller market share) will earn 20. If neither firm spends money on R&D, their costs and prices would remain constant, and the money saved would become part of profits. P&G's profit would increase to 60, and Kimberiy's to 40. However, if one firm continues to do R&D and the other doesn't, the innovating firm will eventually capture most of its competitor's market share. (For example, if Kimberly does R&D and P&G doesn't, P&G can expect to lose 20, while Kimberly's profit increases to 60.) The two firms are therefore in a Prisoners' Dilemma; spending money on R&D is a dominant strategy for each firm.

Why hasn't cooperative behavior evolved? After all, the two firms have been competing in this market for years, and the demand for diapers is fairly stable. For several reasons, a Prisoners' Dilemma involving R&D is particularly hard to resolve. First, it is difficult for a firm to monitor its competitor's R&D activities the way it can monitor price. Second, it can take several years to complete an R&D program that leads to a major product improvement. As a result, tit-for-tat strategies, in which both firms cooperate until one of them "cheats," are less likely to work. A firm may not find out that its competitor has been secretly doing R&D until the competitor announces a new and improved product, and by then it may be too late for the firm to gear up an R&D program of its own.

TABLE 13.16 Competing Through R&D

		Kimberly-dark	
		R&D	No R&D
P&G	R&D	40, 20	80, −20
	No R&D	−20, 60	60, 40

[24] See Michael E. Porter, "The Disposable Diaper Industry," Harvard Business School Case 9-380-175, July 1981; "Innovation Key to Diaper War," *New York Times*, Nov. 25, 1986; and "P&G Moves to Revamp Its Pampers," *Wall Street Journal*, August 9, 1989. P&G developed a superabsorbent chemical to replace the cellulose fluff, allowing for a thinner and lighter diaper.

The ongoing R&D expenditures by P&G and Kimberly-Clark also serve to deter entry. In addition to brand name recognition, these *two* firms have accumulated so much technological know-how and manufacturing proficiency that they would have a substantial cost advantage over any firm just entering the market. Besides building new factories, an entrant would have to spend a considerable amount on R&D to capture even a small share of *the* market. After it began producing, a new firm would have to continue to spend heavily on R&D to reduce its costs over time. Entry would be profitable only if P&G and Kimberly-Clark stop doing R&D, so that the entrant could catch up and eventually gain a cost advantage. But as we have seen, no rational firm would expect this to happen.[25]

13.8 *Bargaining Strategy*

In looking at the Prisoners' Dilemma and related problems, we have assumed that collusion was limited by an inability to make an enforceable agreement. Clearly, alternative outcomes are possible (and likely) if firms or individuals can make promises that can be enforced. The Prisoners' Dilemma illustrated by the pricing problem shown in Table 13.8 is a good example of this. If there were no antitrust laws and both firms could make an enforceable agreement about pricing, they would both charge a high price and make profits of 50. Here, the bargaining problem is simple.

Other bargaining situations are more complicated, however, and the outcome can depend on the ability of either side to make a strategic move that alters its relative bargaining position. For example, consider two firms that are each planning to introduce one of two products, which happen to be complementary goods. As the payoff matrix of Table 13.17 shows. Firm 1 has an

TABLE 13.17 Production Decision

		Firm 2	
		Produce A	Produce B
Firm 1	Produce A	40, 5	50, 50
	Produce B	60, 40	5, 45

[25] Example 15.3 in Chapter 15 examines in more detail the profitability of capital investment by a new entrant in the diaper market.

advantage in producing *A*, so that if both firms produce *A*, Firm 1 will be able to maintain a lower price and will make much higher profits. Similarly, Firm 2 has an advantage in producing product *B*. As should be clear from the payoff matrix, if the two firms could agree about who will produce what, the only rational outcome would be that in the upper right-hand corner. Firm 1 produces *A*, Firm 2 produces *B*, and both firms make profits of 50. Indeed, even *without cooperation* this outcome will result, whether Firm 1 or Firm 2 moves first or both firms move simultaneously The reason is that producing *B* is a dominant strategy for Firm 2, so (*A*, *B*) is the only Nash equilibrium.

Firm 1 would, of course, prefer the outcome in the lower left-hand corner of the payoff matrix. But in the context of this limited set of decisions, it cannot achieve that outcome. Suppose, however, that Firms 1 and 2 are also bargaining over a second issue-whether to join a research consortium that a third firm is trying to form. Table 13.18 shows the payoff matrix for this decision problem. Clearly, the dominant strategy is for both firms to enter the consortium, thereby obtaining increased profits of 40.

Now suppose that Firm 1 *links the two bargaining problems* by announcing that it will join the consortium *only* if Firm 2 agrees to produce product A. (How can Firm 1 make this threat credible?) In this case it is indeed in Firm 2's interest to agree to produce *A* (with Firm 1 producing *B*), in return for Firm 1's participation in the consortium. This example illustrates how a strategic move can be used in bargaining, and why combining issues in a bargaining agenda can sometimes benefit one side at the other's expense.

Two people bargaining over the price of a house is another example of this. Suppose I, as a potential buyer, do not want to pay more than $200,000 for a house that is actually worth $250,000 to me. The seller is willing to part with the house at any price above $180,000 but would like to receive the highest price she can. If I am the only bidder for the house, how can I make the seller think I will walk away rather than pay more than $200,000?

I might declare that I will never, ever pay more than $200,000 for that house. But is such a promise credible? It is if the seller knows that I have a *strong reputation* for toughness and steadfastness and that I have never broken my word on a promise of this sort. But suppose I have no such reputation. Then the seller knows that I have every incentive to make the promise (making it costs nothing), but little incentive to keep it (since this will probably be our

TABLE 13.18 Decision to Join Consortium

		Firm 2	
		Work Alone	Enter Consortium
Firm 1	Work Alone	10, 10	10, 20
	Enter Consortium	20, 10	40, 40

only business transaction together). As a result, this promise by itself is not likely to improve my bargaining position.

The promise can work, however, if it is combined with a strategic move that gives it credibility Such a strategic move must reduce my flexibility-limit my options-so that I have no choice but to keep the promise. A possible move would be to make an enforceable bet with a third party-for example, "If I pay more than $200,000 for that house, I'll pay you $60,000." Alternatively, if I am buying the house on behalf of my company, the company might insist on authorization by the Board of Directors for a price above $200,000, and an' nounce that the board will not meet again for several months. In both cases, my promise becomes credible because I have destroyed my ability to break it. The result is less flexibility-and more bargaining power.

Summary

1. A game is cooperative if the players can communicate and arrange binding contracts; otherwise it is noncooperative. In either kind of game, the most important aspect of strategy design is understanding your opponent's position, and (if your opponent is rational) correctly deducing the likely response to your actions. Misjudging an opponents position is a common mistake, as Example 13.1, "Acquiring a Company," illustrates.[26]
2. A Nash equilibrium is a set of strategies such that each player is doing the best it can, given the strategies of the other players. An equilibrium in dominant strategies is a special case of a Nash equilibrium; a dominant strategy is optimal no matter what the other players do. A Nash equilibrium relies on the rationality of each player. A maximin strategy is more conservative because it maximizes the minimum possible outcome.
3. Some games have no Nash equilibria in pure strategies, but have one or more equilibria in mixed strategies. A mixed strategy is one in which the player makes a random choice among two or more possible actions, based on a set of chosen probabilities.
4. Strategies that are not optimal for a oner-shot game may be optimal for a repeated game. Depending on the number of repetitions, a "tit-for-tat" strategy, in which one plays cooperatively as long as one's competitor does the same, may be optimal for the repeated Prisoners' Dilemma.
5. In a sequential game, the players move in turn. In some cases, the player who moves first has an advantage. Players may then have an incentive to try to precommit themselves to particular actions before their competitors can do the same.

[26] Here is the solution to company As problem: *It should offer nothing for Company T's stock.* Remember that Company T will accept an offer only if it is greater than the per share value under current management. Suppose you offer $50. Thus, Company T will accept this offer only if the outcome of the exploration project results in a per share value under current management of $50 or less. Any values between $0 and $100 are equally likely. Therefore the *expected value* of Company T's stock, *given that it accepts the offer,* i.e., given that the outcome of the exploration project leads to a value less than $50, is $25, so that under the management of Company A the value would be (1.5)($25) = $37.5, which is less than $50. In fact, for any price *P*, if the offer is accepted. Company A can expect a value of only $(\frac{3}{4})P$.

6. An empty threat is a threat that one would have no incentive to carry out. If one's competitors are rational, empty threats are of no value. To make a threat credible, it is sometimes necessary to make a strategic move by constraining one's later behavior, so that there would be an incentive to carry out the threat.

7. To deter entry, an incumbent firm must convince any potential competitor that entry will be unprofitable. This may be done by investing, and thereby giving credibility to the threat that entry will be met by price warfare. Strategic trade policies by governments sometimes have this objective.

8. Bargaining situations are examples of cooperative games. As with noncooperative games, in bargaining one can sometimes gain a strategic advantage by limiting one's flexibility.

Questions for Review

1. What is the difference between a cooperative and a noncooperative game? Give an example of each.

2. What is a dominant strategy? Why is an equilibrium stable in dominant strategies?

3. Explain the meaning of a Nash equilibrium. How does it differ from an equilibrium in dominant strategies?

4. How does a Nash equilibrium differ from a gamers maximin solution? In what situations is a maximin solution a more likely outcome than a Nash equilibrium?

5. What is a "tit-for-tat" strategy? Why is it a rational strategy for the infinitely repeated Prisoners' Dilemma?

6. Consider a game in which the Prisoners' Dilemma is repeated 10 times, and both players are rational and fully informed. Is a tit-for-tat strategy optimal in this case? Under what conditions would such a strategy be optimal?

7. Suppose you and your competitor are playing the pricing game shown in Table 13.8. Both of you must announce your prices at the same time. Might you improve your outcome by promising your competitor that you will announce a high price?

8. What is meant by "first-mover advantage"? Give an example of a gaming situation with a first-mover advantage.

9. What is a "strategic move"? How can the development of a certain kind of reputation be a strategic move?

10. Can the threat of a price war deter entry by potential competitors? What actions might a firm take to make this threat credible?

11. A strategic move limits one's flexibility and yet gives one an advantage. Why? How might a strategic move give one an advantage in bargaining?

Exercises

1. In many oligopolistic industries, the same firms compete over a long period of time, setting prices and observing each other's behavior repeatedly. Given that the number of repetitions is large, why don't collusive outcomes typically result?

2. Many industries are often plagued by overcapacity-firms simultaneously make major investments in capacity expansion, so that total capacity far exceeds demand. This happens in industries in which demand is highly volatile and unpredictable, but also in industries in which demand is fairly stable. What factors lead to overcapacity? Explain each briefly.

3. Two computer firms, *A* and B, are planning to market network systems for office information management. Each firm can develop either a fast, high-quality system (*H*), or a slower, low-quality system (*L*). Market research indicates that the resulting profits to each firm for the alternative strategies are given by the following payoff matrix:

		Firm B	
		H	*L*
Firm A	*H*	30, 30	50, 35
	L	40, 60	20, 20

a. If both firms make their decisions at the same time and follow *maximin* (low-risk) strategies, what will the outcome be?
b. Suppose both firms try to maximize profits, but Firm *A* has a head start in planning, and can commit first. Now what will the outcome be? What will the outcome be if Firm *B* has the head start in planning and can commit first?
c. Getting a head start costs money (you have to gear up a large engineering team). Now consider the *two-stage* game in which *first,* each firm decides how much money to spend to speed up its planning, and *second,* it announces which product (H or L) it will produce. Which firm will spend more to speed up its planning? How much will it spend? Should the other firm spend *anything* to speed up its planning? Explain.

4. Two firms are in the chocolate market. Each can choose to go for the high end of the market (high quality) or the low end (low quality). Resulting profits are given by the following payoff matrix:

		Firm 2	
		Low	High
Firm 1	Low	−20, −30	900, 600
	High	100, 800	50, 50

a. What outcomes, if any, are Nash equilibria?
b. If the manager of each firm is conservative and each follows a maximin strategy, what will be the outcome?
c. What is the cooperative outcome?
d. Which firm benefits most from the cooperative outcome? How much would that firm need to offer the other to persuade it to collude?

5. Two major networks are competing for viewer ratings in the 8:00-9:00 P.M. and 9:00-10:00 P.M. slots on a given weeknight. Each has two shows to fill this time period and is juggling its lineup. Each can choose to put its "bigger" show first or to place it second in the 9:00-10:00 P.M. slot. The combination of decisions leads to the following "ratings points" results:

		Network 2	
		First	Second
Network 1	First	18, 18	23, 20
	Second	4, 23	16, 16

a. Find the Nash equilibria for this game, assuming that both networks make their decisions at the same time.
b. If each network is risk averse and uses a maximin strategy, what will be the resulting equilibrium?
c. What will be the equilibrium if Network 1 makes its selection first? If Network 2 goes first?
d. Suppose the network managers meet to coordinate schedules, and Network 1 promises tc schedule its big show first. Is this promise credible, and "what would be the likely outcome?

6. We can think of U.S. and Japanese trade policies as a Prisoners' Dilemma. The two countries are considering policies to open or close their import markets. Suppose the payoff matrix is:

		Japan	
		Open	Close
U.S.	Open	10, 10	5, 5
	Close	−100, 5	1, 1

a. Assume that each country knows the payoff matrix and believes that the other country will act in its own interest. Does either country have a dominant strategy? What will be the equilibrium policies if each country acts rationally to maximize its welfare?

b. Now assume that Japan is not certain that the U.S. will behave rationally. In particular, Japan is concerned that U.S. politicians may want to penalize Japan even if that does not maximize U.S. welfare. How might this affect Japan's choice of strategy? How might this change the equilibrium?

7. You are a duopolist producer of a homogeneous good. Both you and your competitor have *zero* marginal costs. The market demand curve is

$$P = 30 - Q$$

where $Q = Q_1 + Q_2$. Q_1 is your output, and Q_2 is your competitor's output. Your competitor has also read this book.

a. Suppose you are to play this game only once. If you and your competitor must announce your outputs at the same time, how much will you choose to produce? What do you expect your profit to be? Explain.

b. Suppose you are told that you must announce. your output before your competitor does. How much will you produce in this case, and how much do you think your competitor will produce? What do you expect your profit to be? Is announcing first an advantage or a disadvantage? Explain briefly. *How much would you pay* to be given the option of announcing either first or second?

c. Suppose instead that you are to play the first round of a *series of ten rounds* (with the same competitor). In each round you and your competitor announce your outputs at the same time. You want to maximize the sum of your profits over the ten rounds. How much will you produce *in the first round?* How much would you expect to produce in the tenth round? The ninth round? Explain briefly.

d. Once again you will play a series of ten rounds. This time, however, in each round your competitor will announce its output before you announce yours. How will your answers to (c) change in this case?

***8.** Defendo has decided to introduce a revolutionary video game, and as the first firm in the market,' it will have a monopoly position for at least some time. In deciding what type of manufacturing plant to build, it has the choice of two technologies. Technology A is publicly available,and will result in annual costs of:

$$C_A(q) = 10 + 8q$$

Technology *B* is a proprietary technology developed in Defenders research labs. It involves higher fixed cost of production, but lower marginal costs:

$$C_B(q) = 60 + 2q$$

Defendo's CEO must decide which technology to adopt. Market demand for the new product is $P = 20 - Q$, where Q is total industry output.

a. Suppose Defendo were certain that it would maintain its monopoly position in the market for the entire product lifespan (about five years) without threat of entry. Which technology would you advise the CEO to adopt? What would be Defendo's profit given this choice?

b. Suppose Defendo expects its archrival, Offendo, to consider entering the market shortly after Defendo introduces its new product. Offendo will have access only to Technology *A*. If Offendo does enter the market, the two firms will play a Cournot game (in quantities) and arrive at the Cournot-Nash equilibrium.

(i) .If Defendo adopts Technology *A* and Offendo enters the market, what will be the profits of both firms? Would Offendo choose to enter the market given these profits?

(ii) If Defendo adopts Technology B and Offendo enters the market, what will be the profit of each firm? Would Offendo choose to enter the market given these profits?

(iii) Which technology would you advise the CEO of Defendo to adopt given the threat of possible entry? What will be Defended profit given this choice? What will be consumer surplus given this choice?

c. What happens to social welfare (the sum of consumer surplus and producer profit) as a result of the threat of entry in this market? What happens to equilibrium price? What might this imply about the role of *potential* competition in limiting market power?

9. Three contestants, *A*, *B*, and *C*, each have a balloon and a pistol. From fixed positions, they fire at each other's balloon. When a balloon is hit/ its owner is out When only one balloon remains, its owner is the winner, and receives a $1000 prize. At the outset, the players decide by lot the order in which they will fire, and each player can choose any remaining balloon as his target. Everyone knows that *A* is the best shot and always hits the target, that *B* hits the target with probability .9, and that *C* hits the target with probability .8. Which contestant has the highest probability of winning the $1000? Explain why.