chapter 15

>> Oligopoly

CAUGHT IN THE ACT

The agricultural products company Archer Daniels Midland (also known as ADM) likes to describe itself as "supermarket to the world." Its name is familiar to many Americans not only because of its important role in the economy but also because of its advertising and sponsorship of public television programs. But on October 25, 1993, ADM itself was on camera.

On that day executives from ADM and its Japanese competitor Ajinomoto met at the Marriott Hotel in Irvine, California, to discuss the market for lysine, an additive used in animal feed. (How is lysine produced? It's excreted by genetically engineered bacteria.) In this and subsequent meetings, the two companies joined with several other competitors to set targets for the market price of lysine. Each company also agreed to limit its production in order to achieve those targets. Agreeing on specific limits would be their biggest challenge—or so they thought.

AP/Wide World Photos

The law catches up with a colluding oligopolist.

What the participants in the meeting didn't know was that they had a bigger problem: the FBI had bugged the room and was filming them with a camera hidden in a lamp.

What the companies were doing was illegal. To understand why it was illegal and why the companies were doing it anyway, we need to examine the issues posed by industries that are neither perfectly competitive nor pure monopolies. In this chapter we focus on *oligopoly*, an industry in which there are only a few producers. As we'll see, oligopoly is a very important reality—much more important, in fact, than monopoly and arguably more typical of modern economies than perfect competition.

Although much that we have learned about both perfect competition and monopoly is relevant to oligopoly, oligopoly also raises some entirely new issues. Among other things, firms in an oligopoly are often tempted to engage in the kind of behavior that got ADM, Ajinomoto, and other lysine producers into trouble with the

What you will learn in this chapter:

- The meaning of **oligopoly**, and why it occurs
- Why oligopolists have an incentive to act in ways that reduce their combined profit, and why they can benefit from **collusion**
- How our understanding of oligopoly can be enhanced by using **game theory**, especially the idea of the **prisoners' dilemma**
- How repeated interactions among oligopolists can help them achieve **tacit collusion**
- How oligopoly works in practice, under the legal constraints of antitrust law

law. For example, in 2002 five of the largest music companies and three of the largest music retailers in the United States settled government charges that they worked together to keep the prices of CDs artificially high during the 1990s.

We will begin by examining what oligopoly is and why it is so important. Then we'll turn to the behavior of oligopolistic industries. Finally, we'll look at *antitrust* policy, which is primarily concerned with trying to keep oligopolies "well behaved."

The Prevalence of Oligopoly

An **oligopoly** is an industry with only a small number of producers. A producer in such an industry is known as an **oligopolist.**

At the time of that elaborately bugged meeting, no one company controlled the world lysine industry, but there were only a few major producers. An industry with only a few sellers is known as an **oligopoly;** a firm in such an industry is known as an **oligopolist.**

Oligopolists obviously compete with each other for sales. But ADM and Ajinomoto weren't like firms in a perfectly competitive industry, which take the price at which they can sell their product as given. Each of these firms knew that its decision about how much to produce would affect the market price. That is, like monopolists, each of the firms had some *market power*. So the competition in this industry wasn't "perfect."

When no one firm has a monopoly, but producers nonetheless realize that they can affect market prices, an industry is characterized by **imperfect competition.**

Economists refer to a situation in which firms compete but also possess market power—which enables them to affect market prices—as **imperfect competition.** As we saw in Chapter 14, there are actually two important forms of imperfect competition: oligopoly and *monopolistic competition.* Of these, oligopoly is probably the more important in practice.

Although lysine is a multibillion-dollar business, it is not exactly a product familiar to most consumers. However, many familiar goods and services are supplied by only a few competing sellers, which means the industries in question are oligopolies. For example, most air routes are served by only two or three airlines: in recent years, regularly scheduled shuttle service between New York and either Boston or Washington, D.C. has been provided only by Delta and US Airways. Similarly, most long-distance telephone service is supplied by one of three carriers: AT&T, MCI, and Sprint. Most cola beverages are sold by Coca-Cola and Pepsi. This list could go on for many pages.

Rhonda Sidney/The Image Works

Froot Loops or Wheaties? Four firms control nearly 83 percent of the breakfast cereal market.

It's important to realize that an oligopoly isn't necessarily made up of large firms. What matters isn't size per se; the question is how many competitors there are. When a small town has only two grocery stores, grocery service there is just as much an oligopoly as air shuttle service between New York and Washington.

Why are oligopolies so prevalent? Essentially, oligopoly is the result of the same factors that sometimes produce monopoly, but in somewhat weaker form. Probably the most important source of oligopoly is the existence of *economies of scale*, which give bigger producers a cost advantage over smaller ones. When these economies of scale are very strong, they lead to monopoly, but when they are not that strong they lead to competition among a small number of firms. For example, larger grocery stores typically have lower costs than smaller stores. But the advantages of large scale taper off once grocery stores are reasonably large, which is why only two or three stores often survive in small towns.

If oligopoly is so common, why has most of this book focused on competition in industries where the number of sellers is very

large? And why did we study monopoly, which is relatively uncommon, first? The answer has two parts. First, much of what we learn from the study of perfectly competitive markets—about costs, entry and exit, and efficiency—remains valid despite the fact that many industries are not perfectly competitive. Second, the analysis of oligopoly turns out to present some puzzles for which there is no easy solution. It is almost always a good idea—in exams and in life—first to deal with the questions you can answer, then to puzzle over the harder ones. We have simply followed the same strategy, developing the relatively clear-cut theories of perfect competition and monopoly first, and only then turning to the puzzles presented by oligopoly.

economics in action

Some Oligopolistic Industries

In practice, it is not always easy to determine an industry's market structure just by looking at the number of sellers. Many oligopolistic industries contain a number of small "niche" producers, which don't really compete with the major players. For example, the U.S. airline industry includes a number of regional airlines like Shuttle America, which flies propeller planes between places like Trenton, New Jersey, and Bedford, Massachusetts; if you count these carriers, the U.S. airline industry contains dozens of sellers, which doesn't sound like competition among a small group. But there are only a handful of national competitors like American and United, and on many routes, as we've seen, there are only two or three competitors.

To get a better picture of market structure, economists often use the "four-firm concentration ratio," which asks what share of industry sales is accounted for by the top four firms. (Why four? The federal government normally doesn't release data on share of industry sales within the top four, lest it be accused of giving away corporate secrets.)

TABLE 15-1

Four-Firm Concentration Ratios

Industry	Concentration ratio	Largest firms
1. Cigarettes	98.9	Phillip Morris, R. J. Reynolds, Lorillard, Brown and Williamson
2. Breweries	89.7	Anheuser-Busch, Miller, Coors, Stroh's
3. Batteries	90.1	Duracell, Energizer, Rayovac
4. Light bulbs	88.9	Westinghouse, General Electric
5. Breakfast cereals	82.9	Kellogg's, General Mills, Post, Quaker Oats
6. Automobiles	79.5	General Motors, Ford, DaimlerChrysler

Source: US Census Bureau, 1997.

Table 15-1 shows some industries with very high four-firm concentration ratios, along with the names of the largest firms in each industry. These names are familiar—not only because these are big companies but also because they advertise a lot. And that is not an accident. As we will see shortly, oligopolistic firms often choose *not* to compete much on price, trying to win customers in other ways—such as through ad campaigns. ■

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>> QUICK REVIEW

- In addition to perfect competition and monopoly, *oligopoly* and monopolistic competition are also important types of market structure. They are forms of *imperfect competition*.
- Oligopoly is a common market structure. It arises from the same forces that lead to monopoly, except in weaker form.

>>CHECK YOUR UNDERSTANDING 15-1

1. Explain why each of the following industries is an oligopoly, not a perfectly competitive industry.
   a. The world oil industry, where a few countries near the Persian Gulf control much of the world's oil reserves
   b. The microprocessor industry, where two firms, Intel and its bitter rival AMD, dominate the technology
   c. The wide-bodied passenger jet industry, where all planes are manufactured either in Boeing's plant in Seattle or in Airbus's plant in Toulouse, France

Solutions appear at back of book.

Understanding Oligopoly

How much will a firm produce? Up to this point we have always answered: the quantity that maximizes its profits. The assumption that firms maximize profits is enough to determine their output under perfect competition and for a monopolist.

When it comes to oligopoly, however, we run into some difficulties. Indeed, economists often describe the behavior of oligopolistic firms as a "puzzle."

A Duopoly Example

An oligopoly consisting of only two firms is a **duopoly.** Each firm is known as a **duopolist.**

Let's begin looking at the puzzle of oligopoly with the simplest version, an industry in which there are only two producing firms—a **duopoly**—and each is known as a **duopolist.**

Going back to our opening story, imagine that ADM and Ajinomoto are the only two producers of lysine. To make things even simpler, suppose that once a company has incurred the fixed cost needed to produce lysine, the marginal cost of producing another pound is zero. So the companies are concerned only with the revenue they receive from sales.

Table 15-2 shows a hypothetical demand schedule for lysine and the total revenue of the industry at each price–quantity combination.

If this were a perfectly competitive industry, each firm would have an incentive to produce more as long as the market price was above marginal cost. Since the

TABLE 15-2

A Demand Schedule for Lysine

Price of lysine (per pound)	Quantity of lysine demanded (millions of pounds)	Total revenue (millions)
$12	0	$0
11	10	110
10	20	200
9	30	270
8	40	320
7	50	350
6	60	360
5	70	350
4	80	320
3	90	270
2	100	200
1	110	110
0	120	0

marginal cost is assumed to be zero, this would mean that at equilibrium lysine would be provided free.

However, surely the firms would not be that stupid. With only two firms in the industry, each would realize that by producing more it would drive down the market price. So each firm would, like a monopolist, realize that profits would be higher if it limited its production.

So how much will the two firms produce?

One possibility is that the two companies will engage in **collusion**—they will cooperate to raise each other's profits. The strongest form of collusion is a **cartel,** an arrangement that determines how much each firm is allowed to produce. The world's most famous cartel is the Organization of Petroleum Exporting Countries, described in Economics in Action on page 377; as its name indicates, it's actually an agreement among governments rather than firms. There's a reason this most famous of cartels is an agreement among governments: cartels among firms are illegal in the United States and many other jurisdictions. But let's ignore the law for a moment (which is, of course, what ADM and Ajinomoto did in real life—to their own detriment).

Sellers engage in **collusion** when they cooperate to raise each others' profits. A **cartel** is an agreement by several producers that increases their combined profits by telling each one how much to produce.

So suppose that ADM and Ajinomoto were to form a cartel and that this cartel decided to act as if it were a monopolist, maximizing total industry profits. It's obvious from Table 15-2 that in order to maximize the combined profits of the firms, this cartel should set total industry output at 60 million pounds of lysine, which would sell at a price of $6 per pound, leading to revenue of $360 million, the maximum possible. Then the only question would be how much of that 60 million pounds each firm gets to produce. A "fair" solution might be for each firm to produce 30 million pounds.

But even if the two firms agreed on such a deal, they might have a problem: each of the firms would have an incentive to break its word and produce more than the agreed-upon quantity.

Collusion and Competition

Suppose that the presidents of ADM and Ajinomoto were to agree that each would produce 30 million pounds of lysine over the next year. Both would understand that this plan maximizes their combined profits. And both would have an incentive to cheat.

To see why, consider what would happen if Ajinomoto honored its agreement, producing only 30 million pounds, but ADM ignored its promise and produced 40 million pounds. This increase in total output would drive the price down from $6 to $5 per pound, the price at which 70 million pounds are demanded. The industry's total revenue would fall from $360 million ($6 × 60 million pounds) to $350 million ($5 × 70 million pounds). However, ADM's revenue would *rise*, from $180 million to $200 million. Since we are assuming a marginal cost of zero, this would mean a $20 million increase in ADM's profits.

But Ajinomoto's president might make exactly the same calculation. And if *both* firms were to produce 40 million pounds of lysine, the price would drop to $4 per pound. So each firm's profits would fall, from $180 million to $160 million.

Why do individual firms have an incentive to produce more than the quantity that maximizes their joint profits? Because neither firm has as strong an incentive to limit its output as a true monopolist would.

Let's go back for a minute to the theory of monopoly. We know that a profit-maximizing monopolist sets marginal cost (which in this case is zero) equal to marginal revenue. But what is marginal revenue? Producing an additional unit of a good has two effects:

1. A positive *quantity* effect: one more unit is sold, increasing total revenue by the price at which that unit is sold.
2. A negative *price* effect: in order to sell that last unit, the monopolist must cut ihe market price on *all* units sold.

The negative price effect is the reason marginal revenue for a monopolist is less than the market price.

But when considering the effect of increasing production, a firm is concerned only with the price effect on its own units of output, not those of its fellow oligopolists. Both ADM and Ajinomoto suffer a negative price effect if ADM decides to produce extra lysine and so drives down the price. But ADM cares only about the negative price effect on the lysine it produces, not about the loss to Ajinomoto.

This tells us that an individual firm in an oligopolistic industry faces a smaller price effect than a monopolist—and therefore that the marginal revenue that such a firm calculates is higher. So it will seem to be profitable for any one company in an oligopoly to increase production, even if that increase reduces the profits of the industry as a whole.

If everyone thinks that way, however, the result is that everyone earns a lower profit!

Until now, we have been able to analyze producer behavior by asking what a producer should do to maximize profits. But even if ADM and Ajinomoto are both trying to maximize profits, what does this predict about their behavior? Will they engage in collusion, reaching and holding to an agreement that maximizes their combined profits? Or will they engage in **noncooperative behavior,** with each firm acting in its own self-interest, even though this has the effect of driving down everyone's profits? Both strategies sound like profit maximization. Which will actually describe their behavior?

When firms ignore the effects of their actions on each others' profits, they engage in **noncooperative behavior.**

Now you see why oligopoly presents a puzzle: there are only a small number of players, making collusion a real possibility. If there were dozens or hundreds of firms, it would be safe to assume they would behave noncooperatively. When there are only a handful of firms in an industry, however, it's hard to determine whether collusion will actually materialize.

Since collusion is more profitable than noncooperative behavior, firms have an incentive to collude if they can. One way to make do so is to formalize it—sign an agreement (maybe even make a legal contract) or establish some financial incentives for the companies to set their prices high. But in the United States and many other nations, you can't do that—at least not legally. Companies cannot make a legal contract to keep prices high: not only is the contract unenforceable, but writing it is a one-way ticket to jail. Neither can they sign a gentlemen's agreement, which lacks the force of law but perhaps exerts moral force—that's illegal, too. In fact, executives from rival companies rarely meet without lawyers present, who make sure that the conversation does not stray into inappropriate territory. Even hinting at how nice it would be if prices were higher can bring you an unwelcome interview with the Justice Department or the Federal Trade Commission, both of which enforce the laws against oligopolistic collusion. For example, at the time of writing, the Justice Department had begun to consider whether to open a formal inquiry into a series of meetings held between Monsanto and Pioneer Hi-Bred International, two companies that account for 60 percent of the U.S. market in maize and soybean seed. The two companies, parties to a licensing agreement involving genetically modified seed, claimed that no illegal discussions of price-fixing occurred in those meetings. But the fact that the two firms discussed prices as part of the licensing agreement is enough to ensure, according to some experts, that a formal investigation will eventually be launched.

Sometimes, as we've seen, oligopolistic firms just ignore the rules. But more often they find ways to achieve collusion without a formal agreement. As we'll see in the next section, one important factor in determining how hard it is to achieve collusion is how easy it is for a firm to increase its output quickly in order to capture sales from its rival.

Competing in Prices versus Competing in Quantities

In our duopoly example, we've assumed that firms choose a level of output and sell that output at whatever the market price turns out to be. That's actually a pretty good description of the way the lysine market works. But in other industries, such

as automobiles, firms don't choose a level of output; they choose a *price* and sell as much as they can at that price. Does this make any difference?

Yes, it does, at least when we analyze noncooperative behavior. In choosing what to do, an oligopolist must always be concerned about whether a noncooperative rival firm will respond by *undercutting* her. The oligopolist must be concerned that a rival firm will take some action that allows it to steal some of her sales and capture a larger share of the market. And, it turns out, the answer to whether a rival is willing to engage in undercutting behavior depends on how difficult it is for him to increase output to satisfy the additional customers he gains by his undercutting.

Let's consider a hypothetical example using Airbus and Boeing, duopolists in the large passenger aircraft industry, to gain some intuition. For these firms, deciding their production capacity—how much output they can produce over, say, the next two or three years—is their most important decision. Why? Passenger aircraft are very large and are built in batches, a few planes at a time, in huge hangars. The determining factor in how many planes can be built at any given time is the size of the company's existing production facilities, which can take years to build.

So this means that when Airbus, for example, sets its maximum production capacity at 50 planes per year, Boeing can feel comfortably assured that Airbus won't be easily able to increase this number anytime soon. This, in turn, has important implications for Boeing's actions. If Boeing also sets its production capacity at 50 planes per year, it can safely assume that Airbus's production capacity is *given* and that, as a result, the market will be split 50–50 for each manufacturer. Airbus won't be able to quickly increase its output and steal some of Boeing's customers by offering them a lower price. The end result is that the total output of the industry is less than the output under perfect competition, and each firm earns a profit. Economists refer to this kind of behavior as *quantity competition* or *Cournot* behavior, after the nineteenth-century French economist who devised the model. The basic insight of the Cournot model is that when firms are restricted in how much they can produce, it is easier for them to avoid excessive competition and to "divvy up" the market, thereby pricing above marginal cost and earning profits.

But how does the behavior of oligopolists change when they are not constrained by a limited production capacity? Let's assume that American Airlines and British Airways are duopolists and that they have exclusive rights to fly the Chicago–London route. When the economy is strong and lots of people want to fly between Chicago and London, American Airlines and British Airways are likely to find the number of passengers they can carry constrained by their production capacity—for example, the number of landing slots available. So in this environment they are likely to behave according to the Cournot model and price above marginal cost—say, charging $800 per round trip. But when the business climate is poor, the two airlines are likely to find that they have lots of empty seats at a fare of $800 and that capacity constraints are no longer an issue. What will they do?

Recent history tells us they will engage in a price war by slashing ticket prices. They are no longer able to maintain Cournot behavior because at the ticket price of $800, each has excess capacity. If American Airlines were to try to maintain a price of $800, it would soon find itself undercut by British Airways, which would charge $750 and steal all its customers. In turn, American Airlines would undercut British Airways by charging $700—and so on. As long as each firm finds that it can make additional sales by cutting price, each will continue cutting until price is equal to marginal cost. (Going any lower would cause them to incur an avoidable loss.) This type of behavior is known as *price competition* or *Bertrand* behavior, after another nineteenth-century French economist. The logic behind the Bertrand model is that when firms produce perfect substitutes and have sufficient capacity to satisfy demand when price is equal to marginal cost, then each firm will be forced to engage in competition by undercutting its rival's price until the price reaches marginal cost—that is, perfect competition.

Oligopolists would, understandably, prefer to avoid Bertrand behavior because it earns them zero profits. Lacking an environment that imposes constraints on their output capacity, firms try other means to avoid direct price competition—such as producing products that are not perfect substitutes but are instead differentiated. We'll examine this strategy in more detail later in this chapter, just noting here that producing differentiated products allows oligopolists to cultivate a loyal set of customers and to charge prices higher than marginal cost.

Even in the absence of limitations on production capacity, firms are often able to maintain collusive behavior (although it may be somewhat harder to do). In the next section, we'll see why such informal collusion often works but sometimes fails.

economics in action

The Great Vitamin Conspiracy

It was a bitter pill to swallow. In late 1999 some of the world's largest drug companies (mainly European and Japanese) agreed to pay billions of dollars in damages to customers after being convicted of a huge conspiracy to rig the world vitamin market.

The conspiracy began in 1989 when the Swiss company Roche and the German company BASF began secret talks about raising prices for vitamins. Soon a French company, Rhone-Poulenc, joined in, followed by several Japanese companies and other companies around the world. The members of the group, which referred to itself as "Vitamins Inc.," met regularly—sometimes at hotels, sometimes at the private homes of executives—to set prices and divide up markets for "bulk" vitamins (like vitamin A, vitamin C, and so on). These bulk vitamins are sold mainly to other companies, such as animal feed makers, food producers, and so on, which include them in their products. Indeed, it was the animal feed companies that grew suspicious about the prices they were being charged, which led to a series of investigations. The case eventually broke open when Rhone-Poulenc made a deal with U.S. officials to provide evidence about the conspiracy; the French company was concerned that rumors about price-fixing would lead U.S. officials to block its planned merger with another company.

This was a huge conspiracy—it makes the lysine case look like, well, chicken feed. How could it have happened?

The main answer probably lies in different national traditions about how to treat oligopolists. The United States has a long tradition of taking tough legal action against price-fixing, as we have just described. European governments, however, have historically been much less stringent; indeed, in the past some European governments have actually encouraged major companies to form cartels. Modern European law on competition is not that different from that in the United States, but the European cultural tradition of viewing conspiracies to raise prices as normal business practice has not entirely died out. ■

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>>QUICK REVIEW

- Some of the key issues in oligopoly can be understood by looking at the simplest case, a *duopoly*
- By acting as if they were a single monopolist, oligopolists can maximize their combined profits. So there is an incentive to form a *cartel*.
- However, each firm has an incentive to cheat—to produce more than it is supposed to under the cartel agreement. So there are two principal outcomes: successful *collusion* or behaving *noncooperatively* by cheating.
- It is likely to be easier to achieve informal collusion when firms in an industry face capacity constraints.

>>CHECK YOUR UNDERSTANDING 15-2

1. Which of the following factors increase the likelihood that oligopolists will collude? The likelihood that oligopolists will act noncooperatively and raise output? Explain your answers.
   a. The firm's initial market share is small.
   b. The firm has a cost advantage over its rivals.
   c. The firm's customers face additional costs when they switch from the use of one firm's product to another firm's product.
   d. The firm and its rivals are currently operating at maximum production capacity, which cannot be altered in the short run.

Solutions appear at back of book.

Games Oligopolists Play

In our duopoly example and in real life, each oligopolistic firm realizes both that its profit depends on what its competitor does and that its competitor's profit depends on what it does. That is, the two firms are in a situation of **interdependence.**

In effect, the two firms are playing a "game" in which the profit of each player depends not only on its own actions but on those of the other player. The area of study of such games, known as **game theory,** has many applications, not just to economics but also to military strategy, politics, and other social sciences.

Let's see how game theory helps us understand oligopoly.

When the decisions of two or more firms significantly affect each others' profits, they are in a situation of **interdependence.**

The study of behavior in situations of interdependence is known as **game theory.**

The Prisoners' Dilemma

Game theory deals with any situation in which the reward to any one player—the **payoff**—depends not only on his or her own actions but also on those of other players. In the case of oligopolistic firms, the payoff is simply the firm's profit.

When there are only two players, as in a duopoly, the interdependence between the players can be represented with a **payoff matrix** like that shown in Figure 15-1. Each row corresponds to an action by one player (in this case, ADM); each column corresponds to an action by the other (in this case, Ajinomoto). For simplicity, let's assume that ADM can pick only one of two alternatives: produce 30 million pounds of lysine or produce 40 million pounds. Ajinomoto can make only the same choice.

The reward received by a player in a game, such as the profits earned by an oligopolist, is that player's **payoff.**

A **payoff matrix** shows how the payoff to each of the participants in a two-player game depends on the actions of both. Such a matrix helps us analyze interdependence.

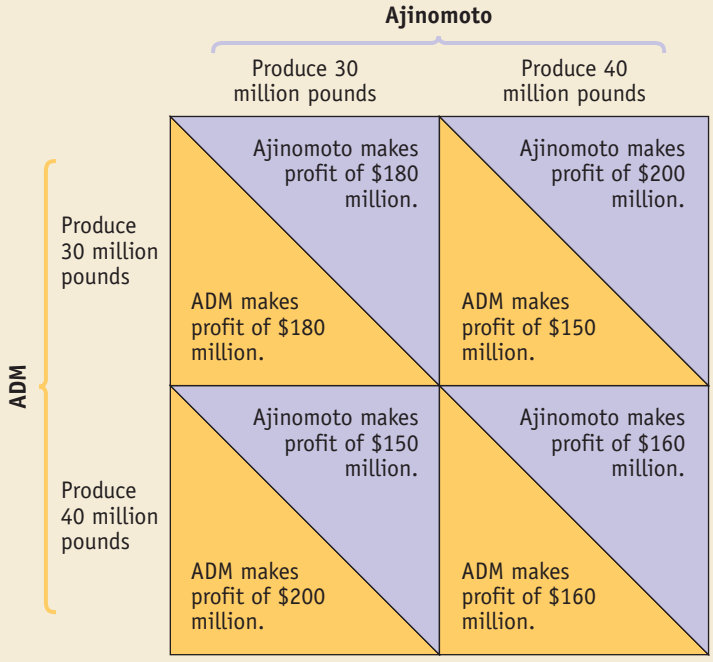
The matrix contains four boxes, each divided by a diagonal line. Each box shows the payoff to the two firms that results from a pair of choices; the number below the diagonal shows ADM's profits, the number above the diagonal shows Ajinomoto's profits.

These payoffs show what we concluded from our earlier analysis: the combined profits of the two firms are maximized if they each produce 30 million pounds. Either firm can, however, increase its own profits by producing 40 million pounds while the

Figure 15-1

A Payoff Matrix

Two firms, ADM and Ajinomoto, must decide how much lysine to produce. The profits of the two firms are *interdependent*: each firm's profit depends not only on its own decision but on the other's decision. Each row represents a decision by ADM, each column one by Ajinomoto. Both firms will be better off if they both choose the lower output; but it is in each firm's individual interest to choose higher output.



other produces only 30 million pounds. But if both produce the larger quantity, both will have lower profits than if they had held their output down.

The particular situation shown here is a version of a famous—and seemingly paradoxical—case of interdependence that appears in many contexts. Known as the **prisoners' dilemma,** it is a type of game in which the payoff matrix implies the following:

- Each player has an incentive, regardless of what the other player does, to cheat—to take an action that benefits it at the other's expense
- When both players cheat, both are worse off than they would have been if neither had cheated.

Prisoners' dilemma is a game based on two premises: (1) Each player has an incentive to choose an action that benefits itself at the other player's expense. (2) When both players act in this way, both are worse off than if they had chosen different actions.

The original illustration of the prisoners' dilemma occurred in a fictional story about two accomplices in crime—let's call them Thelma and Louise—who have been caught by the police. The police have enough evidence to put them behind bars for 5 years. They also know that the pair have committed a more serious crime, one that carries a 20-year sentence; unfortunately, they don't have enough evidence to convict the women on that charge. To do so, they would need each of the prisoners to implicate the other in the second crime.

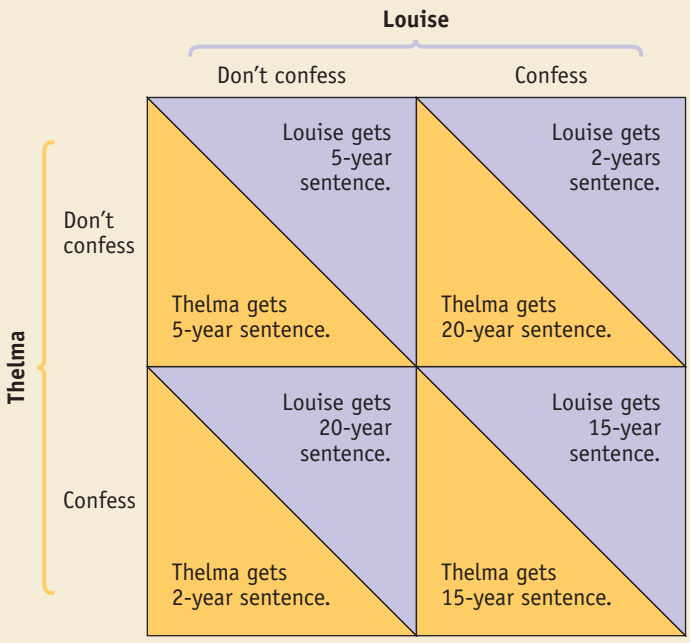
So the police put the miscreants in separate cells and say the following to each: "Here's the deal: If neither of you confesses, you know that we'll send you to jail for 5 years. If you confess and implicate your partner, and she doesn't do the same, we'll reduce your sentence from 5 years to 2. But if your partner confesses and you don't, you'll get the maximum 20 years. And if both of you confess, we'll give you both 15 years."

Figure 15-2 shows the payoffs that face the prisoners, depending on the decision of each to remain silent or to confess. (Usually the payoff matrix reflects the players' payoffs, and higher payoffs are better than lower payoffs. This case is an exception: a higher number of years in prison is bad, not good!) Let's assume that the prisoners have no way to communicate and that they have not sworn an oath not to harm each other or anything of that sort. So each acts in her own self-interest. What will they do?

Figure 15-2

The Prisoners' Dilemma

Each of two prisoners, held in separate cells, is offered a deal by the police—a light sentence if she confesses and implicates her accomplice but her accomplice does not do the same, a heavy sentence if she does not confess but her accomplice does, and so on. It is in the joint interest of both prisoners not to confess; it is in each one's individual interest to confess.



The answer is clear: both will confess. Look at it first from Thelma's point of view: she is better off confessing, regardless of what Louise does. If Louise doesn't confess, Thelma's confession reduces her own sentence from 5 years to 2. If Louise *does* confess, Thelma's confession reduces her sentence from 20 to 15 years. Either way, it's clearly in Thelma's interest to confess. And because she faces the same incentives, it's clearly in Louise's interest to confess, too. To confess in this situation is a type of action that economists call a *dominant strategy.* An action is a **dominant strategy** when it is the player's best action regardless of what action the other player takes. It's important to note that not all games have a dominant strategy—it depends on the structure of payoffs in the game. But in the case of Thelma and Louise, it is clearly in the interest of the police to structure the payoffs so that confessing is a dominant strategy for each person. So as long as the two prisoners have no way to make an enforceable agreement that neither will confess (something they can't do if they can't communicate, and the police certainly won't allow them to do because the police want to compel each one to confess), Thelma and Louise will each act in a way that hurts the other.

So if each prisoner acts rationally in her own interests, both will confess. Yet if neither of them had confessed, both would have received a much lighter sentence! In a prisoners' dilemma, each player has a clear incentive to act in a way that hurts the other player—but when both make that choice, it leaves both of them worse off.

When Thelma and Louise both confess, they reach an *equilibrium* of the game. We have used the concept of equilibrium many times in this book; it is an outcome in which no individual or firm has any incentive to change his or her action. In game theory, this kind of equilibrium, in which each player takes the action that is best for her given the actions taken by other players, and vice versa, is known as a **Nash equilibrium,** after the mathematician John Nash. (Nash's life was chronicled in the best-selling biography *A Beautiful Mind*, which was made into a movie.) Because the players in a Nash equilibrium do not take into account the effect of their actions on others, this is also known as a **noncooperative equilibrium.**

Now look back at Figure 15-1; ADM and Ajinomoto are in the same situation as Thelma and Louise. Each firm is better off producing the higher output, regardless of what the other firm does; yet if both produce 40 million pounds, both are worse off than if they had followed their agreement and produced only 30 million pounds.

In both cases, then, the pursuit of individual self-interest—the effort to maximize profits or to minimize jail time—has the perverse effect of hurting both players.

Prisoners' dilemmas appear in many situations. For Inquiring Minds on page 374 describes an example from the days of the Cold War.

Clearly, the players in any prisoners' dilemma would be better off if they had some way of enforcing cooperative behavior—if Thelma and Louise had both sworn to a code of silence, or if ADM and Ajinomoto had signed an enforceable agreement not to produce more than 30 million pounds of lysine.

But in the United States an agreement setting the output levels of two oligopolists isn't just unenforceable, it's illegal. So it seems that the undesirable noncooperative equilibrium is the only possible outcome. Or is it?

Overcoming the Prisoners' Dilemma: Repeated Interaction and Tacit Collusion

Thelma and Louise in their cells are playing what is known as a *one-shot* game—that is, they play the game with each other only once. They get to choose once and for all whether to confess or hang tough, and that's it. However, most of the games

PITFALLS

PLAYING FAIR IN THE PRISONERS' DILEMMA

One common reaction to the prisoners' dilemma is to assert that it isn't really rational for either prisoner to confess. Thelma wouldn't confess because she'd be afraid Louise would beat her up or feel guilty because Louise wouldn't do that to her.

But this kind of answer is, well, cheating—it amounts to changing the payoffs in the payoff matrix. To understand the dilemma, you have to play fair and imagine prisoners who care *only* about the length of their sentences.

Luckily, when it comes to oligopoly, it's a lot easier to believe that the firms care only about their profits. There is no indication that anyone at ADM felt either affection for or fear of Ajinomoto, or vice versa; it was strictly about business.

An action is a **dominant strategy** when it is a player's best action regardless of the action taken by the other player.

A **Nash equilibrium,** also known as a **noncooperative equilibrium,** is the result when each player in a game chooses the action that maximizes his or her payoff given the actions of other players, ignoring the effects of that action on the payoffs received by those other players.

FOR INQUIRING MINDS

PRISONERS OF THE ARMS RACE

Between World War II and the late 1980s, the United States and the Soviet Union were locked in a seemingly endless struggle that never broke out into open war. During this Cold War, both countries spent huge sums on arms, sums that were a significant drain on the U.S. economy and eventually proved a crippling burden for the Soviet Union, whose underlying economic base was much weaker. Yet neither country was ever able to achieve a decisive military advantage.

As many people pointed out, both nations would have been better off if they had both spent less on arms. Yet the arms race continued for 40 years.

Why? As political scientists were quick to notice, one way to explain the arms race was to suppose that the two countries were locked in a classic prisoners' dilemma. Each government would have liked to achieve decisive military superiority, and each feared military inferiority; but both would have preferred a stalemate with low military spending to one with high spending. However, each government rationally chose to engage in high spending. If its rival did not spend heavily, this would lead to military superiority; *not* spending heavily would lead to inferiority if the other government continued its arms buildup. So the countries were trapped.

TASS/Sovfoto

Caught in the prisoners' dilemma: heavy military spending hastened the collapse of the Soviet Union.

The answer to this trap could have been an agreement not to spend as much; indeed, the two sides tried repeatedly to negotiate limits on some kinds of weapons. But these agreements weren't very effective. In the end the issue was resolved as heavy military spending hastened the collapse of the Soviet Union in 1991.

that oligopolists play aren't one-shot; instead, they expect to play the game repeatedly with the same other firms. An oligopolistic firm usually expects to be in business for many years, and it knows that its decision today about whether to cheat is likely to affect the way other firms treat it in the future. So a smart oligopolist doesn't just decide what to do based on the effect on profits in the short run. Instead, the firm engages in **strategic behavior,** taking account of the effects of today's action on the future actions of other players in the game. And under some conditions oligopolists that behave strategically can manage to behave as if they had an agreement to collude.

A firm engages in **strategic behavior** when it attempts to influence the future behavior of other firms.

Suppose that ADM and Ajinomoto expect to be in the lysine business for many years and therefore to play the game of cheat versus collude shown in Figure 15-1 many times. Would they really betray each other time and again?

Probably not. Suppose that ADM considers two strategies. In one strategy it always cheats, producing 40 million pounds of lysine each year, regardless of what Ajinomoto does. In the other strategy, it starts off with good behavior, producing only 30 million pounds in the first year, and watches to see what its rival does. If Ajinomoto also keeps its production down, ADM will stay cooperative, producing 30 million pounds again for the next year. But if Ajinomoto produces 40 million pounds, ADM will take the gloves off and also produce 40 million pounds next year. This latter strategy—start off behaving cooperatively, but thereafter do whatever the other player did in the previous period—is generally known as **tit for tat**.

A strategy of **tit for tat** involves playing cooperatively at first, then doing whatever the other player did the previous period.

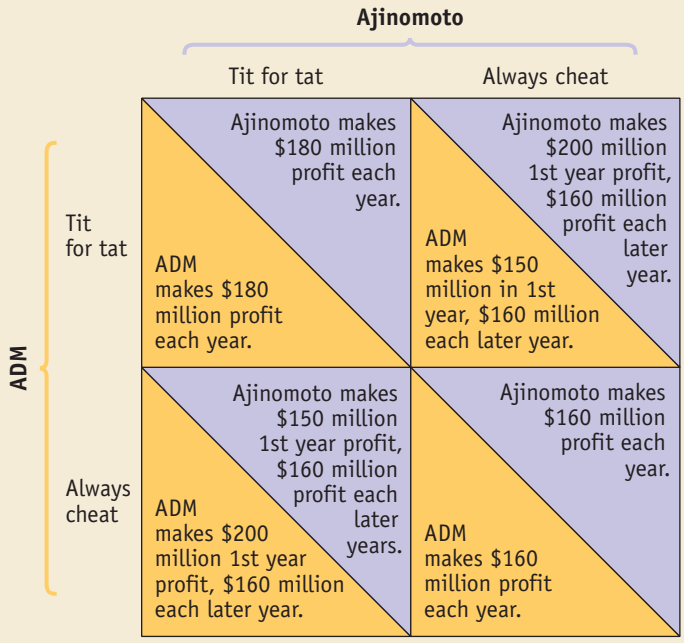
"Tit for tat" is a form of strategic behavior, which we have just defined as behavior intended to influence the future actions of other players. "Tit for tat" offers a reward for cooperative behavior—if you behave cooperatively, so will I. It also provides a punishment for cheating—if you cheat, don't expect me to be nice in the future.

The payoff to ADM of each of these strategies would depend on which strategy Ajinomoto chooses. Consider the four possibilities, shown in Figure 15-3:

Figure 15-3

How Repeated Interaction Can Justify Collusion

A strategy of "tit for tat" involves playing cooperatively at first, then following the other player's move. This rewards good behavior and punishes bad behavior. If the other player cheats, playing "tit for tat" will lead to only a short-term loss in comparison to playing "always cheat." But if the other player plays "tit for tat," also playing "tit for tat" leads to a long-term gain. So a firm that expects other firms to to play "tit for tat" may well choose to do the same, leading to successful tacit collusion.



1. If ADM plays "tit for tat" and so does Ajinomoto, both firms will earn $180 million each year.
2. If ADM plays "always cheat" but Ajinomoto plays "tit for tat," ADM earns $200 million the first year but only $160 million per year thereafter.
3. If ADM plays "tit for tat" but Ajinomoto plays "always cheat," ADM earns only $150 million in the first year but $160 million per year thereafter.
4. If ADM plays "always cheat" and Ajinomoto does the same, both firms will earn $160 million each year.

Which strategy is better? In the first year, ADM does better playing "always cheat," whatever its rival's strategy: it assures itself that it will get either $200 million or $160 million (which of the two payoffs it actually receives depends upon whether Ajinomoto play "always cheat" or "tit for tat"). This is better than what it would get in the first year if it played "tit for tat": either $180 million or $150 million. But by the second year, a strategy of "always cheat" gains ADM only $160 million per year for the second and all subsequent years, regardless of Ajinomoto's actions. This amount is inferior to the amount ADM would gain by playing "tit for tat": for the second and all subsequent years, it would never get any less than $160 million and would get as much as $180 million if Ajinomoto played "tit for tat" as well. So which strategy is more profitable depends on two things: how many years ADM expects to play the game and what strategy its rival follows.

If ADM expects the lysine business to end in the near future, it is in effect playing a one-shot game. So it might as well grab what it can, even if it expects to remain in the lysine business for many years (therefore to find itself repeatedly playing this game with Ajinomoto) and expects, for some reason, Ajinomoto always to cheat. That is, ADM should follow the old rule "Do unto others before they do unto you."

But if ADM expects to be in the business for a long time and thinks Ajinomoto is likely to play "tit for tat," it will make more profits over the long run by playing "tit for tat," too. It could have made some extra short-term profits by cheating at the

beginning, but this would provoke Ajinomoto into cheating too, and would, in the end, mean lower profits.

The lesson of this story is that when oligopolists expect to compete with each other over an extended period of time, each individual firm will often conclude that it is in its own best interest to be helpful to the other firms in the industry. So it will restrict its output in a way that raises the profits of the other firms, expecting them to return the favor. Even though the firms have no way of making an enforceable agreement to limit output and raise prices, they manage to act "as if" they had such an agreement. When this happens, we say that firms engage in **tacit collusion.**

When firms limit production and raise prices in a way that raises each others' profits, even though they have not made any formal agreement, they are engaged in **tacit collusion.**

The Kinked Demand Curve

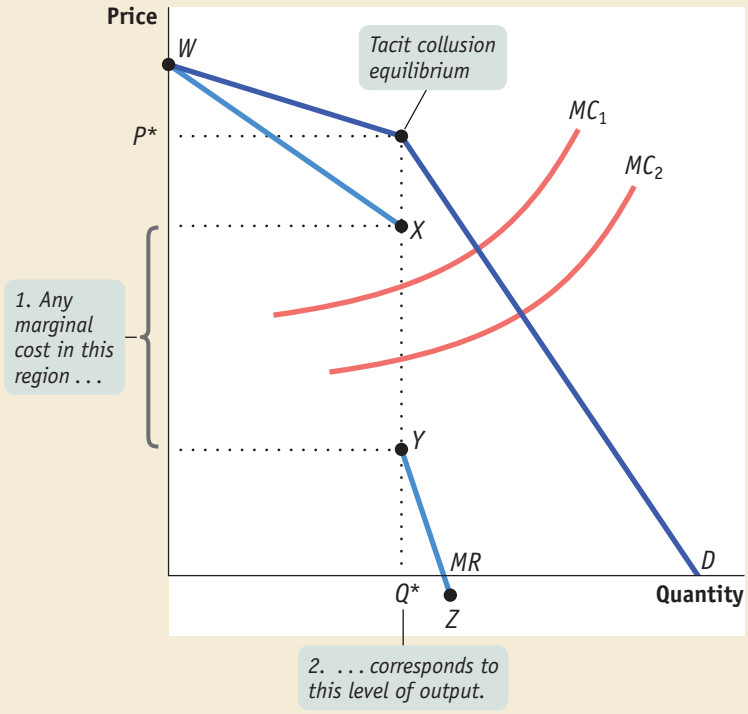
Once an oligopolistic industry has achieved tacit collusion, individual producers have an incentive to behave carefully—they don't want to do anything to disrupt the collusion. They must behave carefully because under tacit collusion there is no safe communication channel between producers. When a producer changes her output, there is a danger that tacit collusion will collapse as rivals interpret her action as a noncooperative move. As a consequence, the output of an oligopolist may not respond to changes in marginal cost. If she increases her output, her rivals may interpret this as cheating, leading them to retaliate and cut prices. But if she reduces her output, she has no assurance that rivals will follow her actions by cutting output and raising their prices. In fact, they may respond by leaving their prices unchanged and stealing some of her sales.

Figure 15-4 illustrates this behavior. At the original tacit collusion equilibrium, the oligopolist produces the equilibrium quantity Q^* and receives the equilibrium price P^*, located on her demand curve, D. This demand curve shows how the price she receives for her good varies as she changes her output. As you can see, this demand curve has a special shape—it is *kinked* at the price and quantity combination associated with the tacit collusion equilibrium, P^* and Q^*.

Figure 15-4

The Kinked Demand Curve

This oligopolist believes that her demand curve is kinked at the tacit collusion price and quantity levels, P^* and Q^*. That is, she believes that if she lowers her price her rivals will retaliate and lower their prices as well, leading to only a small gain in sales. So her demand curve is very steep to the right of P^* and Q^*. But the oligopolist believes that if she raises her price her rivals will refuse to raise their prices and will steal a substantial number of her customers, leading to a large fall in sales. So her demand curve is very flat to the left of P^* and Q^*. The kink in the demand curve leads to the break XY in the marginal revenue curve. As shown by the marginal cost curves, MC_1 and MC_2, any marginal cost curve that lies within the break leads the firm to produce the same output level, Q^*. So starting at the tacit collusion outcome, changes in marginal cost within a certain range will leave the firm's output quantity unchanged. But large changes in marginal cost—changes that cause the marginal cost curve to cut the marginal revenue curve in the segment WX or the segment YZ—will lead to changes in output quantity.



On one side, the demand curve slopes steeply downward at output levels greater than Q*. The reason is that the oligopolist believes that if she produces more than Q*, she will gain very few sales because her rivals will retaliate by also producing more and cutting their prices.

On the other side, the demand curve is very flat. If the oligopolist reduces her output below Q*, she does not expect rivals to reduce their output as well. Consequently, she will lose a relatively large number of sales if she lowers her output and raises her price as her rivals capture a substantial share of her customers. You might ask why the industry can't reestablish tacit collusion at a higher price and lower output after our oligopolist cuts her output and raises her price. It is possible, but by no means assured, that the industry can reestablish tacit collusion. So it is reasonable for an oligopolist to fear that tacit collusion will not be reestablished and to behave as if her demand curve is kinked as in Figure 15-4.

Now that we have explained the source of the oligopolist's **kinked demand curve,** let's examine how this affects her response to a change in marginal cost. The kink in the demand curve *D* generates a break in the oligopolist's marginal revenue curve, *MR*, shown by the gap between the points *X* and *Y*. Two marginal cost curves pass through that break in the marginal revenue curve: MC_1 corresponds to a situation of higher marginal cost, and MC_2 corresponds to a situation of lower marginal cost.

An oligopolist who believes she will lose a substantial number of sales if she increases her price but will gain only a few additional sales she it lowers her price, away from the tacit collusion outcome, faces a **kinked demand curve.**

Recall that according to the optimal output rule, a firm will maximize profits by producing the output level at which marginal revenue is equal to marginal cost. But given the break between *X* and *Y* in the oligopolist's marginal revenue curve, any marginal cost curves that lie within that break—like MC_1 and MC_2—will generate the same optimal output level, Q*. To put it in a slightly different way, starting from the tacit collusive output level Q*, the oligopolist's output level is unresponsive to changes in marginal cost within a certain range. If marginal cost falls substantially, the oligopolist is more likely to risk a breakdown in collusion and increase her output; in this case, the marginal cost curve cuts the marginal revenue curve in the segment *YZ*. And if marginal cost rises substantially, shifting the marginal cost curve up so that it cuts the marginal revenue curve in the segment *WX*, then the oligopolist is likely to raise her price despite the risk of losing sales to rivals. But if marginal cost changes within a limited range—the range defined by *XY*—the producer will leave her output level unchanged rather than risk a breakdown in tacit collusion.

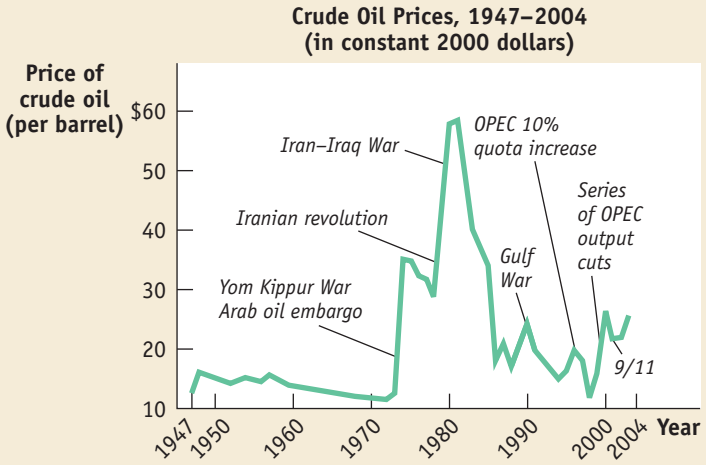
The behavior described by the kinked demand curve appears justified when a producer believes that she alone is facing a change in marginal cost—that is, when the change is unique to her. But when the change in marginal cost is clearly shared throughout the industry, this behavior is much less plausible. In that case, each producer knows that a change in a rival's output level is just a response to a change in the general level of marginal cost, not a hostile act of noncooperation. Consequently, all the producers in the industry are likely to respond to a change in marginal cost by adjusting their output and thereby maintain collusion.

economics in action

The Rise and Fall and Rise of OPEC

Call it the cartel that does not need to meet in secret. The Organization of Petroleum Exporting Countries, usually referred to as OPEC, includes 11 national governments; 2 other oil-exporting countries, Norway and Mexico, are not formally part of the cartel but act as if they were. (Russia, also an important oil exporter, has not yet become part of the club.) Unlike corporations, which can be and are legally prohibited by governments from reaching agreements about production and prices, national governments can talk about whatever they feel like. OPEC members routinely meet to try to set targets for production.

Figure 15-5 The Ups and Downs of the Oil Cartel



The Organization of Petroleum Exporting Countries is a legal cartel that has had its ups and downs. From 1974 to 1985 it succeeded in driving world oil prices to unprecedented levels; then it collapsed. In 1998 the cartel once again became effective.

Source: WTRG Economics

These nations are not particularly friendly with each other. Indeed, OPEC members Iraq and Iran fought a spectacularly bloody war with each other in the 1980s. And, in 1990, Iraq invaded another member, Kuwait. (A mainly American force based in yet another OPEC member, Saudi Arabia, drove the Iraqis out of Kuwait.)

Yet the members of OPEC, like each other or not, are like players in a game with repeated interactions. In any given year it is in their combined interest to keep output low and prices high; but it is also in the interest of any one producer to cheat and produce more than the agreed-upon quota—unless that producer believes that this action will bring future retaliation.

So how successful is the cartel? Well, it's had its ups and downs.

Figure 15-5 shows the price of oil in constant dollars (that is, the value of a barrel of oil in terms of other goods) since 1947. OPEC first demonstrated its muscle in 1974: in the aftermath of a war in the Middle East, several OPEC producers limited their output—and they liked the results so much that they decided to continue the practice. Following a second wave of turmoil in the aftermath of Iran's 1979 revolution, prices shot still higher.

By the mid-1980s, however, there was a growing glut of oil on world markets, and cheating by cash-short OPEC members became widespread. The result, in 1985, was that producers who had tried to play by the rules—especially Saudi Arabia, the largest producer—got fed up, and collusion collapsed.

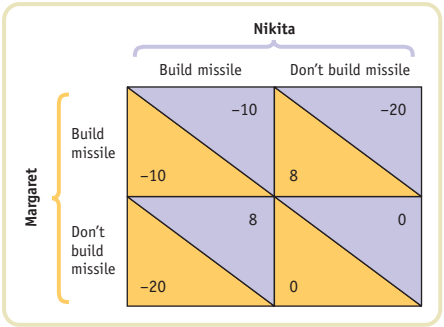
The cartel began to act effectively again at the end of the 1990s, thanks largely to the efforts of Mexico's oil minister to orchestrate output reductions. To assure greater adherence to production targets, OPEC meets very frequently—seven times in 2003 alone—seeking to keep the price of a barrel of oil in the range of $22 to $28. And this discipline appears to be paying off; a decrease of 900,000 barrels per day in late 2003 coupled with rising demand from China and production difficulties in Iraq resulted in oil prices above $28 a barrel in early 2004. ■

>>QUICK REVIEW

- Economists use *game theory* to study firms' behavior when there is *interdependence* between their *payoffs*. The game can be represented with a *payoff matrix*.
- When each firm has an incentive to cheat, but both are worse off if both cheat, the situation is known as *prisoners' dilemma*. This game appears in many contexts. Depending on the payoffs, a player may or may not have a *dominant strategy*.
- Players who fail to take their interdependence into account arrive at a *Nash*, or *noncooperative*, *equilibrium*. But if a game is played repeatedly, players may engage in *strategic behavior*, sacrificing short-run profit to influence future behavior.
- In repeated prisoners' dilemma games, *tit for tat* is often a good strategy, leading to successful *tacit collusion*.
- The *kinked demand curve* illustrates how tacit collusion can make an oligopolist unresponsive to changes in her marginal cost within a certain range when those changes are unique to her.

>>CHECK YOUR UNDERSTANDING 15-3

1. Find the Nash (noncooperative) equilibrium actions of the accompanying payoff matrix. Which actions maximize the total payoff of Nikita and Margaret? Why is it unlikely that they will choose those actions without some communication?



2. Which factors make it more likely that oligopolists will play noncooperatively? More likely that they will engage in tacit collusion? Explain.

a. Each oligopolist expects several new firms to enter the market in the future.

b. It is very difficult for a firm to detect whether another firm has raised output.

c. The firms have coexisted while maintaining high prices for a long time.

Oligopoly in Practice

In Economics in Action on page 000 we described the cartel known as "Vitamins Inc.," which effectively promoted collusion for many years. The conspiratorial dealings of the vitamin makers were not, fortunately, the norm. But how do oligopolies usually work in practice? The answer depends both on the legal framework that limits what companies can do and on the ability of many industries to cooperate without formal agreements.

The Legal Framework

To understand oligopoly pricing in practice, we must be familiar with the legal constraints under which oligopolistic firms operate. In the United States, oligopoly first became an issue during the second half of the nineteenth century, when the growth of railroads—themselves an oligopolistic industry—created a national market for many goods. Large firms producing oil, steel, and many other products soon emerged. The industrialists quickly realized that profits would be higher if they could limit price competition. So many industries formed cartels—that is, they signed formal agreements to limit production and raise prices. Until 1890, when the first legislation against such cartels was passed, this was perfectly legal.

However, although these cartels were legal, they weren't legally *enforceable*—members of a cartel couldn't ask the courts to force a firm that was violating its agreement to reduce its production. And firms often did violate their agreements, for the reason already suggested by our duopoly example: there is always a temptation for each firm in a cartel to produce more than it is supposed to.

In 1881 clever lawyers at John D. Rockefeller's Standard Oil Company came up with a solution—the so-called *trust*. In a trust, shareholders in all the major companies in an industry placed their shares in the hands of a board of trustees, in effect merging the companies into a single firm that could then engage in monopoly pricing. In this way, the Standard Oil Trust established what was essentially a monopoly of the oil industry; it was soon followed by trusts in sugar, whiskey, lead, cottonseed oil, and linseed oil.

Eventually there was a public backlash, driven partly by concern about the economic effects of the trust movement, partly by fear that the owners of the trusts were simply becoming too powerful. The result was the Sherman Antitrust Act of 1890, which was intended both to prevent the creation of more monopolies and to break up existing ones. At first this law went largely unenforced. But over the decades that followed, the federal government became increasingly committed to making it difficult for oligopolistic industries either to become monopolies or to behave like them. Such efforts are known to this day as **antitrust policy.**

Antitrust policy refers to the efforts of the government to prevent oligopolistic industries from becoming or behaving like monopolies.

One of the most striking early actions of antitrust policy was the breakup of Standard Oil in 1911. (Its components formed the nuclei of many of today's large oil companies—Standard Oil of New Jersey became Exxon, Standard Oil of New York became Mobil, and so on.) In the 1980s a long-running case led to the breakup of Bell Telephone, which once had a monopoly of both local and long-distance phone service in the United States.

The details of antitrust policy can be exceedingly complex, especially because corporations can and do fight costly legal battles against decisions they dislike. The core of what antitrust means in practice can, however, be understood by turning, once again, to our lysine example. In that example, there are two obvious ways for the companies to avoid getting trapped in the prisoners' dilemma. One is the solution they actually tried: for the companies to meet with each other to agree to produce less and get higher prices. The other is to eliminate conflict by combining the two companies into one—let one company buy the other, or let them exchange stock and merge.

However, antitrust law makes both of these solutions illegal. If the executives meet to collude on prices, their companies will be fined and they can be sent to jail. If the companies try to merge, the Justice Department or the Federal Trade Commission will tell them that they cannot.

So what's an oligopolist to do?

Tacit Collusion and Price Wars

If a real industry were as simple as our lysine example, it probably wouldn't be necessary for the company presidents to meet or do anything that could land them in jail. Both firms would realize that it was in their mutual interest to restrict output to 30 million pounds each and that any short-term gains to either firm from producing more would be much less than the later losses as the other firm retaliated. So even without any explicit agreement, the firms would probably achieve the tacit collusion needed to maximize their combined profits.

Real industries are nowhere near that simple; nonetheless, in most oligopolistic industries, most of the time, the sellers do appear to succeed in keeping prices above their noncooperative level. Tacit collusion, in other words, is the normal state of oligopoly.

Although tacit collusion is common, however, it rarely allows an industry to push prices all the way up to their monopoly level, because the collusion is usually far from perfect. A variety of factors make it hard for an industry to coordinate on high prices.

Large Numbers Suppose that there were three instead of two firms in the lysine industry and that each was currently producing only 20 million pounds. You can confirm for yourself that in that case any one firm that decided to produce an extra 10 million pounds would gain more in short-term profits—and lose less once another firm responded in kind—than in our original example. The general point is that the more firms there are in an oligopoly, the less is the incentive of any one firm to behave cooperatively, taking into account the impact of its actions on the profits of the other firms.

Complex Products and Pricing Schemes In our lysine example the two firms produce only one product. In reality, however, oligopolists often sell thousands or even tens of thousands of different products. Under these circumstances, keeping track of what other firms are producing and what prices they are charging is difficult. This makes it hard to determine whether a firm is cheating on the implicit agreement.

Differences in Interests In the lysine example, a tacit agreement for the firms to split the market equally is a natural outcome, probably acceptable to both firms. In real industries, however, firms often differ both in their perceptions about what is fair and in their real interests.

For example, suppose that Ajinomoto was a long-established lysine producer and ADM a more recent entrant to the industry. Ajinomoto might feel that it deserved to continue producing more than ADM, but ADM might feel that it was entitled to 50 percent of the business. (A disagreement along these lines was one of the contentious issues in those meetings the FBI was filming.)

Alternatively, suppose that ADM's marginal costs were lower than Ajinomoto's. Even if they could agree on market shares, they would then disagree about the profit-maximizing level of output.

Bargaining Power of Buyers Often oligopolists sell not to individual consumers but to large buyers—other industrial enterprises, nationwide chains of stores, and so on. These large buyers are in a position to bargain for lower prices: they can approach a company, ask for a discount, and warn that they will go to its competitors if they don't get it. One reason that large retailers like Wal-Mart are able to charge lower prices than small-scale operations is precisely their ability to use their size to extract lower prices from their suppliers.

These difficulties in enforcing tacit collusion have sometimes led companies to defy the law and create illegal cartels. We've already examined the cases of the lysine industry and the bulk vitamin industry. An older, classic example was the U.S. electrical equipment conspiracy of the 1950s, which led to the indictment of no less than 40 companies and jail sentences for some executives. The industry was one in which tacit collusion was especially difficult because of all of the reasons mentioned above. There were many firms—40 companies were indicted. They produced a very complex array of products, often more or less custom-built for particular clients. They differed greatly in size, from giants like General Electric to family firms with only a few dozen employees. And the customers in many cases were large buyers like electrical utilities, which would normally try to force suppliers to compete for their business. Tacit collusion just didn't seem practical—so executives met secretly and illegally to decide who would bid what price for which contract.

For Inquiring Minds on page 000 describes yet another price-fixing conspiracy: the one between the very posh auction houses Sotheby's and Christie's.

FOR INQUIRING MINDS

THE ART OF CONSPIRACY

If you want to sell a valuable work of art, there are really only two places to go: Christie's, the London-based auction house, or Sotheby's, its New York counterpart and competitor. Both are classy operations—literally: many of the employees of Christie's come from Britain's aristocracy, and many of Sotheby's come from blue-blooded American families that might as well have titles. They're not the sort of people you would expect to be seeking plea bargains from prosecutors.

But on October 6, 2000, Diana D. Brooks, the very upper-class former president of Sotheby's, pleaded guilty to a conspiracy. With her counterpart at Christie's, she had engaged in the illegal practice of price-fixing—agreeing on the fees they would charge people who sold artwork through either house. As part of her guilty plea, and in an effort to avoid going to jail, she agreed to help in the investigation of her boss, the former chairman of the company.

Why would such upper-crust types engage in illegal practices? For the same reasons that respectable electrical industry executives did the same thing. By definition, no two works of art are alike; it wasn't easy for the two houses to collude tacitly, because it was too hard to determine what commissions they were charging on any given transaction. To increase profits, then, the companies felt that they needed to reach a detailed agreement. They did, and they got caught.

Because tacit collusion is often hard to achieve, most oligopolies charge prices that are well below what the same industry would charge if it were controlled by a single firm—or what they would charge if they were able to collude explicitly. In addition, sometimes collusion breaks down and there is a **price war.** A price war sometimes involves simply a collapse of prices to their noncooperative level; sometimes they even go *below* that level, as sellers try to put each other out of business or at least punish what they regard as cheating.

A **price war** occurs when tacit collusion breaks down and prices collapse.

Product Differentiation and Price Leadership

Lysine is lysine: there was no question in anyone's mind that ADM and Ajinomoto were producing the same good and that consumers would make their decision about which company's lysine to buy based on the price.

In many oligopolies, however, firms produce products that consumers regard as similar but not identical. A $10 difference in the price won't make many customers switch from a Ford to a Chrysler, or vice versa. Sometimes the differences between products are real, like differences between Froot Loops and Wheaties; sometimes, like differences between brands of vodka (which is *supposed* to be tasteless), they exist mainly in the minds of consumers. Either way, the effect is to reduce the intensity of the competition among the firms; consumers will not all rush to buy whichever product is cheapest.

As you might imagine, oligopolists welcome the extra market power that comes when consumers think that their product is different from that of competitors. So in many oligopolistic industries, firms make considerable efforts to create the perception that their product is different—that is, they engage in **product differentiation.**

Firms engage in **product differentiation** when they try to convince buyers that their product is different from the products of other firms in the industry.

A firm that tries to differentiate its product may do so by altering what it actually produces, adding "extras," or choosing a different design. It may also use advertising and marketing campaigns to create a differentiation in the minds of consumers, even though its product is more or less identical to the products of rivals.

A classic case of how products may be perceived as different even when they are really pretty much the same is over-the-counter medication. For many years there were only three widely sold pain relievers—aspirin, ibuprofen, and acetaminophen. Yet these generic pain relievers were marketed under a number of brand names, each brand using a marketing campaign implying some special superiority (one classic slogan was "contains the pain reliever doctors recommend most"—that is, aspirin).

Whatever the nature of product differentiation, oligopolists producing differentiated products often reach a tacit understanding not to compete on price. For example, during the years when the great majority of cars sold in the United States were produced by the Big Three auto companies, there was a sort of unwritten rule that none of the three companies would try to gain market share by making its cars noticeably cheaper than those of the other two.

But then who would decide on the overall price of cars? The answer was normally that General Motors, the biggest of the three, would announce its prices for the year first; then the other companies would match it. This pattern of behavior, in which some company tacitly sets prices for the industry as a whole, is known as **price leadership.**

In **price leadership,** one firm sets its price first, and other firms then follow.

Interestingly, firms that have a tacit agreement not to compete on price often engage in vigorous **nonprice competition**—adding new features to their products, spending large sums on ads that proclaim the inferiority of their rivals' offerings, and so on.

Firms that have a tacit understanding not to compete on price often engage in intense **nonprice competition,** using advertising and other means to try to increase their sales.

Perhaps the best way to understand the mix of cooperation and competition in such industries is with a political analogy. During the long Cold War between the United States and the Soviet Union, the two countries engaged in intense rivalry for global influence. They not only provided financial and military aid to their allies; they sometimes supported forces trying to overthrow governments allied with their rival (as the Soviet Union did in Vietnam in the 1960s and early 1970s, and as the United States did in Afghanistan from 1979 until the collapse of the Soviet Union in 1991). They even sent their own soldiers to support allied governments against rebels (as the United States did in Vietnam and the Soviet Union did in Afghanistan). But they did *not* get into direct military confrontations with each other; open warfare between the two superpowers was regarded by both as too dangerous—and tacitly avoided.

Price wars aren't as serious as shooting wars, but the principle is the same.

economics in action

Air Wars

The first time Robert Crandall, then CEO of American Airlines, tried to collude on prices, he was blunt: in 1983 he called the head of rival Braniff (now defunct) and proposed in so many words (many of them unprintable) that the two airlines both raise fares 20 percent. Alas for Crandall, the conversation was being taped.

Eight years later, Crandall tried a more legal approach: declaring himself a "statesman," he raised American's fares in the hopes that rivals would follow suit. But they didn't, and the airline lost many passengers.

On both occasions the airline industry was in the midst of a price war. Indeed, price wars—in which fares fall 50 percent or more for a time, then soar again—are something of an industry specialty.

Why are airlines so prone to price wars? There are at least three reasons, all bearing on the problems of tacit collusion we have just discussed. First, although each airline tries to differentiate its product, creating a perception among consumers that it offers better service, most fliers choose airlines on the basis of schedule and price—period. So competition is intense. Second, airline pricing is complex: as discussed in Chapter 14, airlines engage in complex price-discrimination schemes that make it hard to figure out when tacit collusion is being broken. Finally, airlines differ in their interests: many of the most severe price wars have been set off by attempts of a new competitor to break into established markets. ■

>>QUICK REVIEW

- Oligopolies operate under legal restrictions in the form of *antitrust policy*. But many succeed in achieving tacit collusion.
- Tacit collusion is limited by a number of factors, including large numbers of firms, complex pricing, and conflicts of interest among firms. When collusion breaks down, there is a *price war*.
- To limit competition, oligopolists often try to achieve *product differentiation*. When products are differentiated, it is sometimes possible for an industry to achieve tacit collusion through *price leadership*.
- Oligopolists often avoid competing directly on price, engaging in *nonprice competition* through advertising and other means instead.

>>CHECK YOUR UNDERSTANDING 15-4

1. Which of the following factors are likely to be interpreted by government regulators as evidence of collusion? Which are not? Explain.
   a. For many years the price in the industry has changed infrequently, and all the firms in the industry charge the same price. The largest firm publishes a catalog containing a "suggested" retail price. Changes in price coincide with changes in the catalog.
   b. There has been considerable variation in the market shares of the firms in the industry over time.
   c. Firms in the industry build into their products unnecessary features that make it hard for consumers to switch from one company's products to another's.
   d. Firms meet yearly to discuss their yearly sales forecasts.
   e. Firms tend to adjust their prices upward at the same times.

How Important Is Oligopoly?

We have seen that many industries are characterized neither by monopoly nor by perfect competition, but by the small-group competition known as oligopoly. When we try to analyze oligopoly, the economist's usual way of thinking—asking how self-interested individuals would behave, then analyzing their interaction—does not work as well as we might hope, because we do not know whether rival firms will engage in noncooperative behavior or manage to engage in some kind of collusion. Given the prevalence of oligopoly, then, is the analysis we developed in earlier chapters, which was based on perfect competition, still useful?

The conclusion of the great majority of economists is yes. For one thing, important parts of the economy are fairly well described by perfect competition. And even though many industries are oligopolistic, in many cases the limits to collusion keep prices relatively close to marginal costs—in other words, the industry behaves "almost" as if it were perfectly competitive.

It is also true that predictions from supply and demand analysis are often valid for oligopolies. For example, in Chapter 4 we saw that price controls will produce shortages. Strictly speaking, this conclusion is certain only for perfectly competitive industries. But in the 1970s, when the U.S. government imposed price controls on the definitely oligopolistic oil industry, the result was indeed to produce shortages and lines at the gas pumps.

So how important is it to take account of oligopoly? Most economists adopt a pragmatic approach. As we have seen in this chapter, the analysis of oligopoly is far more difficult and messy than that of perfect competition; so in situations where they do not expect the complications associated with oligopoly to be crucial, economists prefer to adopt the working assumption of perfectly competitive markets. They always keep in mind the possibility that oligopoly might be important; they recognize that there are important issues, from antitrust policies to price wars, where trying to understand oligopolistic behavior is crucial.

We will follow the same approach in the chapters that follow.

• A LOOK AHEAD •

We're not yet done with our investigation of market structures other than perfect competition. There are quite a few industries that don't seem to fit either the definition of oligopoly or the definition of perfect competition. Consider, for example, the restaurant business. There are many restaurants, so it's not an oligopoly. But restaurants aren't price-takers, like wheat farmers, so it's not perfectly competitive. What is it?

The answer lies in the next chapter, which turns to the concept of *monopolistic competition*.

SUMMARY

1. Many industries are **oligopolies:** there are only a few sellers. In particular, a **duopoly** has only two sellers. Oligopolies exist for more or less the same reasons that monopolies exist, but in weaker form. They are characterized by **imperfect competition:** firms compete but possess market power.
2. Predicting the behavior of **oligopolists** poses something of a puzzle. The firms in an oligopoly could maximize their combined profits by acting as a **cartel,** setting output levels for each firm as if they were a single monopolist; to the extent that firms manage to do this, they engage in **collusion.** But each individual firm has an incentive to produce more than it would in such an arrangement—to engage in **noncooperative behavior.** Informal collusion is likely to be easier to achieve in industries in which firms face capacity constraints.
3. The situation of **interdependence,** in which each firm's profit depends noticeably on what other firms do, is the subject of **game theory.** In the case of a game with two players, the **payoff** of each player depends both on its own actions and on the actions of the other; this interdependence can be represented as a **payoff matrix.** The structure of payoffs in the payoff matrix determines whether or not a player has a **dominant strategy** in a game.
4. **Duopolists** face a particular type of game known as a **prisoners' dilemma;** if each acts independently in its own interest, the resulting **Nash equilibrium** or **noncooperative equilibrium** will be bad for both. However, firms that expect to play a game repeatedly tend to engage in **strategic behavior,** trying to influence each other's future actions. A particular strategy that seems to work well in such situations is **tit for tat,** which often leads to **tacit collusion.**
5. The **kinked demand curve** illustrates how an oligopolist who faces unique changes in her marginal cost within a certain range may choose not to adjust her output and price in order to avoid a breakdown in tacit collusion.
6. In order to limit the ability of oligopolists to collude and act like monopolists, most governments pursue an **antitrust policy** designed to make collusion more difficult. In practice, however, tacit collusion is widespread.
7. When tacit collusion breaks down, there is a **price war.** Oligopolists try to avoid price wars in various ways, such as through **product differentiation** and through **price leadership,** in which one firm sets prices for the industry. Another is through **nonprice competition,** which uses less dangerous ways of increasing sales, like advertising.

KEY TERMS

Oligopoly, p. 364
Oligopolist, p. 364
Imperfect competition, p. 364
Duopoly, p. 366
Duopolist, p. 366
Collusion, p. 367
Cartel, p. 367
Noncooperative behavior, p. 368
Interdependence, p. 371
Game theory, p. 371
Payoff, p. 371
Payoff matrix, p. 371
Prisoners' dilemma, p. 372
Dominant strategy, p. 373
Nash equilibrium, p. 373
Noncooperative equilibrium, p. 373
Strategic behavior, p. 374
Tit for tat, p. 374
Tacit collusion, p. 376
Kinked demand curve, p. 377
Antitrust policy, p. 379
Price war, p. 381
Product differentiation, p. 382
Price leadership, p. 382
Nonprice competition, p. 382

PROBLEMS

1. The accompanying table shows the demand schedule for vitamin D. Suppose that the marginal cost of producing vitamin D is zero.

Price of vitamin D (per ton)	Quantity of vitamin D demanded (tons)
$8	0
7	10
6	20
5	30
4	40
3	50
2	60
1	70

   a. Suppose that BASF is the only producer of vitamin D and acts as a monopolist. It currently produces 40 tons of vitamin D at $4 per ton. If BASF were to produce 10 tons more, what would be the price effect for BASF? What would be the quantity effect? Would BASF therefore have an incentive to produce those 10 additional tons?

   b. Now suppose that Roche enters the market by also producing vitamin D and the market is now a duopoly. BASF and Roche agree to produce 40 tons of vitamin D in total, 20 tons each. BASF cannot be punished for deviating from the agreement with Roche. If BASF, on its own, were to deviate from that agreement and produce 10 tons more, what would be the price effect for BASF? What would be the quantity effect for BASF? Would BASF have an incentive to produce those 10 additional tons?

2. The market for olive oil in New York City is controlled by two families, the Sopranos and the Contraltos. Both families will ruthlessly eliminate any other family that attempts to enter the New York City olive oil market. The marginal cost of producing olive oil is constant and equal to $40 per gallon. There is no fixed cost. The accompanying table gives the market demand schedule for olive oil.

Price of olive oil (per gallon)	Quantity of olive oil demanded (gallons)
$100	1,000
90	1,500
80	2,000
70	2,500
60	3,000
50	3,500
40	4,000
30	4,500
20	5,000
10	5,500

   a. Suppose the Sopranos and the Contraltos form a cartel. Calculate the total revenue for their cartel and the marginal revenue for each additional gallon. How many gallons of olive oil would the cartel sell in total and at what price? The two families share the market equally (each produces half of the total output of the cartel). How much profit does each family make?

   b. Uncle Junior, the head of the Soprano family, breaks the agreement and sells 500 more gallons of olive oil than under the cartel agreement. Assuming the Contraltos maintain the agreement, how does this affect the price for olive oil and the profits earned by each family?

   c. Anthony Contralto, the head of the Contralto family, decides to punish Uncle Junior by increasing his sales by 500 gallons as well. How much profit does each family earn now?

3. In France, the market for bottled water is controlled by two large firms, Perrier and Evian. Each firm has a fixed cost of 1 euro and marginal cost of 2 euros per liter of bottled water. The accompanying table gives the market demand schedule for bottled water in France.

Price of bottled water (euros per liter)	Quantity of bottled water demanded (liters)
10	0
9	1
8	2
7	3
6	4
5	5
4	6
3	7
2	8
1	9

   a. Suppose the two firms form a cartel and act as a monopolist. Calculate marginal revenue for the cartel. What will the monopoly price and output be? Assuming the firms divided the output evenly, how much will each produce and what will each firm's profits be?

   b. Now suppose Perrier decides to increase production by 1 liter. Evian doesn't change its production. What will the new market price and output be? What is Perrier's profit? What is Evian's profit?

   c. What if Perrier increases production by 3 liters? Evian doesn't change its production. What would its output and profits be relative to those in part b?

   d. What do your results tell you about the likelihood of cheating on such agreements?

4. To preserve the North Atlantic fish stocks, it is decided that only two fishing fleets, one from the United States and the

other from the European Union (EU) can fish in those waters. The accompanying table shows the market demand schedule per week for fish from these waters. All the costs are fixed costs, so fishing fleets maximize revenue.

Price of fish (per pound)	Quantity of fish demanded (pounds)
$17	1,800
16	2,000
15	2,100
14	2,200
12	2,300

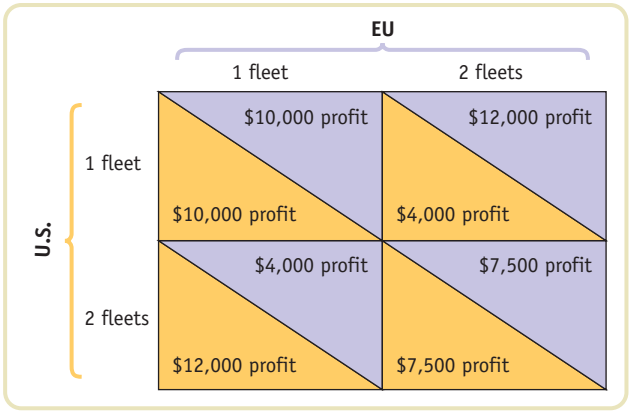
a. If both fishing fleets collude, what is the revenue-maximizing output for the North Atlantic fishery? What price will a pound of fish sell for?

b. If both fishing fleets collude and share the output equally, what is the revenue to the EU fleet? to the U.S. fleet?

c. Suppose the EU fleet cheats by expanding its own catch by 100 pounds per week. The U.S. fleet doesn't change its catch. What is the revenue to the U.S. fleet? to the EU fleet?

d. In retaliation for the cheating by the EU fleet, the U.S. fleet also expands its catch by 100 pounds per week. What is the revenue to the U.S. fleet? to the EU fleet?

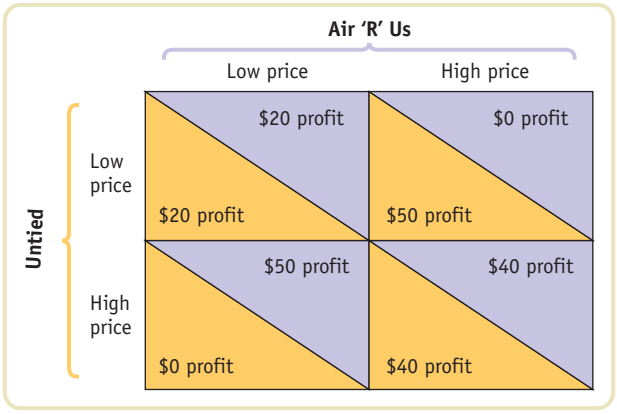
5. The fisheries agreement in Problem 4 breaks down, so that the fleets behave noncooperatively. Assume that the U.S. and the EU each can send out either one or two fleets. Also assume that the more fleets in the area, the more fish they catch in total but the lower the catch of each fleet. The accompanying matrix shows the profit (in dollars) per week earned by the two sides.



a. What is the noncooperative Nash equilibrium? Will each side choose to send out one or two fleets?

b. Suppose the fish stocks are depleting. Each region considers the future when they will both be fishing these waters and come to a "tit-for-tat" agreement whereby each side will send only one fleet out as long as the other does the same. If either of them breaks the agreement and sends out a second fleet, the other will also send out two and will continue to do so until its opposite sends out only one fleet. If both play this "tit-for-tat" strategy, how much profit will each make every week?

6. Untied and Air 'R' Us are the only two airlines operating flights between Collegeville and Bigtown. That is, they operate in a duopoly. Each airline can charge either a high price or a low price for a ticket. The accompanying matrix shows their payoffs, in profits per seat (in dollars), for any choice that the two airlines can make.



a. Suppose the two airlines play a one-shot game—that is, they interact only once and never again. What will be the Nash (noncooperative) equilibrium in this one-shot game?

b. Now suppose the two airlines play this game twice. And suppose each airline can play one of two strategies: it can play either "always charge the low price" or "tit for tat"—that is, it starts off charging the high price in the first period, and then in the second period it does whatever the other airline did in the previous period. Write down the payoffs to Untied from the following four possibilities:

i. Untied plays "always charge the low price" when Air 'R' Us also plays "always charge the low price."

ii. Untied plays "always charge the low price" when Air 'R' Us plays "tit for tat."

iii. Untied plays "tit for tat" when Air 'R' Us plays "always charge the low price."

iv. Untied plays "tit for tat" when Air 'R' Us also plays "tit for tat."

7. Suppose that Coke and Pepsi are the only two producers of cola drinks, so that they operate in a duopoly. Both companies have zero marginal cost and a fixed cost of $100,000.

a. Assume first that consumers regard Coke and Pepsi as identical products. Currently both are sold for $0.20 per can, and at that price each company sells 4 million cans per day.

i. How large is Pepsi's profit?

ii. If Pepsi were to raise its price to $0.30 cents per can, what would happen to its profit?

b. Now suppose that each company advertises to differentiate its product from the other company's. As a result of advertising, Pepsi realizes that if it raises or lowers its

price, it will sell less or more of its product, as shown by the demand schedule in the accompanying table.

Price of Pepsi (per can)	Quantity of Pepsi demanded (millions of cans)
$0.10	5
0.20	4
0.30	3
0.40	2
0.50	1

If Pepsi now were to raise its price $0.30 per can, what would happen to its profit?

b. Comparing your answer to part a(i) and to part b, what is the maximum amount Pepsi would be willing to spend on advertising?

8. Philip Morris and Reynolds spend huge sums of money each year to advertise their tobacco products in an attempt to steal customers from each other. Suppose each year Philip Morris and Reynolds have to decide whether or not they want to spend money on advertising. If neither firm advertises, each will earn a profit of $2 million. If they both advertise, each will earn a profit of $1.5 million. If one firm advertises and the other does not, the firm that advertises will earn a profit of $2.8 million and the other firm will earn $1 million.

a. Use a payoff matrix to depict this problem.

b. Suppose Philip Morris and Reynolds can write a binding contract about what they will do. What is the cooperative solution to this game?

c. What is the Nash equilibrium? Explain why this is the likely outcome in the absence of any binding agreement.

9. Over the last 30 years the Organization of Petroleum Exporting Countries (OPEC) has had varied success in forming and maintaining its cartel agreements. Explain how the following factors may contribute to the difficulty of forming and/or maintaining its price and output agreements.

a. New oil fields are discovered and increased drilling is undertaken in the Gulf of Mexico and the North Sea by nonmembers of OPEC.

b. Crude oil is a product that is differentiated by sulfur content: it costs less to refine low-sulfur crude oil into gasoline. Different OPEC countries possess oil reserves of different sulfur content.

c. Cars powered by hydrogen are developed.

10. Suppose you are an economist working for the Antitrust Division of the Department of Justice. You are given the task of determining whether or not three firms in a particular industry are guilty of forming a collusive agreement. However, there is no direct evidence that these firms formed any explicit agreements. You are provided with the following facts. Assess each of them and explain whether or not it supports the allegation of collusive behavior.

a. The three firms in the industry have market shares of 45%, 20%, and 15%. There are many other firms in the industry, but each of them has no more than a 2% share of the market.

b. Last year when the largest firm announced a price increase of 16%, the other two major firms increased their prices to the same level within a day.

c. Each firm sells a differentiated product.

d. Each of the three firms advertises that it will match the lowest price of any of the other firms in the industry.

11. The industry for small, single-engine airplanes is oligopolistic, and it has achieved tacit collusion. Each firm currently sells 10 airplanes at a price of $200,000 each. Each firm believes that it will sell 1 fewer airplane if it raises the price by $5,000. And each firm also believes that it can sell 1 more airplane if it lowers the price by $10,000. That is, each firm has a kinked demand curve.

a. How much additional revenue will a firm generate if it produces 1 more (the 11th) airplane?

b. How much revenue will a firm lose if it produces 1 fewer airplane?

c. If the marginal cost of producing an airplane is $120,000, how many airplanes will each firm produce, and at what price?

d. If the marginal cost of producing an airplane is $140,000, how many airplanes will each firm produce, and at what price?

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