factor ρ^*. Take our Bertrand model[11] and assume that there are n identical firms in the market. Each has profit π_m/n per period if it participates in the cartel and one-off total monopoly profit π_m if it deviates. Deviation is not profitable, therefore, if

$$\frac{\pi_m}{n}(1+\rho+\rho^2+\ldots)=\frac{\pi_m}{n(1-\rho)}>\pi_m \Rightarrow \frac{1}{n}>1-\rho \Rightarrow \rho(n)>1-\frac{1}{n} \qquad (14.8)$$

Note that if $n=2$, equation (14.8) gives the critical probability adjusted discount factor $\rho^*(2)=0.5$ found earlier. If, by contrast, $n=4$ we have $\rho^*(4)=0.75$ and if $n=10$ we have $\rho^*(10)=0.9$. The intuition is easy to see. A firm in the cartel has to share the cooperative profits with other cartel members. As a result, the returns to collusion fall as the number of cartel members increases. By contrast, the returns to deviation typically do not decrease with n. Deviation is, in other words, more profitable as industry concentration falls, i.e., as n increases.

Hay and Kelley (1974) provide compelling support for this proposition that successful cartels are more likely in concentrated industries. Their analysis of the prosecutions of sixty-two cartels by the US Department of Justice from 1963–1972 is summarized in Table 14.4 below. These data show a direct correlation between the four-firm concentration ratio and the likelihood of cartel formation.[12]

Significant Entry Barriers

Easy entry undermines collusion because one of two things must happen when a new firm enters a cartelized market. Either the entrant does not join the cartel and then is free to compete against the cartel members forcing them to act more competitively, or the entrant joins the cartel so that the cooperative profits must now be shared across more members. In either case, the profitability of the cartel and therefore the motivation to maintain cooperative behavior is diminished.

Frequent and Regular Orders

An industry in which firms receive infrequent orders will not be one conducive to price-fixing. When orders are infrequent, it takes longer to punish a firm that cheats on the

Table 14.4 Cartels and industry concentration

Number of Conspirators	2	3	4	5	6	7	8	9	10	11–15	16–20	21–25	> 25	Total
Number of Cases	1	7	8	4	10	4	3	5	7	5	2	–	6	62
Trade Association	–	–	1	–	4	1	–	1	3	1	1	–	6	18

	Four–Firm Concentration Ratios				
Concentration (percentage)	0–25%	25–50%	51–75%	76–100%	Total
Number of Cases	3	9	17	21	50

Source: Hay and Kelley (1974)

[11] In the exercises, you are asked to conduct the same analysis for Cournot competitors.

[12] Concentration ratios were available for only fifty of these cartels. We comment on the importance of trade associations below. See also Posner (1970).

Reality Checkpoint

European Cartel Was, Like, Totally Tubular!

As noted in the text, the €1.5 billion fine imposed by the European Commission in December 2012 is the largest single price-fixing fine ever imposed by the Commission and the firms involved include some of world's largest electronics firms, such as LG Electronics, Philips, Samsung, Panasonic, and Toshiba. Contrary to our suggestion that market growth facilitates collusion, the cartels in this case were formed to manage a declining market, namely, the market for old-fashioned cathode ray tubes (CRT) used in TVs and computer monitors before the advent of plasma and liquid crystal display technologies. While the market for CRT tubes was still strong in 1996 when the cartel was first started, it went into decline in 2000–2001 in the wake of a general recession and the growing use of the newer display technologies. Nevertheless, the cartel survived for at least another five years and likely would have lasted longer had the Commission not begun unannounced inspections of the companies' offices and documents in 2007.

The success of the two cartels is likely due to the high degree of organization each exhibited. For the ten years of their operation, officials from each firm met regularly to fix prices, allocate market shares and specific customers, set capacity and output levels at each firm, and exchange other sensitive information. The colluders also carefully monitored each member's compliance with the agreement by reviewing production and sales at each firm and even by visiting each other's plants to insure production capacity was being held in check.

These implementation meetings also reflected the deep involvement of almost all management officials in a carefully orchestrated hierarchy of regular meetings. Top officials would meet regularly to set the main points of the agreements at golf events that to the outside eye might appear to be benign social get-togethers. Conspirators therefore referred to these top-level meetings as "green(s) meetings." This distinguished them from the meetings of lower-level management held to implement the agreements, referred to as "glass meetings," and that were held on a much more frequent monthly and sometimes even weekly basis in both Asia and Europe.

Participants in both "greens" and "glass" meetings clearly knew what they were about and that it was illegal. One uncovered document reviewing the price-setting discussion included the mandate that: "*producers need to avoid price competition through controlling their production capacity*." Another document began with the explicit warning that: "*Everybody is requested to keep this a secret as it would be serious damage if it is open to customers or European Commission*," and many documents included the instruction: "*Please dispose the following document after reading it*."

As noted, the fines imposed are the largest the European Commission has ever levied as a price-fixing punishment. However, unlike the United States, the European Commission has no ability to level criminal charges against specific individuals and seek personal fines or imprisonment against them. Many lawyers and public policy experts consider this a major weakness in the European system.

Source: J. Kanter, "Europe Fines Electronics Makers $1.92 Billion," *New York Times* 5 December 2012, B3; and European Commission Press Release, Antitrust, "Commission Fines Producers of TV and Computer Monitor Tubes € 1.47 Billion for Two Decade-Long Cartels," http://europa.eu/rapid/press-release_IP-12-1317_en.htm, December 5, 2012.

cartel agreement and this obviously makes cheating more attractive. The math behind this intuition is straightforward. The critical discount factor ρ^* is a per period discount factor (day, week, month ...) that can be converted into an annual discount factor if we know the relevant time period. The longer the time between orders, the higher the critical factor will be. Imagine, for example, that orders are monthly and $\rho^* = 0.9$. This is equivalent to an annual discount factor of $0.9^{12} = 0.28$. By contrast, if the period between orders is six months, then the annual discount factor is $0.9^2 = 0.81$. Simply put, less frequent orders implies that it takes longer to detect and punish a firm that cheats on the cartel agreement.

Irregularly sized orders also hamper collusive efforts. Take our Bertrand case, but suppose that in the current period ($t = 0$) a large order is received that has profit $\lambda\pi_m$, with $\lambda > 1$, while all later profits are expected to return to π_m per period. A slightly modified equation (14.8) gives the condition for the cartel to be self-sustaining in the face of this large order:

$$\frac{\pi_m}{n}(\lambda + \rho + \rho^2 + \ldots) = \frac{\pi_m}{n}\left(\lambda + \frac{\rho}{(1-\rho)}\right) > \lambda\pi_m \Rightarrow \lambda + \frac{\rho}{(1-\rho)} > \lambda n \qquad (14.9)$$

Solving this for ρ gives the critical probability-adjusted discount factor

$$\rho^*(\lambda, n) = \frac{\lambda(n-1)}{1 + \lambda(n-1)} \qquad (14.10)$$

Suppose that $n = 2$ and $\lambda = 1$ (no large orders). Then we have the earlier Bertrand condition that the probability-adjusted discount factor necessary for collusion must exceed $\rho(1, 2) = 0.5$. If, by contrast, $n = 2$ and $\lambda = 2$, then the critical discount factor necessary for collusion is $\rho > \rho(2, 2) = 2/3$. From equation (14.10), it is easy to show that the critical discount factor $\rho^*(\lambda, n)$ is increasing in the parameter λ. Again, the intuition is clear. The temptation to "steal" the profits from a one-time extra large order can be sufficiently great to undermine what otherwise would have been a successful cartel.[13]

Rapid Market Growth

Cartels are more likely to be sustainable in growing markets and more likely to be unstable in declining markets. Once again, the intuition is simple to see. Take the case where the market is expected to grow over time. Deviation "early" in the market's growth generates profits as usual but now runs the risk of sacrificing the larger profits that the cartel will generate as the market grows. The opposite argument applies, of course, if the market is expected to decline over time. In this case, there is a stronger temptation to cheat and get out now while the gains from doing so are reasonably good.

Technological or Cost Symmetry

Symmetry among industry firms in terms of technology and costs is another market feature that can support cartel formation. Our earlier analysis suggests one reason why this should be the case. When two firms have different costs it will be more difficult to formulate a collusive agreement that they both find satisfactory. A firm is more able to formulate a collusive agreement with a firm that "looks like" it does rather than one that does not. In

[13] The same argument applies regarding demand uncertainty. With random demand, there will occassionally be a positive demand shock and this is essentially equivalent to a large unexpected order.

addition, detailed negotiations over prices and market shares are much more straightforward when firms are similar.

To see this point more formally, think of a Bertrand model in which each firm has a marginal cost that rises with its output. At any price set by the cartel, the firms whose marginal cost rises fastest will have the smallest output in the cartelized equilibrium. Let there be n firms in the cartel and denote the profit of firm i as firm i's share s_i times the total industry profit π_m, i.e., as $s_i\pi_m$, we can number the firms in decreasing order of their profit shares, so that $s_1 \geq s_2 \geq s_3 \geq \ldots \geq s_i \geq \ldots \geq s_n$ with, of course $s_1 + s_2 + \ldots + s_n = 1$. For firm i to be willing to remain in the cartel the condition is:

$$s_i\pi_m(1 + \rho + \rho^2 + \ldots) = \frac{s_i\pi_m}{(1-\rho)} > \pi_m \Rightarrow s_i > 1 - \rho \Rightarrow \rho(s_i) > 1 - s_i \qquad (14.11)$$

If all the firms have equal profit shares $s_i = 1/n$ this simplifies to our "standard" Bertrand case of equation (14.8). By contrast, when profit shares are different, the firm with the lowest profit share determines the binding probability-adjusted discount factor used in equation (14.11). The smaller the share of the smallest firm, the higher that discount factor has to be for collusion to be sustainable.

Multi-Market Contact

The fact that the same firms in an industry meet many times, i.e., the fact that the game is repeated, is perhaps the crucial element facilitating collusion. It is therefore tempting to suspect that a similar force is at work when rival firms compete in several distinct markets. That is, competing against the same set of rivals in many markets at one point in time is similar in some respect to competing against the same set of rivals in one market over several periods. Cheating in one period risks punishment and the loss of cartel profits in many subsequent periods, whereas cheating in one market could risk punishment and the loss of cartel profits in the other markets. This intuition would suggest that multi-market contact should again be a feature that facilitates collusion.

Unfortunately, the foregoing intuition is somewhat misleading because time is in fact different from space. In the multi-market case a firm can cheat on all of its collusive arrangements across different markets at the same point in time whereas it requires the passage of time to cheat across different time periods. Nevertheless our intuition may well be correct when the colluding firms have asymmetric market shares in the different markets in which they compete.[14]

For example, suppose that two firms A and B each operate in two markets, 1 and 2. Let aggregate cartel profits in each market be π_m per period. The profit share for firm A in each of these markets is s_{A1} and s_{A2}, respectively, and we assume that $s_{A1} > 1/2$ while $s_{A2} < 1/2$. Hence, for firm B $s_{B1} = 1 - s_{A1} < 1/2$ and $s_{B2} = 1 - s_{A2} > {}^1\!/_2$. In other words, firm A is the "large" firm in market 1 and firm B is the "large" firm in market 2. As an example, A might be a US firm and B a European firm with market 1 being the US and market 2 being the EU. To keep matters simple, further assume that the two firms have the same time preferences and the same discount rates. In other words, they have the same probability-adjusted discount factors. Finally, assume that in each market competition, if it occurs, is in prices (Bertrand).

[14] See Bernheim and Whinston (1990) for a more complete analysis of this insight.

If we treat the two markets separately, we know from our discussion in the previous section that collusion is sustainable in market 1 only if the probability-adjusted discount factor for each firm is greater than $1 - s_{B1} > 1/2$ and in market 2 only if the probability-adjusted discount factor for each firm is greater than $1 - s_{A2} > 1/2$. Now consider the two markets together. Take firm A. Firm A knows that if it deviates from the collusive agreement in either market then it will be punished in both. If firm A is contemplating deviation it should deviate in both markets. In these circumstances, for deviation *not* to be profitable it must be that:

$$(s_{A1} + s_{A2})\pi_m(1 + \rho + \rho^2 + \ldots) = \frac{(s_{A1} + s_{A2})\pi_m}{(1 - \rho)} \geq 2\pi_m$$

$$\Rightarrow (s_{A1} + s_{A2}) > 2(1 - \rho) \Rightarrow \rho(s_{A1}, s_{A2}) \geq 1 - \frac{(s_{A1} + s_{A2})}{2} \tag{14.12}$$

The analogous result applies for firm B: $\rho(s_{B1}, s_{B2}) \geq 1 - \frac{(s_{B1} + s_{B2})}{2}\rho(s_{B1}, s_{B2}) \geq 1 - \frac{(s_{B1} + s_{B2})}{2}$.

To see the point about multi-market contact let's make it simple and suppose that firm A has profit share $s_{A1} = s$ in market 1 and $1 - s$ in market 2, with $s > 1/2$ to reflect asymmetric positions. Analogously, firm B has profit share $s_{B1} = 1 - s$ in market 1 and s in market 2. From (14.12) the cartel between firms A and B is sustainable when they operate in both markets for any probability-adjusted discount factor greater than or equal to 1/2 (which is the standard Bertrand result again). However, the probability adjusted discount factor would have to be greater than s, which by assumption is greater than 1/2, if the firms collaborate in only one market. Multi-market contact can then support cooperation. What is necessary is first, that the colluding firms have asymmetric positions in the markets in which they jointly operate and second, that the asymmetry is reduced when all the markets in which they compete our considered. In our example, each firm had a share in excess of 1/2 in any one market. However, aggregated across both markets each firm has a share of 1/2.

Product Homogeneity

The empirical evidence reported in Hay and Kelley (1974) and the conventional wisdom of government authorities and the courts is that collusion is easier to sustain when the cartel members produce homogeneous or nearly homogeneous products. Again, there is an intuitive basis for this finding that stems from the complexity of the cartel agreement. First, homogeneous products implies that a price-fixing cartel has to set and monitor only one price, while by contrast, collusion in pricing differentiated products requires agreeing on and monitoring a different price for each product. This raises a second issue. Setting such a set of distinct prices when the products are differentiated requires that the cartel members agree on just how much differentiation there really is. This is a far from simple matter especially as its resolution will largely determine each firm's share of the cartel profits. Thirdly, punishment of deviation becomes more complex in a differentiated products context. Should all non-deviating firms punish a deviant or should punishment be confined to those whose products are the closest substitutes to the deviant's product? If the latter, can punishment be targeted to affect only the deviant firm or will there be spillover effects to other members of the cartel?

It should be noted, however, that there is a potential advantage to product differentiation for cartel sustainability. When the cartel members sell differentiated brands, each of which has substantial brand loyalty, then the temptation to cheat falls. If consumers exhibit considerable loyalty to their favorite brand then a deviant firm will find it hard to win much business even when it secretly cuts its price. However, the weight of the evidence suggests that cartels will be more successful—and therefore more likely—when they offer fairly homogenous products.

Other Factors

Several other important factors facilitate the formation and continuation of cartel agreements. Monitoring the cartel agreement is easier when prices are *observable*. Factors that facilitate a cartel's task of monitoring its members and responding to transgressions swiftly therefore favor collusion. Regulations that require government agencies to publish the bids they have received assist price monitoring by bid-rigging cartels. On private sector contracts, a *trade association* among the companies can help to facilitate collusive bidding behavior. The Hay and Kelley study noted above (Table 14.4) provides evidence of the importance of such trade associations in sustaining "large number" cartels.

In many consumer product markets *most-favored-customer* and *meet-the-competition clauses* can help to maintain a price-fixing agreement among firms.[15] *Most-favored-customer clauses* guarantee that if the seller offers the same product to another buyer at a lower price, the first buyer will receive a rebate equal to the difference in the two prices, whereas *meet-the-competition clauses* guarantee that a firm will match any lower price offered by another seller. It might seem surprising to think of these clauses as being anti- rather than pro-competitive but a moment's thought should indicate how they each can work to maintain cartel discipline.

The *most-favored-customer clause* severely restricts the temptation of any seller to reduce its price because the price reduction has to be offered to all previous buyers as well. Similarly, *meet-the-competition clauses* make the process of detecting cheating particularly effective, because now the firms offering these guarantees have vast numbers of unpaid market watchers in the person of every consumer who has bought the product. At the same time, such clauses effectively bind the hands of the firms that offer them.

If meet-the-competition clauses have anticompetitive effects why are consumers lured by such guarantees? A price-matching clause is valuable to any one buyer who is assured of getting the very best deal possible. However, because that buyer then becomes implicitly a monitor of prices on behalf of the colluding firms, there is an externality to the buyer's purchase of which the buyer may be unaware. Moreover, such monitoring will lead to prices being set higher (albeit identical) for all consumers. So, in fact, the equilibrium outcome will be one in which all buyers are worse off.

Meet the competition clauses can also strengthen the trigger strategies that support collusive behavior among firms. To get some idea as to just how powerful this effect can be, consider a simple one-period pricing game between two firms. The payoff matrix shown in Table 14.5 describes this prisoners' dilemma game. The one-shot nature of the game leads the firms to the only Nash equilibrium in which both firms price low. Now consider what happens when we permit both firms to publish meet-the-competition guarantees that are

[15] See Salop (1986) for more details on these competition clauses.

Table 14.5 Pay-off matrix for a 2x2 pricing game

		Strategy for Firm 2	
		Price High	Price Low
Strategy for Firm 1	Price High	(12, 12)	(5, 14)
	Price Low	(14, 5)	(6, 6)

legally and instantaneously binding.[16] These guarantees render the off-diagonal price pairs in Table 14.5 unattainable. There is no opportunity to undercut one's cartel partner when each firm has announced a meet-the-competition policy that goes into effect immediately. Because the combinations of one firm pricing low and the other firm pricing high are unattainable, neither firm has any incentive to deviate from the Price High policy. The cartel works even in this simple one-period setting.

One way for a cartel in an unstable market to reinforce the trigger strategy is to establish a *centralized sales agency*, as in the famous De Beers diamond cartel, or a trade association. Either institutional arrangement can monitor and report upon both market conditions and individual firm performance. Monitoring may be further facilitated by agreements to divide the market explicitly, say by percentage of total sales or by geographic territory.

To summarize, cooperative price-fixing agreements are facilitated when an industry exhibits characteristics that make the detection and the deterrence of cheating easier. Such factors include the presence of only a few firms selling homogeneous products on a reasonably frequent basis and under relatively stable market conditions. All of these factors have been found to be present in the prosecution of numerous recent international cartels.[17] Agreements on market division, whether by geography or sales, also make it easier to monitor the behavior of cartel members. The potential for punishment, in some cases, violence, is greatly enhanced by such features and should never be understated.[18]

The number of price-fixing conspiracies prosecuted each year suggest that the conditions described above are often met. In turn, this is clear support for the Folk Theorem. Cartels happen. Moreover, we only know about the cartels that are detected. There may be many more collusive agreements that we do not (yet) know. The next question then becomes how policy and policy makers should deal with the potential for collusion.[19]

14.4 COLLUSION: THE ROLE OF THE ANTITRUST AUTHORITIES

While cartels may eventually fail as a result of their inherent internal conflicts, the evidence of active cartels makes it clear that the authorities cannot rely on this force alone if they wish to limit collusive agreements. Indeed, Levenstein and Suslow (2006) note in a recent survey of various cartels that "in many case studies . . . cheating was simply not a problem for the cartel" (78). Hence, the authorities will have to take explicit action themselves if they wish to limit cartel formation.[20]

16 This is perfectly legal because the price-matching guarantees are offered to buyers rather than communicated to other sellers.

17 See Connor (2001) for a detailed and very readable analysis of these cartels.

18 A number of cartels in New York City have used violence to enforce their market power.

19 *The Informant* (2000) by Kurt Eichenwald provides an informative and amusing illustration of the lysine cartel that operated in the 1990s and the difficulties this case raised for the antitrust authorities.

20 Kaplow (2011) provides an excellent discussion of policy with respect to cartels.

14.4.1 Antitrust Enforcement: Detection and Fines

Common to all law enforcement effort, antitrust officials enforcing the prohibition of price-fixing agreements have essentially two distinct but related tools. The first of these is detection (which we will take to include successful prosecution). Stricter enforcement can take the form of closer monitoring thus increasing the probability q that the cartel will be uncovered and successfully prosecuted in any period: but only, of course, at an increased cost associated with stricter enforcement. (Such costs are why the authorities are unlikely to set q = 1.) The second tool is the penalty F applied when a cartel is uncovered and brought to justice. Rather than expend resources to increase the probability q that this happens, the authorities can instead raise the penalty F paid by guilty conspirators.

Modeling antitrust enforcement in terms of the detection rate q and the penalty F that is paid upon successful detection may seem quite limiting. The justification for this simplification though is that it permits the role of detection and fines to be illustrated by a reasonably simple modification of our earlier analysis. Assume that the authorities set the probability of detection q. Cartel investigation takes one period. If detected by the end of period t the cartel is disbanded at the end of the period and the firms return to the noncooperative game permanently. Detection in period t also leads to the imposition of a fine F, where F is set by the antitrust authorities. It is convenient to think of F as being backdated to the beginning of period t. We assume that the basic probability that the game will continue is as before as given by p and that this is independent of the detection probability.

Now consider what happens at the beginning of some initial period, $t = 0$. With probability (1–q) the cartel is not detected in which case the cartel operates in that period and continues to period 1 with probability p. Expected profit is:

$$V_1 = (1-q)(\pi^M + \rho V^C)$$

The first term in the second bracket is profit in the current period (0) given that the cartel is not detected. The second term uses the same reasoning as we used to derive equation (14.3). Given that cartel is not detected in period 0 the "cartel game" begins again in period 1 and so has expected profit V^C, which has to be probability discounted one period.

With probability q the cartel is detected by the end of period 0, in which case each cartel member has to pay the fine F, the cartel stops operating but the firms continue to compete in each subsequent period with probability p. Expected profit in this eventuality is:

$$V_2 = q\left(\pi^M - F + \frac{\rho}{1-\rho}\pi^N\right)$$

Putting these equations together, the expected present value of profit for a cartel member is $V^C = V_1 + V_2$:

$$V^C = (1-q)(\pi^M + \rho V^C) + q\left(\pi^M - F + \frac{\rho}{1-\rho}\pi^N\right) \tag{14.13}$$

Solving for V^C gives:

$$V^C = \frac{\pi^M - qF + \left(\frac{\rho q}{1-\rho}\right)\pi^N}{1-\rho(1-q)} \tag{14.14}$$

As before, this must be compared with the gains from defecting from the cartel, namely, $\pi^D + \frac{\rho}{(1-\rho)}\pi^N$. A little more algebra then reveals that the condition required for the cartel to succeed now is:

$$\rho \geq \rho^* = \frac{\pi^D - \pi^M}{(1-q)(\pi^D - \pi^N)} + \frac{qF}{(1-q)(\pi^D - \pi^N)} \tag{14.15}$$

It is straightforward to see that equation (14.15) collapses to our earlier condition (14.7), as both the probability q of uncovering the cartel and the fine F paid by price conspirators goes to zero. As both q and F rise, however, equation (14.15) shows that the critical discount factor ρ^* also rises. Yet while both q and F are important, they are not symmetric. It does not matter how large the fine F is if q equals zero because then there is zero chance of having to pay the fine. The implication of F falling to zero, though, is less severe. This would mean that the second term in (14.15) vanishes, but from the first term we can see that increases in q still work to raise ρ^*. This is because while detection does not lead to a fine any longer, it does still impose a cost on the cartel in that once uncovered, we have assumed that the cartel must revert back to the noncooperative equilibrium.

While the foregoing model is relatively simple, it does carry one very important point. This is that the role of antitrust policy is not to remedy collusive activity after it has happened but to prevent it from happening in the first place. By raising the discount factor necessary for successful cartelization, it becomes less likely that the cartel members can refrain from cheating. Take our Bertrand example. We know that $\pi^M = 1{,}800$, $\pi^D = 3{,}600$, and $\pi^N = 0$, so that in the absence of any enforcement policy, i.e., if $q = F = 0$, the critical probability factor is $\rho^* = 0.5$. However, if q alone is increased to 0.25, we then have $\rho^* = 0.67$. If, in addition, we add a penalty F equal to the firm's collusive profit of \$1800, ρ^* rises further to 0.8333. Moreover, the reality may be that the probability of detection q itself depends on how aggressively the cartel pursues monopoly profits, as noted early on by Block, Nold, and Sidak (1981). If so, then to avoid detection the cartel may need to collude on a price that, while greater than the noncooperative price, is still well below that of pure monopoly. In this case, the threat of antitrust action has a doubly preventive effect. First, by limiting the profit from collusion, it again makes collusion less likely. Second, by inducing cartel members to collude on a lower price, antitrust policy limits the harm from collusion should it still occur.

Which tool—fines or increased probability of apprehension and conviction—should the authorities use? Uncovering and prosecuting price-fixing conspiracies requires careful surveillance and legal work, which is expensive. In contrast fines may be imposed rather costlessly. This suggests that a heavy reliance on substantial punishment is likely to be the more cost-effective strategy. In turn, this helps to explain why the law imposes treble damages in private antitrust lawsuits. The general rule is that some reliance on both detection and fines is appropriate, though the latter may play the dominant role.

14.4.2 Detecting Collusion

As just noted, uncovering a price-fixing conspiracy is difficult. Knowing the conditions that make collusion more likely can help the authorities focus their scarce resources in the right places but even then detection is not easy. In practice, most detection is the result of complaints by customers and, increasingly, by one member of the cartel "finking" on its partners so as to escape or limit its own prosecution. In addition, the authorities sometimes get lucky and the conspiracy will be revealed by firms in the industry who have been unhappy

either with the shares that they have been allocated in the cartel or because they have been excluded altogether.[21] However, such luck cannot be counted on as a practical procedure.

The difficulty is that detection in our sense means more than simply uncovering cartel-like behavior. It means legally proving that a collusive agreement existed. This is harder than it may at first appear because the cartel members have one very powerfull advantage over government prosecutors: they are the ones with the true information about the nature of market demand and production and transportation cost. Indeed, even if one firm admits to colluding the others can still plead not guilty. The best the authorities can do is to review market data and internal firm documents and so present as compelling a case as possible. An obvious obstacle in such effort though is that much of that data will be provided by the very same firms who are being investigated. In this setting, a collusive outcome can be made to appear to be competitive. This problem has been termed the *indistinguishability theorem* by Harstad and Philips (1990).[22]

To show the indistinguishability theorem in action, we consider a case in which the European Commission ultimately rendered a verdict against ICI and Solvay, the two firms that control the European market for soda ash, which is a raw material used in glass manufacture. ICI and Solvay had operated a number of cartel agreements for many years. Solvay supplied continental Europe while ICI supplied the United Kingdom, Ireland, and the British Commonwealth. These explicit agreements terminated in 1972, but there was no subsequent market interpenetration by the two producers. In the 1980s, prices in the United Kingdom rose some 15 to 20 percent above those in continental Europe, which the Commission argued was greater than the transport costs across the English Channel. The Commission judged that the lack of market invasion by either firm into the other's historic regional market—especially in the face of such price differentials—was strong evidence of continued tacit collusion by the two firms.

While the Commission's judgment may appear to be sound, there is a counter argument. If each firm has the same marginal cost schedule and if each sets its price equal to marginal cost plus the cost of transportation across the Channel, no cross-market penetration will ever occur. Such pricing behavior would reflect true rivalry, would lead to prices well below the collusive level, and yet there would be no market invasion of one firm by the other. Unless the regulatory agency has independent data on transportation costs, the nature of demand on each side of the Channel, and also on production costs, it cannot make a definitive case that the continued market segmentation is the result of collusive action. Given the available information, authorities may have great difficulty distinguishing between the collusive and competitive explanations of the observed data.

The situation facing government authorities is not hopeless. Careful analysis of the data can provide evidence sufficiently convincing that either a conviction or a settlement in which the cartel members agree to desist will result. Otherwise, we would see no successful price-fixing prosecutions at all. Studies by Porter and Zona (1993) and (1999) are good illustrations

[21] A classic example of this is the garbage-hauling business in New York, which was controlled by a trade association between firms who carved up the city between them. If a firm in the cartel took business away from another member, then the association forced the offending company to pay compensation amounting to "up to forty times the monthly pickup charge." Any firm attempting to enter the industry was met by arson and physical violence. Ex-mobsters who had been the victims of the financial penalties and violence provided some of the evidence necessary to break the cartel. (S. Raab, "To Prosecutors, Breakthrough After 5 Years of Scrutiny," *The New York Times*, June 23, 1995, p. 3)

[22] For a much more detailed exposition of the indistinguishability theorem see Philips (1995a). See also LaCasse (1995).

of the kind of hard and thoughtful work that is necessary. Both of these studies use differences between the bidding behavior of cartel members and non-cartel members to identify the former. The first of these concerned a cartel of construction firms involved in bidding on highway paving projects on Long Island in the early 1980s. Here Porter and Zona (1999) found that the while non-cartel members with losing bids had bids that were closely related to their costs, this was not true of cartel members who submitted losing bids. Similarly, Porter and Zona (1999) looked at school milk procurement auctions in which a cartel was active, but in which there were also non-cartel members bidding in the auctions. Here they found that non-cartel members' bids increased with distance from the firm to the school district, as would be expected, while cartel members' bids often decreased with distance.

Osborne and Pitchik (1987) propose a capacity-based test for detecting collusion. Recall our discussion in Chapter 12 of the Spence (1977) and Dixit (1980) models in which a large firm invests in extra capacity as part of its strategy toward rivals. Osborne and Pitchik argue that extra capacity may play a similar disciplinary role in cartels. In the case of Bertrand price competition, for example, only a firm with a large capacity can threaten retaliation against cartel cheaters. Hence, there is a reason for cartel members to acquire large amounts of capacity even if it will not be used if a collusive agreement is reached and output is held well below capacity. Yet, as Osborne and Pitchik (1987) note, it is likely that the firms choose their capacities before the collusive agreement is implemented and that therefore it is unlikely that each will choose exactly the same amount of capacity. Accordingly, when collusion subsequently begins, the price versus marginal cost distinction may be the same for each firm but the profit per unit of capacity will be greater for the firm with the smaller amount of capacity. Not only will the smaller firm have a higher profit per unit of capacity, but Osborne and Pitchik (1987) also show that this difference will increase as the total amount of excess capacity grows.[23] Philips (1995b) subsequently used this result to confirm the suspicion voiced by a number of British analysts, namely that there was a collusive agreement between the two main British producers of white salt, British Salt (BS) and ICI Weston Point (WP). He found that the BS profit per unit of capacity varied from 30 percent to over 100 percent more than the WP profit per capacity, and that this multiple increased precisely as the ratio of industry sales per unit of capacity rose.

Some recent papers suggest that a little significant price variation both across firms and over time may signal collusive activity.[24] Athey, Bagwell, and Sanchirico (2004) show that while random cost shocks would lead Bertrand competitors to change their prices from one period to the next, colluding firms will hold prices steady if they are sufficiently patient, i.e., if the discount factor is close to one.

Harrington and Chen (2006) offer a different model that has a similar result in which colluders are aware that their customers may recognize that a cartel has formed. In their model, prices rise relative to cost as the cartel forms and then stabilize with very little response to cost shocks. Here again, the collusive price tends to be somewhat rigid.

Abrantes-Metz, Froeb, Geweke, and Taylor (2006) look at a cartel comprised of suppliers of "fin-fish" (cod, haddock, perch, and flounder) to US Army bases from 1984–89. That cartel collapsed at the end of this period at which point, the average price fell by 16 percent.

[23] Davidson and Deneckere (1990) offer a similar analysis.

[24] The recent papers are similar in spirit to Sweezy's (1939) paper suggesting that each colluding firm faces a "kinked" demand curve at the cartel price. A firm that raises its price even a bit will find itself the high-priced firm and lose much of its market—the firm's demand curve is relatively flat. Yet if the firm reduces it price, it will launch a price war in which all firms cut price with little increase in the amount sold by any one firm—the firm's demand curve is relatively steep. As a result, firms tend to keep prices unchanged even in the face of shocks.

More critically, these authors note that with the cartel over, the variation in prices across firms and types of fish increased by nearly three-fold as measured by the coefficient of variation (the standard deviation divided by the mean). This tends to confirm the theoretical arguments that a lack of price variation can serve as a marker for collusive activity.

In a similar vein, Marshall, Marx, and Raiff (2008) study the famous lysine cartel of the 1990s. They find that the creation of the cartel was accompanied by a change in the nature of price announcements. Prior to the cartel, price announcements were made by different firms at different times and were close to simultaneous with the date of the price change in itself. Once the cartel was established, however, price announcements were made at much more regularly timed intervals and quickly supported by all firms. These announcements were now made with substantial lead time before the price actually changed and they seemed to bear little relation to cost.

These studies are all useful in alerting authorities to possible clues regarding the existence of a collusive agreement. Empirically however, they all have the advantage of reviewing a cartel that has already been discovered. It is the question of how best to do this that lies at the heart of the issue.

14.4.3 Leniency (Amnesty) Programs and Cartel Detection

Interestingly enough, many if not most of the antitrust success against cartels in recent years has come about as the result of a member of the cartel confessing to the authorities. The reason for this is clear. An increasing number of regulatory authorities have enacted leniency or amnesty programs as a way of combating cartels. While the actual programs enacted in different regions differ in their details, they typically have the form: "The first member of a cartel to provide evidence that leads to successful prosecution of the cartel receives lenient treatment. Everybody else is subject to heavy fines." Since 1993, the US authorities have granted complete immunity to the first firm to come forward if the authorities have not yet started to investigate. However, even if an investigation has been started, a lighter sentence or even total amnesty might still be offered. This granting of total amnesty to the first confessing firm in the absence of an active investigation has also recently been introduced in Europe and has proven central to successful prosecution of the cartels.[25] Such new programs have been wildly successful in the eyes of the authorities. As the Antitrust Division of the US Department of Justice has said:

> Today, the Amnesty Program is the Division's most effective generator of large cases, and it is the Department's most successful leniency program. Amnesty applications over the past year have been coming in at the rate of approximately two per month—a more than *twenty-fold increase* as compared to the rate of applications under the old Amnesty Program. Given this remarkable rate of amnesty applications, it certainly appears that the message has been communicated. (http://www.usdoj.gov/atr/public/speeches/2247.htm)

Why has granting amnesty proven so successful in breaking cartels? One reason is that such a program encourages finking by cartel members if they believe that an investigation has been started. Leniency programs effectively put the prisoners' dilemma to work on behalf of the authorities. However, as Motta and Polo (2003) and Spagnolo (2004), among others, have pointed out, that explanation cannot be the whole story. For while leniency

[25] For further details of the precise conditions under which amnesty might be granted, see the speech by the Deputy Assistant Attorney General at http://www.usdoj.gov/atr/public/speeches/2247.htm.

encourages confessions once an investigation is under way, it also raises the possibility of getting out of the cartel free of prosecution and thereby increases the expected net gains from starting a cartel in the first place.

The fundamental difficulty is really one that bedevils all attempts to measure the impact of deterrence efforts. One only sees the outcome when deterrence fails, i.e., when a cartel is formed—and caught. One does not know how many cartels are formed but escape detection and, even more important, how many cartels might have been formed but were not because of the threat of being caught and fined.

Miller (2009) addresses precisely these issues in a very original and important paper. He develops a stochastic model of endogenous cartel information and then examines what happens when an amnesty program is introduced. The model makes two very clear predictions. The first is that the introduction of the amnesty program should, if it leads to increased detection, cause an immediately noticeable rise in the number of cartels detected and prosecuted. The second prediction is that if the first prediction is validated—if the number of cartels detected rises significantly with the introduction of the amnesty

Reality Checkpoint

Leniency Program Succeeds—Only Too Well

The Competition Directorate of the European Commission introduced its leniency program in 2002 and updated the program in December 2006. The new program guidelines include the following provisions:

- Fines are up to 30 percent of the sales value affected by the cartel, multiplied by the number of years over which the cartel operated;
- Cartel members will also be fined an "entry fee" for joining the cartel, which will be between 15 and 25 percent of annual sales in the sectors affected by the cartel;
- Repeat offenders can have their fines doubled for a second offence, tripled for a third offence, and so on;
- Fines can be further increased for companies that do not cooperate with the Commission's investigation and for the ring-leader in the cartel;
- Fines can be decreased if a company fully cooperates with the cartel investigation.
- Companies that "blow the whistle" on the cartel receive full immunity from punishment.

The problem is that this policy appears to be almost too successful. The lure of immunity has generated more than 200 applications since 2002. While this has led to a series of high-profile successes, it also runs the risk of overwhelming the seventy specialist investigators. Even with evidence provided by immunity applicants, cartel investigations currently take at least three years to complete. The flood of immunity applications threatens to drag this out even more. In response, the competition commissioner Neelie Kroes has floated the idea of offering "direct settlements": reduced fines in return for cooperation with the cartel investigation and the promise not to appeal the Commission's final ruling. However, this proposal faces many practical and legal obstacles. So, for the time being, it looks as if the investigators will have to soldier on with their increased workload unless, of course, some of the rapidly growing revenues from fines are used to hire additional investigators!

Source: "Cartels Feel Pain of Kroes Crusade," *Financial Times*, Companies International, March 29, 2007.

program—and then falls to a rate below that observed before the amnesty program began, then one can infer with certainty that the program is deterring cartel formation. Working with US data, Miller's (2009) simulations suggest that the US amnesty program may have cut the rate of cartel formation by roughly 40 percent. That would certainly justify the claims of success for this program made by antitrust officials.

14.5 EMPIRICAL APPLICATION: ESTIMATING THE EFFECTS OF PRICE-FIXING

As noted earlier in this chapter, detecting and prosecuting price-fixing agreements requires real resources. Indeed, much of the analysis above makes clear just how difficult and therefore expensive it is to achieve a serious rate of detection. Even if cartels would otherwise be relatively common—and we think the evidence is that they would be—it may still not be cost effective to allocate any significant amount of scarce resources to combating them if they only raise prices a small amount. Moreover, the fines to be imposed on successful cartel members should in principle be related to the damage that they cause. For both reasons, we need to have estimates of the price effects of collusive agreements. In turn, this requires that the authorities, or more properly their expert econometric witnesses, estimate three sets of outcomes: the duration of the cartel, the price(s) charged and quantity (or quantities) sold by the cartel during the period the cartel is active, and the price(s) that the cartel would have charged if there had been no cartel—the "but for" price(s).

Of these, undoubtedly the most challenging is determining the "but for" price because this requires estimating something inherently unobservable in any direct manner. Several approaches have been suggested for estimating the "but-for" price. First, we could estimate key demand and cost parameters and use these to simulate a model of noncooperative behavior, thereby obtaining the "but for" price from the simulated market equilibrium. Second, we could use a before-and-after approach. That is, identify a period during which the cartel was not active and generate a measure of the prices charged in that period relative to the price observed during the operation of the cartel. Third, we could specify and estimate a reduced-form, time-series econometric model to estimate demand and supply interactions in the market and include a dummy or other variable to capture the impact of the cartel. Of these, the second and third are the most commonly used.[26]

The econometric method is typically applied[27] by estimating a reduced-form price equation of the form:

$$P_{it} = \alpha + \beta \mathbf{y}_{it} + \gamma \mathbf{w}_{it} + \delta \mathbf{s}_{it} + \lambda \mathbf{D}_{it} + \varepsilon_{it} \tag{14.16}$$

Here, P_{it} is price in region i at time t, $\mathbf{y}_{it}$ is a vector of variables that affect demand (income, prices of other goods), $\mathbf{w}_{it}$ is a vector of variables that affect supply (factor prices), $\mathbf{s}_{it}$ is a vector of market structure variables (concentration, some measure of the strength of economies of scale), $\mathbf{D}_{it}$ is a vector of dummy variables intended to capture the impact of the cartel, and ε_{it} is an error term. This is referred to as a reduced form equation because it is derived from an equilibrium condition equating demand and supply functions, which are functions themselves of underlying structural parameters that are not directly estimated.

[26] Connor (2001) provides a detailed discussion of the use of the before-and-after method in estimating impact of the lysine cartel.

[27] Baker and Rubinfeld (1999) discuss the use of this method.

A potential drawback of this approach is, of course, that it is very demanding on data. There needs to be sufficient "before and after" the cartel observations to give reliable estimates of the dummy variable coefficients and some of the variables in $\mathbf{w}_{it}$ such as factor costs can only be obtained with the consent of the firms that are accused of being parties to the cartel. There will often also be problems with endogeneity of the right-hand side variables requiring an instrumental-variables estimation technique, with the "correct" choice of instruments.

There are, however, examples where a variant of the econometric technique has been used with great effect. One such example is Kwoka (1997), who estimated the price impact of a long-running cartel to rig prices in a particular set of real estate auctions held in the District of Columbia.

The auctions related to properties that were either foreclosed as a result of mortgage default or were being sold under court supervision: the latter are referred to as nisi auctions. The cartel members constituted a relatively small and stable set of real estate investors who specialized in the purchase and subsequent resale of this type of property. They operated the cartel by designating a bidder who would submit an agreed winning bid at the auction while the other cartel members either did not bid or deliberately bid low. A non-cartel member who turned up at such an auction was discouraged in various ways. For example, the cartel members might make negative remarks about the property, or the non-member might be paid not to bid or might be allowed to purchase just one property. One measure of the success of this cartel at deterring entry and sustaining the cartel is that the cartel appears to have operated successfully for roughly fourteen years, from January 1976 to August 1990.

At the end of each public auction the cartel members then conducted a second, private, "knockout" auction among themselves to determine the final ownership of the property. Because this auction was conducted as a normal ascending bid auction, the property went to the high bidder: presumably the cartel member who valued the property most highly. The winner of the public auction would then be reimbursed for the price that had been paid, and the remaining difference between the public auction price and the knockout auction price would be distributed as side payments to the members of the bidding ring.

To see how this collusive arrangement works among N members in the bidding ring, we denote the true value of the property by V, the public auction-winning bid by P, and the knockout auction bid by K. Only P and K are observable. There are $N-1$ losing bidders who each receive a pay-off of S where

$$S = \frac{K - P}{N - 1} \tag{14.17}$$

Every member of the ring knows that a member will be paid at least S if the member loses in the knockout auction. The winner of the knock out gets $V-K$ and so in equilibrium $S = V-K$. In other words, the true value of the property is $V = K + S$. Using equation (14.17) this condition implies gives:

$$V = K + \frac{K - P}{N - 1} = \frac{N}{(N - 1)}K - \frac{P}{(N - 1)} = P + \frac{N}{(N - 1)}(K - P) \tag{14.18}$$

Kwoka adds a bit more structure to the model by assuming that the fixed public auction price P on which the bidding ring agreed was a "constant fraction of a property's competitive valuation." If this fraction is m then $m = V/P$. Substituting $V = mP$ in (14.18) and solving

for K we have the reduced form equation to be estimated:

$$K = P + (m-1)P\frac{(N-1)}{N} \tag{14.19}$$

where the independent variables in the regression are P and $P(N-1)/N$ and m is to be estimated.

Members of the cartel kept detailed records of the identities of all the bidders in each auction and the payoffs made to each losing bidder. These records were central to the eventual prosecution of the cartel. They are also essential to the estimation of the cartel's impact on prices. However, of the twelve individuals that were charged with Sherman Act violations, ten pleaded guilty before trial. Because of this, data are unavailable for these cases. This left Kwoka with data for thirty of the 680 properties affected by the cartel, all of which were auctioned between 1980 and 1988.

Summary statistics for these auctions are reported in Table 14.6. The average number of bidders was 4.6 and ranged from 2 to 9. The average knockout price was 28 percent in excess of the public auction price, or, alternatively, the rigged public auction price was on average 22 percent less than the knockout price.

This is not, however, the full impact of the cartel, because we know that $V = K + S$. Moreover it can be seen from Table 14.6 that there is considerable variance in K/P. Kwoka, therefore, estimated equation (14.19) directly, obtaining the results in column (a) of Table 14.7.

In the first regression in column (a), observe that the coefficients on the two terms P and $P(N-1)/N$ are significant and have the expected signs and the fit is remarkable. In addition, the coefficient on P is (just) insignificantly different from unity, as required by equation (14.19). The coefficient on $P(N-1)/N$ is an estimate of $m-1$, giving $m = 1.86$. Because $P/V = 1/m$, this tells us that $P/V = 0.54$. In other words, the cartel results in public bid prices 46 percent lower than the true valuation of the properties being auctioned.

Kwoka then estimated two refinements on the simple model of equation (14.19). First, of the thirty properties in his sample, nineteen were foreclosure auctions and eleven were nisi auctions. Because the latter are held under court supervision it is possible that the cartel members would be more careful in their public auction bidding. Suppose, therefore, that on nisi actions we have that $V/P = m-d$. Introduce a dummy variable D that takes the value of unity for nisi auctions and zero otherwise. Then the reduced form to be estimated becomes:

$$K = P + (m-1)P\frac{(N-1)}{N} - dDP\frac{(N-1)}{N} \tag{14.20}$$

The results are given in column (b) of Table 14.7. The coefficient on $DP(N-1)/N$ is the estimate of d. It has the correct sign (negative) but is statistically insignificant.

Table 14.6 Summary statistics for the auction cartel

	Mean	*Minimum*	*Maximum*
P	\$25,800	\$8,800	\$44,800
K	\$30,500	\$10,800	\$47,300
N	4.63	2	9
K/P	1.28	1.02	2.46

Table 14.7 Regression results

	(a)	(b)	(c)
P	0.519	0.520	0.703
	(2.18)	(2.15)	(4.47)
$P(N-1)/N$	0.860	0.879	0.481
	(2.58)	(2.58)	(2.01)
$DP(N-1)/N$		−0.045	0.014
		(0.51)	(0.23)
UNEQUAL			3501
			(3.08)
R^2	0.979	0.980	0.995
S	667	433	694

The second refinement modifies the mechanism by which losing bidders in the cartel were compensated. In some auctions, losing bidders were compensated equally while in others the compensation was based on each losing bidder's final but losing bid. The impact of unequal compensation is potentially ambiguous. On the one hand, it might make bidders more aggressive to secure themselves a higher share. On the other hand, aggressive bidding might result in a bidder winning an auction the bidder did not want to win. To test for this impact, Kwoka added a dummy variable UNEQUAL to equation (14.20) and ran the regression for the eighteen auctions in which it was possible to distinguish the compensation mechanism.

The results are given in column (c) of Table 14.7. The coefficient on UNEQUAL is positive and significant, implying that unequal compensation increased the subsequent knockout price. Moreover, the coefficient on $P(N-1)/N$ gives a revised estimate for m of 1.48, implying that the cartel rigged the public auction prices to 32.5 percent below the true property values. From this and the rest of Kwoka's (1997) results, this cartel is seen to have had an unambiguous and significant impact on the prices at which these properties were traded in the public auctions.

Kwoka's (1997) findings are broadly consistent with those of many other researchers. For example, Froeb, Koyak, and Werden (1993) found that a price-rigging scheme involved in supplying frozen fish to the US military raised prices by 23 to 30 percent. Connor (2001) found that the lysine cartel raised the market price by 17 percent, while Morse and Hyde (2000) argue the effect was twice as high at 34 percent. In two exhaustive reviews of the evidence, Lande and Connor (2005) and Connor and Bolotova (2006) find that the median cartel price effect over all time periods and across all cartel types is on the order of 22 to 28 percent, with the effect higher for international rather than purely domestic cartels.[28] All of these suggest that the losses associated with price fixing are substantial and well worth trying to combat—especially given the additional finding by Connor and Bolotova (2006) that the typical cartel lasts eight to nine years.

[28] Sproul (1993) is the one contrary study, finding that industry prices rise slightly *after* an indictment, which he interprets as evidence that cartels keep costs low. Apart from notable data problems, Sproul's (1993) analysis suffers from the difficulty that indictments only come after a long investigation. If the investigation itself triggers a breakdown in the cartel, then prices will fall long before the indictment. What happens at the indictment date then gives little guidance as to the actual cartel price effect.

Summary

At least since the time of Adam Smith, there has been the fear that firms in the same industry may collude and raise prices above the level that would otherwise prevail. The good news over the last dozen years or so is that a large number of such collusive cartels have been caught and successfully prosecuted in the courts both in Europe and North America. The bad news is that this same evidence also reveals that collusion remains a real problem. Somehow firms are able to work out and implement cooperative strategies rather than noncooperative ones. So, while the competition authorities can feel good about the cartels that have been broken, they must also worry that there are many other price-fixing agreements that they have not uncovered.

It is the repetition of strategic interaction that makes cartels possible. Firms rarely meet on the corporate battlefield just once. Instead, they can expect to meet many times, and perhaps in many other markets as well. When a game is played only once, each firm has a strong incentive to cheat on the collusive agreement. Because the agreement is not legally enforceable, there is little any firm can do to deter others from cheating. However, when the game is played repeatedly over a number of periods, the scope for cooperation widens considerably. This is because a firm can threaten to "punish" any cheating on the collusive agreement in one period by being more aggressive in the subsequent periods.

While repetition of the game is necessary for firms to collude successfully, it is not by itself sufficient. In addition to the game being repeated, it must have an indefinite end point. That is, in any given period, there is always a positive probability that the game will be played one more time. Absent these conditions, Selten's Theorem makes clear that a finitely repeated game with a unique noncooperative Nash equilibrium will simply result in that Nash equilibrium being the outcome in each period. However, for repeated games that go on indefinitely, the Folk Theorem makes clear that collusion that allows for all firms to gain relative to the one-shot Nash equilibrium is possible.

We have further shown that an active antitrust policy reduces the likelihood of a cartel being self-sustaining. However, this by no means guarantees that cartels will not be formed. Based on the historical evidence, it appears that the conditions for successful collusion are often met and that when they are formed, cartels significantly raise prices—typically on the order of 20 to 30 percent above the price that competitive behavior would yield. Antitrust concern with price fixing agreements thus appears justified. In this connection, the recent tactic of granting amnesty to the first cartel member who discloses the collusive agreement to the authorities appears to have been very helpful in detecting and deterring collusive behavior.

Problems

1. Suppose that two firms compete in quantities (Cournot) in a market in which demand is described by: $P = 260–2Q$. Each firm incurs no fixed cost but has a marginal cost of 20.
   a. What is the one-period Nash equilibrium market price? What is the output and profit of each firm in this equilibrium?
   b. What is the output of each firm if they collude to produce the monopoly output? What profit does each firm earn with such collusion?

2. Return to the cartel in Problem 1. Suppose that after the cartel is established, one firm decides to cheat on the collusion, assuming that the other firm will continue to produce its half of the monopoly output.
   a. Given the deviating firm's assumption, how much will it produce?
   b. If the deviating firm's assumption is correct, what will be the industry price and the deviating firm's profit in this case?

3. Suppose that the market game described in Problems 1 and 2 is now repeated indefinitely. Show that the collusive agreement can be maintained so long as the probability adjusted discount factor, $\rho > 0.53$.

4. Suppose again that market demand is given by $P = 260–2Q$ and that firms again have

a constant marginal cost of 20, while incurring no fixed cost. Now, however, assume that firms compete in prices (Bertrand) and have unlimited capacity.

a. What is the one-period Nash equilibrium price? Assuming that firms share the market evenly any time they charge the same price, what is the output and profit of each firm in this market equilibrium?
b. What will be the equilibrium output and profit of each firm if each agrees to charge the monopoly price?

5. Return to Problem 4. Assume that the cartel is established at the monopoly price. Suppose one firm now deviates from the agreement assuming that its rival continues to charge the monopoly price.
   a. Given the deviating firm's assumption, what price will maximize its profit?
   b. If its assumption is correct, how much will the profit of the cheating firm be? How much will be the profit of its non-cheating rival?

6. Return again to the cartel in Problems 4 and 5. Now suppose that the market game is repeated indefinitely. What probability adjusted discount factor is necessary now in order to maintain the collusive agreement?

7. Compare your answers in Problems 3 and 6. Based on this comparison, which market setting do you think is more amenable to cartel formation, one of Cournot competition or one of Bertrand competition?

8. Once again, assume Cournot competition in an industry in which market demand is described by $P = 260–2Q$ and in which each firm has a marginal cost of 20. However, instead of two firms, let there now be four.
   a. What is the one-period Nash equilibrium market price? What is the output and profit of each firm in this equilibrium?
   b. What is the output of each firm if they collude to produce the monopoly output? What profit does each firm earn with such collusion?

9. Return to Problem 8. Suppose that one firm decides to cheat on the collusion, assuming that each of the three other firms continue to one-fourth of the monopoly output.
   a. Given the deviating firm's assumption, how much will it produce?
   b. Assuming that its assumption is correct, what will be the industry price and the deviating firm's profit?

10. Consider again your results in Problems 8 and 9. Suppose that the market game is repeated indefinitely. Show that the collusive agreement can be maintained so long as the probability adjusted discount factor, $\rho > 0.610$.

11. Compare your answers in Problems 10 and 3. Based on this comparison, what do you infer about the ability of firms to sustain a collusive agreement as the number of firms in the industry expands?

12. Imagine that in the 1990s, the market demand for the food additive, lysine, had a price elasticity of 1.55. The structure of that market and the (assumed to constant) marginal cost per pound for each firm are shown below:

Firm	*Market Share*	*Marginal Cost*
Ajinomoto	32%	\$0.70
Archer Daniels Midland	32%	\$0.70
Kiyowa Hakko	14%	\$0.80
Sewon/Miwon	14%	\$0.80
Cheil Sugar	4%	\$0.85
Cargill	4%	\$0.85

   a. Use elasticity, market share, and cost data above to determine the weighted average industry equilibrium price if the firms are competing in quantities.
   b. During the 1990s, the lysine producers formed a (now famous) cartel that maintained the shares shown in part a. Under the cartel, the world price of lysine rose to an average of \$1.12 per pound. Total world production at this time was about 100 thousand metric tons per year. A metric ton = 2,200 pounds. What was the total additional profit that the industry earned as a result of the cartel?

13. Suppose that a cartel has just been created and it includes both large and small firms,

each having different average and marginal costs curves. The cartel agreement is for each member to reduce its output by 20 percent from the current level. Suppose that the current level of industry output approximates the competitive output level. Will this 20 percent reduction rule maximize the cartel's profit? Explain why or why not.

14. It has often been noted that cartel firms tend to maintain excessive capacity. This is true, for example, in the case of OPEC (especially for Saudi Arabia). It was also true in the electric turbine conspiracy of the 1950s and, more recently, the international lysine conspiracy of the 1990s, among others. One explanation of this is that the success of the cartel inevitably leads the members to reinvest their profits in new capacity. In this view, the cartel sews the seeds of its own destruction. Based on the analysis of this chapter, can you give an alternative explanation? What implications does your explanation have for the long-run viability of the cartel?

References

Abrantes-Metz, Froeb, Geweke, and Taylor. 2006. "A Variance Screen for Collusion," *International Journal of Industrial Organization* 24 (November): 467–86.

Athey, S., K. Bagwell, and C. W. Sanchirico. 2004. "Collusion and Price Rigidity," *Review of Economic Studies* 71 (April): 317–49.

Baker, J. B., and D. L. Rubinfeld. 1999. "Empirical Methods in Antitrust Litigation: Review and Evidence," *American Law and Economics Review* 1 (Fall): 386–435.

Bernheim, B. D., and M. D. Whinston 1985. "Common Marketing Agency as a Device for Facilitating Collusion." *Rand Journal of Economics*, 16 (Summer), 269–81.

Block, M., F. Nold, and J. Sidak. 1981. "The Deterrent Effect of Antitrust Enforcement," *Journal of Political Economy* 89 (June): 429–45.

Davidson, C., and R. Deneckre 1990. "Excess Capacity and Collusion," *International Economic Review* 31 (May): 521–41.

Dixit, A. 1980. "The Role of Investment in Energy Deterrence." *Economic Journal* 90 (January): 95–106.

Connor, J. M. 2001. *Global Price Fixing: Our Customers Are the Enemy*, Boston: Kluwer Academic Publishers.

Connor, J. M., and Y. Bolotova. 2006. "Cartel Overcharges: Survey and Meta-Analysis," *International Journal of Industrial Organization* 24 (November): 1109–37.

Eichberger J. 1993. *Game Theory for Economics*, New York: Academic Press.

Eichenwald, K. 2000. *The Informant*, New York: Random House.

Friedman, J. 1971. "A Non-Cooperative Equilibrium for Supergames," *Review of Economic Studies* 38 (January): 1–12.

Froeb, L., R. Koyak, and G. Werden. 1993. "What Is the Effect of Bid Rigging On Prices?" *Economics Letters*, 42 (April), 419–23.

Green, E. J., and R. Porter. 1984. "Noncooperative Collusion Under Imperfect Price Information," *Econometrica* 52 (January): 87–100.

Harrington, J., and J. Chen. 2006. "Cartel Pricing Dynamics with Cost Variability and Endogenous Buyer Detection," *International Journal of Industrial Organization* 24 (November): 1185–212.

Harsanyi, J. C. 1973. "Games with Randomly Distributed Payoffs: A New Rationale for Mixed Strategy Equilibrium Points," *International Journal of Game Theory* 2 (December): 1–23.

Harstad, R. M., and L. Phlips, 1990. "Perfect Equilibria of Speculative Futures Markets", in R. Selten, eds. *Game Equilibrium Analysis*, *Vol. II*. Berlin: Springer, 289–307.

Hay, G., and D. Kelley, 1974. "An Empirical Survey of Price-Fixing Conspiracies". *Journal of Law and Economics*, 17 (April), 13–38.

Kaplow, L. 2011. "An Economic Approach to Price Fixing," *Antitrust Law Journal* 77: 343–49.

Kwoka, J. 1997. "The Price Effect of Bidding Conspiracies: Evidence from Real Estate 'Knockouts,'" *Antitrust Bulletin* 42 (Summer): 503–16.

Lande, R., and J. Connor. 2005. "How High Do Cartels Raise Prices?" Implications for

Reform of the Antitrust Sentencing Guidelines". *Tulane Law Review*, 80 (November), 513–70.

LaCasse, C. 1995. "Bid Rigging and the Threat of Government Prosecution". *Rand Journal of Economics*, 26 (Autumn), 398–417.

Levenstein, M., and V. Suslow. 2006. "What Determines Cartel Success?" *Journal of Economic Literature*, 44 (March), 43–95.

Marshall, R. C., L. Marx, and M. E. Raiff. 2008. "Cartel Price Announcements—The Vitamins Industry," *International Journal of Industrial Organization* 26 (May 2008): 762–802.

Miller, N. 2009. "Strategic Leniency and Cartel Enforcement," *American Economic Review* 99 (June): 750–68.

Morse, B. A., and J. Hyde. 2000. "Estimation of Cartel Overcharges: The Case of Archer Daniels Midland and the Market for Lysine," Purdue University, Department of Agricultural Economics, Staff Paper 00-8.

Motta, M., and M. Polo, 2003. "Leniency Programs and Cartel Prosecution," *International Journal of Industrial Organization* 21 (March): 347–49.

Osborne, M. J., and C. Pitchik. 1987. "Cartels, Profits, and Excess Capacity." *International Economic Review*, 28 (June), 413–28.

Phlips, L. 1995a. *Competition Policy: A Game-Theoretic Perspective*. Cambridge, England: Cambridge University Press.

Porter, R. H., and J. D. Zona. 1993. "Detection of Bid Rigging in Procurement Auctions." *Journal of Political Economy*, 101 (June), 518–38.

Posner, R. 1970. "A Statistical Study of Cartel Enforcement," *Journal of Law and Economics* 13 (October): 365–419.

Rotemberg, J., and G. Saloner, 1986. "A Supergame Theoretic Model of Price Wars During Booms," *American Economic Review* 76 (June): 390–407.

Salop, S. 1986. "Practices that (Credibly) Facilitate Oligopoly Coordination." *New Developments in the Analysis of Market Structure*, J. Stiglitz and F. G. Mathewson, Cambridge: MIT Press, 265–90.

Schelling, T. 1960. *The Strategy of Conflict*, Cambridge: Harvard University Press.

Selten, R. 1973. "A Simple Model of Imperfect Competition Where 4 Are Few and 6 Are Many," *International Journal of Game Theory* 2 (December): 141–201. Reprinted in R. Selten, 1988. *Models of Strategic Rationality*, Amsterdam: Kluwer Academic Publishers.

Spagnolo, G. 2004. "Divide et Impera: Optimal Deterrence Mechanisms Against Cartels and Organized Crime", CEPR Discussion Paper No. 4840.

Spence, A. M. 1979. "Entry, Investment, and Oligopolistic Pricing". *Bell Journal of Economics*, 8 (Spring, 1979), 1–19.

Sproul, M. 1993. "Antitrust and Prices," *Journal of Political Economy* 101 (August): 741–54.

Sweezy, P. 1939. "Demand Under Conditions of Oligopoly" *The Journal of Political Economy* Vol. 47, (August), 568–73.

Part Five
Contractual Relations Between Firms

In this part, we examine the various ways in which firms may interact that involve formal and legally enforceable contracts. Such formal relationships employ strategic considerations just as much as do the pricing and production decisions considered in the last several chapters. However, the manifestation of these tactical issues is more nuanced because, by its very nature, a formal contract involves some elements of cooperation as well as the usual ingredient of self-interest.

Chapters 15 and 16 explore the implications of the most binding of all contracts, the marriage agreement, which in the corporate world translates into the merger (or acquisition) agreement. Chapter 15 explores the issues surrounding the merger of two firms that formerly competed against each other in the same product market, a horizontal merger. We show that these happen with greater frequency than simple oligopoly models predict, and some time is taken to determine why. Of course, a merger between two former rivals may be motivated by a desire to reduce competition. Therefore, the antitrust authorities and the courts must often evaluate such mergers and try to forecast the post-merger market outcome. The empirical application in this chapter aims at illuminating recent merger simulation techniques used to evaluate the impact of proposed mergers.

Chapter 16 continues with the merger theme, this time in a vertical or conglomerate setting. Mergers between upstream and downstream firms raise interesting questions of organizational strategy and antitrust policy, such as the double-marginalization question, foreclosure of rivals, and strategic commitment. We end with a discussion of the Hortaçsu and Syverson (2007) study of vertical integration in the ready-mixed concrete industry.

In Chapter 17, we consider vertical price restraints wherein one firm, say an upstream manufacture, imposes either an upper or lower limit on the price that the retailer selling its product can charge. We show that such agreements can be potentially welfare-enhancing for both producers and consumers, but that there is also a chance that they can foster collusion and harm welfare. As an empirical analysis we offer the recent study by Smith and MacKay (2007) on the impact of the *Leegin* decision removing the *per se* illegality of vertical price restraints.

Last, in Chapter 18, we consider non-price vertical restrictions such as exclusive territories, exclusive agency contracts, and the after-market issues raised by the 1992 Kodak case. We also discussion divisionalization. We then use the Sass (2005) study of the US beer industry to provide some evidence on common non-price vertical restrictions.

15

Horizontal Mergers

The merger mania that transformed much of corporate America through the 1990s largely disappeared in the wake of the terrorist attack of September 11, 2001, the corporate scandals at Enron, Tyco, HealthSouth, and WorldCom, and the bursting of the dot.com bubble. There was a resurgence in merger activity from 2004—2008 but that also disappeared with the financial crisis that continues to affect economic activity in the United States. Despite the recent downturn in merger activity, however, there were over 9,500 new merger deals with a total value of $840 billion struck in the year ended 05/31/2011 and over 9,000 merger deals with a total value of $759 billion struck in the year ended 05/31/2012. The urge to merge may not be as strong as it was in the 1990s, but it is by no means absent.

The organization and reorganization of firms brought about by mergers and acquisitions raises several issues. Perhaps the most important of these is: why merge? What is the motivation behind the marriage of two (or more) firms? One possible answer is that a merger creates cost savings by eliminating wasteful duplication or by improving information flows within the merged organization. Similarly, a merger may lead to more efficient pricing and/or improved services to customers. This is the case when two firms producing complementary goods such as nuts and bolts merge.[1]

If the primary motivation for mergers is to reduce costs or rationalize complementary production, mergers are likely to be beneficial to society as well as to the merging firms and ought not to be discouraged. However, mergers can also be viewed as an attempt to create legal cartels. The merged firms come under common ownership and control. Hence, the new corporate entity coordinates what were formerly separate actions with a view to achieving the joint profit-maximizing outcome. By placing such coordination within the boundaries of one firm, a merger legitimizes precisely the kind of behavior that would have been illegal had the two firms remained separate. In this light, mergers can be seen as an undesirable attempt to create and exploit monopoly power in a market.

Mergers pose a difficult challenge for antitrust policy because policy makers need to be able to distinguish between anticompetitive mergers, on the one hand, and those that are not injurious to competition, on the other. This tension is openly acknowledged in the Overview to the Merger Guidelines. “While challenging competitively harmful mergers,

[1] See Section 8.3 in Chapter 8.

the Agency seeks to avoid unnecessary interference within the larger universe of mergers that are either competitively beneficial or neutral."[2]

We explore these issues in this chapter and the next. We examine what economic theory can tell us about the profit rationale for mergers and whether the enhanced profit stems from greater efficiency or from enhanced monopoly power. While the relevant theory is mainly an extension of the Cournot and Bertrand models, we warn the reader in advance that it is nevertheless somewhat challenging. The rewards of a deeper understanding of mergers and merger policy justify, we hope, the necessary extra effort you will have to put in.

Before proceeding further, it is useful to classify merger types because not all mergers are alike. An important source of distinction is the nature of the relationship that exists between the merging firms prior to their combination. This gives rise to three different kinds of mergers. First, there are horizontal mergers. These occur when the firms joining together in the merger were formerly competitors in the same product market. A horizontal merger involves two or more firms that, so far as their buyers are concerned, market substitute products. The proposed 2011 merger of the mobile telecommunications carriers AT&T and T-Mobile is one example of a horizontal merger. The 2008 merger of Delta and Northwest Airlines is another.

Vertical mergers are the second type. Such mergers typically join firms at different stages in the vertical production chain. Consider the proposed purchase by Google of Motorola. These two firms are not direct competitors. Google is primarily a software and services producer, whereas Motorola is a hardware company making products designed to run, among others, Google software. The 2006 purchase of Murphy Farms, a major hog farming enterprise by Smithfield Foods, the largest pork company in the world, is a similar vertical combination. Vertical mergers include more than mergers between upstream-downstream firms. They also include any combination of firms that, prior to the merger, produced complementary goods. The merger between Hewlett-Packard, primarily a producer of software, printers, and scanners, and Compaq, a major personal computer firm, would fall in the vertical category. The merger of CSX and Conrail, two large freight rail companies in the eastern United States, provides another example. An important rationale for this merger was that the two firms provide complementary services to customers who wish to transport goods on one continuous system from the southeast of the United States to the northeast.

Finally, conglomerate mergers involve the combination of firms without either a clear substitute or a clear complementary relationship. General Electric, a firm that produces aircraft engines, electric products, financial services, and through its subsidiary NBC television programming, is one of the world's most successful conglomerate firms. Recent examples of conglomerate mergers include, (1) the purchase of Duracell Batteries by Gillette, (2) the purchase of Snapple (iced tea) and Gatorade (a sports drink) by Quaker Oats, and (3) the merger of CUC International, a health and home-shopping company with HFS, a major hotel firm.

In this chapter, we focus on horizontal mergers. Because these reflect combinations of two or more firms in the same industry, they raise the most obvious antitrust concerns. Vertical and conglomerate mergers are discussed in Chapter 16.

[2] The DOJ/FTC Merger Guidelines can be read at http://www.ftc.gov/bc/docs/horizmer.htm. Section 2 on the potential adverse effects of mergers is particularly relevant.

15.1 HORIZONTAL MERGERS AND THE MERGER PARADOX

As we noted above, horizontal mergers replace two or more former competitors with a single firm. The merger of two firms in a three-firm market changes the industry to a duopoly. The merger of duopolists creates a monopoly. The potential for a merger to create monopoly power is clearly an issue in the horizontal case. Our first order of business is therefore rather surprising. It is to discuss a phenomenon known as the *merger paradox*. The paradox is that it is, in fact, quite difficult to construct a simple economic model in which there are sizable gains for firms participating in a horizontal merger *that is not a merger to monopoly*.[3] We illustrate the paradox using the Cournot model of Section 9.4.[4]

Let's start with a simple example. Suppose we have three firms, each with a constant marginal cost of $c = \$30$ and jointly facing an industry demand curve given by: $P = 150 - Q$. The Cournot equilibrium results in each firm producing one-fourth of the competitive output, or 30, so that total output is 90. The price therefore is $P = \$60$ and each firm earns a profit of $30(\$60 - \$30) = \$900$.

What happens if two of these firms merge? In the wake of a two-firm merger, the industry contains two firms, each of which produces one-third of the competitive output, or 40, so that total output now falls to 80. The price rises to \$70 and each of the two remaining firms earn a profit of \$1,600.

What is the market impact of the merger? First, note that the merger is bad for consumers. Output falls and price rises. Second, the merger is good news for the firm that *did not* merge. The merger allows it to expand its output to 40 units and to sell these at a higher price than previously so that it enjoys a profit increase of $\$1{,}600 - \$900 = \$700$. Finally, we come to the central element in the merger paradox. For the two firms that merge, the merger does not pay off. Previously, each firm produced 30 units and earned a profit of \$900 for a combined pre-merger output and profit of 60 units and \$1,800, respectively. In the post-merger market, however, these two firms have a combined output of only 40 and a total profit of \$1,600. The merger has hurt the firms that merged and brought benefits to their rival. If this example is reflective of a more general result, then we ought not to observe many horizontal mergers. Of course, the paradox is that we do observe such mergers all the time.

Even more paradoxically, the foregoing example is far from being a special case. It is in fact easy to show that a merger will almost certainly be unprofitable in the basic Cournot model so long as the merger does not create a monopoly. To see this more general result, start by assuming a market of $N > 2$ firms, each of which produces a homogeneous product and acts as a Cournot competitor. The firms have identical costs given by the total cost function

$$C(q_i) = cq_i \qquad \text{for i} = 1, .., N, \tag{15.1}$$

where q_i is an output of firm i. Market demand is linear and, in inverse form, is given by the equation

$$P = A - BQ = A - B(q_i + Q_{-i}), \tag{15.2}$$

[3] A merger to monopoly is when all the firms in an industry combine into a single monopoly producer.

[4] The paradox was first formalized in a slightly different form by Salant, Switzer, and Reynolds (1983).