Microeconomics with Ethics

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Chapter 11
Oligopoly Markets

In an *oligopoly market*, several firms (somewhere between two and dozens) supply a product to a market with many consumers. In this chapter we will restrict attention to the case of two firms supplying a market (called a *duopoly*) in order to illustrate the effects of competition. The results will be compared to those from a monopoly market in Chapter 10 and represent a small step in the direction of a fully competitive market. The general effects depicted here will extend to the case of oligopoly, but we will leave the analysis of the more complex interactions that may occur in that setting to an industrial organization course.

We will also illustrate the strategic interaction between the two firms in the context of an *economic game* (also called *game theory*) in which the two firms represent the players, the quantities they choose to produce are their strategies, and their payoffs are the profit they earn in the various outcomes that could arise. The solution to this game will demonstrate one of the most important regularities that arises in all sorts of strategic interactions between competitors, referred to as a Prisoner's Dilemma.

11.1 A Simple Model of a Diamond Market

Learning Objectives

1. Use a simple production model to compare the prices and quantities chosen and profits earned by a monopoly cartel versus a competitive duopoly.

To evaluate the effects of two firms competing against each other selling an identical product we will begin with a very simple production model that is operated by only one monopoly firm. We will assume the firm produces diamonds, referencing an example of a near-monopoly from the real-world. In the first two columns of Table 11.1 is shown a demand schedule for diamonds. Note the units. Prices are in thousands of dollars per diamond and the quantity is in thousands of diamonds. (Let's further assume the time period is a year, when needed) Note also that we have included a space between the price and quantity increments. This is done to better report the marginal changes as occurring in-between the increments rather than shifting the values a half-row downward as was done in Chapter 9.

Side Note: There are two reasons for measuring units in larger values. The first is to add a hint of realism. Diamonds are very expensive and so prices in the Table are more in line with actual diamond prices. The second reason is to encourage students to look carefully at what units variables are measured in and to adjust their calculations accordingly. This is a necessary skill whenever reading graphs or Tables reporting economic data. End Side Note

The third column reports total revenue which is the product of price and quantity. Note that because both prices and quantities are measured in thousands, the product of the two is measured in millions of dollars.

The fourth column shows the marginal revenue … namely the change in total revenue given a change in output. For example the first value in the table is found as follows: MR = ($48,000,000 - $38,000,000)/(4,000 - 3,000) = ($9,000,000/1,000) = $9,000 per diamond. Because the units of column 4 is in thousands of dollars, only the $9 needs to be entered into the cell. Note also that the marginal revenue value is positioned in the row lying in-between the incremental revenue and quantity. Finally, we have included the MR at the price of $10,000 which is easily inferred to have value of $4,000 because it half of the total increment between $5,000 above it and $3,000 below it.

Table 11.1 A Diamond Market

Price ('000s)	Quantity ('000s)	Total Revenue (million)	Marginal Revenue ('000s)	Marginal Cost ('000s)	Total Cost (millions)	Profit (millions)
$13	3	$39	----	---	$12	$27
			$9	4		
12	4	48			16	32
			7	4		
11	5	55			20	35
			5	4		
10	6	60	4	4	24	36
			3	4		
9	7	63			28	35
			1	4		
8	8	64			32	32
			-1	4		
7	9	63			36	27
			-3	4		
6	10	60			40	20

With production costs we will make a simplifying assumption that will make the example easier to work with numerically, but will not alter the result. We will assume that the marginal cost to produce diamonds is a constant $4,000 per diamond for all levels of diamond output. Thus column 5 reports $4 at every output level. Recall, that when cost functions were introduced in Chapter 9, the marginal cost function was u-shaped and mostly increasing in output for most of the relevant output range. When MC is constant it means we have assumed there are no fixed costs in production and that the production function exhibits constant returns to scale throughout the output range. Although this is not very realistic, it makes calculating the final solution considerably simpler. The other implication of a constant MC function is that average total costs (ATC) is also constant and equal to the MC. In other words, constant MC → MC = ATC for all output levels. That means that to calculate total costs, shown in the fifth column, we can simply multiply the MC of $4,000 by each quantity in the table. The final column in Table

11.1 shows profit accruing to the firm at each level of output. It is found by subtracting total cost in column 6 from total revenue in column 3.

The Monopoly Solution

With the assumptions of this model, we can now imagine a monopoly firm in the diamond market. Assuming the objective to maximize its profit, it would achieve this by finding the output level such that MR = MC. In the Table that clearly occurs at output level 6,000 diamonds. The monopoly would price the diamonds at $10,000 each and would earn total profit of $36 million. Except for using a simplified set of production assumptions, nothing is new here compared to Chapter 10. So now let's change the assumptions and see what happens.

The Duopoly Solution

Suppose the diamond monopoly above is originally a private firm owned by one individual who becomes very wealthy after years controlling the diamond market. Suppose at his death, he leaves the firm to his two children, Lars and Ingrid, each of whom control 50% of the business. Suppose also that the father's diamond company owned two mines and each mine contributed exactly 50% of the 6,000 diamonds produced annually. So when Lars and Ingrid take over the business, Lars gets Mine A and Ingrid gets Mine B.

At first, Lars and Ingrid decide to follow the same strategy as their monopolist father, each choosing to supply an equal number of diamonds to the market and splitting the profits. Table 11.2 shows the prices, quantities and profits for both sibling firms under the assumption of equal production. Note that this Table simply splits the quantities and profits from Table 11.1 in half. Note also that the best outcome for them both is to produce 3,000 diamonds and earn $18 million each.

Since these are now two firms with separate owners acting in their best joint-interest we would say the siblings are *colluding* with each other, or are engaged in *collusion*. We can also say that they are operating as a *cartel*. We can also say that the two are engaged in *price-fixing* since another way to describe their behavior is that they've agreed to fix the price at $10,000.

Table 11.2 A Tale of Two Colluding Diamond Firms

Price ('000s)	Firm A Quantity ('000s)	Firm B Quantity ('000s)	Firm A Profit (millions)	Firm B Profit (millions)
$13	1.5	1.5	$13.5	$13.5
$12	2	2	$16	$16
11	2.5	2.5	17.5	17.5
10	3	3	18	18
9	3.5	3.5	17.5	17.5
8	4	4	16	16
7	4.5	4.5	13.5	13.5
6	5	5	10	10

Next, let's suppose that Lars and Ingrid have a fight with each other, as siblings often do, and Ingrid decides that to get back at her brother, she will secretly begin to break their cooperative business deal and instead try to maximize her own company's profit (rather than joint profit as before). She constructs Table 11.3 which illustrates how much profit she could make if she changed her supply of diamonds to the market. However, because she intends to supply extra diamonds secretly, she will assume that her brother will maintain the original cartel agreement and continue to produce 3,000 diamonds. This is a simplifying assumption that we will relax in the next step. Also, whenever one firm assumes the other firm, or firms, will maintain a fixed output level, it is referred to as *Cournot competition*. This is just one of many simple ways to introduce strategic, or competitive, behavior.

To construct the figures for Table 11.3, we fix Firm A's output at 3,000 and then adjust Firm B's output to different levels. At each level, we calculate the market price based on the sum of Firm A and B's outputs, and calculate each firm's profit using the equation $\pi = P*Q - MC*Q = (P - MC)*Q$ For example, in the first row, if firm B chooses to produce 1,000 diamonds, then total diamond output will be 4,000 and reading from the demand schedule in Table 11.1, these quantities can be sold at the price of $12,000. The profits for the two firms are calculated as follows,

Firm A Profit = (12,000 – 4,000)*3,000 = $24,000,000

Firm B Profit = (12,000 – 4,000)*1,000 = $ 8,000,000

We repeat this exercise for discrete levels of Firm B production to determine the values in Table 11.3. Because adjusting firm B's output in 1000 unit increments, generates two maximums at 4,000 and 5,000 diamonds we constructed the intermediate step at Q = 4,500 diamonds to determine Ingrid's maximum profit.

In other words, if Ingrid varies her diamond output, assuming Lars keeps his quantity fixed, then her maximum profit occurs at Q = 4,500, which is 1,500 more than she produced under the cartel arrangement.

Reality Check

In practice, it may be difficult to cheat on the cartel agreement without Lars noticing. What Ingrid could do at first is to price discriminate. That is, continue to sell her 3,000 diamonds in the usual places at the original price of $10,000, but secretly begin selling additional diamonds at a lower price to a hidden network of diamond merchants. These merchants will sell to consumers who are not willing to pay as much as $10,000, but are willing to pay a discounted price of $8000 or $7000. As long as Ingrid sells these for more than her marginal cost of $4000, her profits will increase above her cartel level.

Eventually, consumers will learn of the discount diamond market and demand for the original diamonds will fall. Both Lars and Ingrid will have excess supply at the $10,000 price and will only be able to sell them all by lowering the price. Once these adjustments occur, the final price and total quantities should converge to the values in Table 11.3 if Ingrid stops her price discrimination.

At the new equilibrium, Ingrid supplies 4,500 diamonds to the market while Lars supplies 3,000. Ingrid's profit increases to $22.25 million, up from $18 million in the cartel. Lars' profit falls from $18 million to $13.5 million. Ingrid will also be happy she is upsetting her brother!

Table 11.3 Two Diamond Firms – Firm B Cheats

Price ('000s)	Firm A Quantity ('000s)	Firm B Quantity ('000s)	Firm A Profit (millions)	Firm B Profit (millions)
12	3	1	24	8
11	3	2	21	14
10	3	3	18	18
9	3	4	15	20
8.5	3	4.5	13.5	20.25
8	3	5	12	20
7	3	6	9	18
6	3	7	6	14

Perhaps at first, Lars will be fooled into thinking there has been an unexpected drop in diamond demand and attribute the lower prices to a shift in the demand curve. However, eventually he is likely to learn through the diamond grapevine that his sister has been secretly selling more diamonds than she had previously agreed and is reneging on their arrangement. This will surely inspire retaliation in this brother-sister duel.

Suppose Lars, learning that his sister is now selling 4,500 diamonds in the market, decides to maximize his own individual profit rather than sticking to the cartel arrangement. To help in his decision, Lars constructs Table 11.4 under the assumption that his sister will keep her output fixed at 4,500 diamonds.

Notice that Lars' new profit maximum requires him to increase his production to 3,750 diamonds, up from 3,000 in the cartel. Because of the higher market supply, the price of diamonds falls to $7,750 and Lars profit increases to just over $14 million. Ingrid's profit falls to $16.875 million because of the price decrease.

Table 11.4 Two Diamond Firms – Both Firms Cheat

Price ('000s)	Firm A Quantity ('000s)	Firm B Quantity ('000s)	Firm A Profit (millions)	Firm B Profit (millions)
11.5	0	4.5	$0	$33.75
10.5	1	4.5	6.5	29.25
9.5	2	4.5	11	24.75
8.5	3	4.5	13.5	20.25
8	3.5	4.5	14	18
7.75	3.75	4.5	14.0625	16.875
7.5	4	4.5	14	15.75
6.5	5	4.5	12.5	11.25
5.5	6	4.5	9	6.75

In the next step we should expect Ingrid to respond to her brother's move and re-optimize herself. If they are smart, they would both hire an economist who could derive a response function that would indicate the optimal output, given any output level the other sibling chooses. Using a little calculus, those economists would derive the following optimal response functions,

$$Q_B = 6{,}000 \; - \; \tfrac{1}{2}\, Q_A \qquad \text{for Ingrid}$$

$$Q_A = 6{,}000 \; - \; \tfrac{1}{2}\, Q_B \qquad \text{for Lars}$$

Note when Ingrid plugs in Lars output of 3,000 diamonds, her best response is to produce 4,500 diamonds. When Lars plugs in 4,500 diamonds, his best response is 3,750, just as presented in the Tables above.

By solving these two equations in two unknowns, we can find where this strategic interaction will ultimately converge. It will be at Q = 4000 diamonds for each. Simply plug 4,000 into each equation above to see that if Lars produces 4,000 so will Ingrid, and vice versa. The market price to sell 8,000 diamonds is $8,000 per diamond.

At these output levels Lars and Ingrid will each make $16 million in profit, which is less than the $18 million they each made when they operated as a cartel, and is the key result of this exercise. If Lars and Ingrid compete with each other in a duopoly market, their individual profit-seeking incentives will induce them to increase their outputs and lower the price of their product. As a result they will each make less profit then they did when they operated as a cartel. In other words, competition causes lower prices and higher outputs. The reverse is also indicated: namely, monopolization, or collusion, or cartel formation, causes higher prices and lower outputs.

There is a short-term first-mover advantage too. Note that Ingrid, who deviates first from the cartel agreement (i.e., cheats), will earn more profit in the transition to the final equilibrium. This is a key reason why cartels have been shown are difficult to maintain; everyone realizes that cheating first is best … and so someone usually does so.

This movement in prices and output can be shown (we won't do so here) to continue as more firms enter and compete in a market. Thus, if a market consists of an oligopoly, with, say, 5 firms competing, then prices will be lower and total market output higher than in a duopoly market with only two firms. With 20 firms, prices will be even lower and output even higher. There is a limit to these changes and that limit will be demonstrated in Chapter 12 when we introduce perfect competition.

Reality Check

The model we used to present these results is extremely simple. Each firm is given only one choice variable, output, and all the information about the demand curve is known with certainty. In real world markets, strategic interaction will be much more complicated. Firms strategies may involve changes in product quality, advertising, sales efforts, and production costs. Information about competitors' actions will not be known with certainty. Also, adjustments in strategies will take time to see what effect they are likely to have.

Despite the complexity of the real world, the simple model is still expected to reveal a fundamental tendency to reduce the price and raise output when there is more competition. Since this is how firms would react in a simple model, we expect the same tendency in the real world. We can also observe these tendencies in general in comparing pricing and output levels in different markets. What the complexity of the real world does complicate, is in making accurate numerical predictions. The purpose of this course is to reveal the likely directions of changes in the cause and effect relationships between market variables, and that we can accomplish with simple models.

Key Takeaways

1. Compared to a monopoly cartel, a duopoly market outcomes generates a lower price, higher total output and lower firm profit.
2. Cheating, or breaking a cartel arrangement, is especially advantageous to the first-mover. This incentive often causes cartels to fall apart.
3. The self-interested motivation to make greater short-term profit is what causes output to rise. The law of demand causes prices to fall. The long-term effect when all competing firms act in this way, is that profit falls.
4. As more firms compete, as with an oligopoly compared to a duopoly, the price falls further, total output increases further, and firm profit falls.

11.2 Welfare Effects of a Duopoly

Learning Outcome

1. Compare total profit, consumer surplus and market welfare between monopoly and duopoly markets.

Finally, let's measure total market surplus in the case of a duopoly and compare it to the monopoly outcome. Market surplus, or market welfare, consists of the sum of consumer surplus plus the profit earned by all of the firms. Figure 11.1 shows the demand curve that was used in the previous exercise. Combinations of the letters a-g are used to represent the revenues, costs, profits and surplus values. For example, the letter "a" represents the area of the triangle bounded by the demand curve, the price line drawn at $10,000, and the vertical axis.

In the monopoly outcome, or the outcome when Lars and Ingrid act like a cartel, the total quantity produced was 6,000 diamonds and the market price was set at $10,000. Total revenue earned by the two firms combined is given by areas (b + d + f) = $10,000 * 6,000 = $60 million. Total costs for the monopoly is area (f) = $4,000 * 6,000 = $24 million and total profit is areas (b + d) = $60 – $24 = $36 million. Consumer surplus is given as area (a) = ½ (16,000 – 10,000)* 6,000 = $18 million.

Total market welfare in the monopoly outcome is

$$MW = \pi + CS = 36 + 18 = \$54{,}000{,}000$$

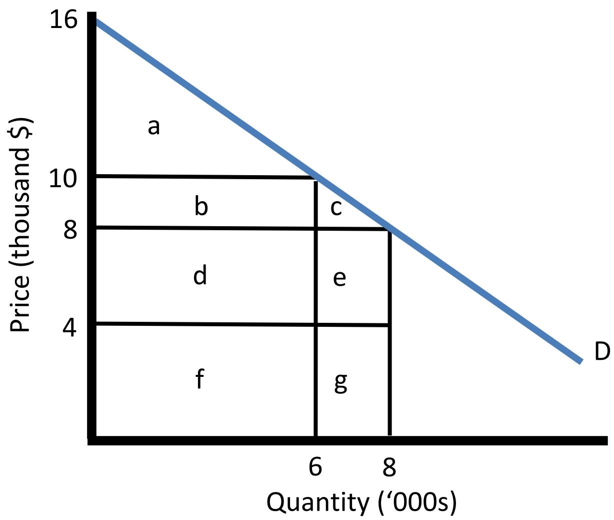
Next, calculate the duopoly values. The total combined quantity produced by the two firms was 8,000 diamonds and the market price was set at $8,000. Total revenue earned by the two firms combined is given by areas (d + e + f + g) = $8,000 * 8,000 = $64 million. Total costs for the duopoly is areas (f + g) = $4,000 * 8,000 = $32 million and total profit is areas (d + e) = $64 –

$32 = $32 million. Consumer surplus is given as areas (a + b + c) = ½ (16,000 – 8,000)* 8,000 = $32 million.

Total market welfare in the monopoly outcome is

$$MW = \pi + CS = 32 + 32 = \$64{,}000{,}000$$

Figure 11.1 Welfare Effects of Duopoly



The effects of moving from monopoly to duopoly are noteworthy and are shown in Table 11.5. Competition reduces total firm profit, raises consumer welfare and, because the extra benefits to consumers are larger than the losses to producers, increases market welfare. There is more overall happiness being generated by market activity when there is competition between two firms, compared to a monopoly. This also means there is an increase in economic efficiency, caused largely by the increase in production, and hence improvements in productive efficiency, that occurs with competition. This is the main reason why it is good to have more market competition.

Table 11.5 Welfare Effects of Competition

Change in Producer Profit	- $4,000,000
Change in Consumer Surplus	+ $14,000,000
Change in Market Welfare	+ $10,000,000

But it is important to note that "good overall" is not the same as "good for everyone." Firms or businesses will suffer losses from competition, especially if the monopoly case was originally a cartel with two firms colluding. When one firm cheats in the cartel agreement, both firms ultimately suffer losses.

However, suppose the original monopoly consists of an incumbent firm, while the second firm is a new entrant. In this case, both firms do not lose from competition. Instead, the entering firm will benefit because its opportunity cost was to produce nothing before and earn zero profit. When it enters the market and competes, its profit rises to $16 million (assuming it takes over half the market). The incumbent firm loses badly, however, with profit falling by $20 million. As a result, we should expect incumbent firms to be very resistant to competition. In Chapter 16 we'll show a variety of methods firms use in the real world to try to restrict competition in their own markets. This is much more common than you may think.

Also, if one is interested in improving outcomes in markets to generate higher levels of well-being, increasing the competition on markets is one way to achieve it. Much more on this issue follows in subsequent chapters.

Key Takeaways

1. Total firm profit is measurably lower in a duopoly market, relative to a cartel monopoly.
2. An incumbent monopoly firm measurably loses profit when a new firm enters the market. Hence, we can expect incumbent firms to resist competition by entering firms.
3. A newly entering firm makes positive profit that is did not have previously. Therefore, we can expect newly established firms to promote competition.
4. Consumer surplus is measurably higher in a duopoly market, relative to a cartel monopoly.
5. Total market welfare, also economic efficiency, is measurably higher in a duopoly relative to a monopoly.
6. The benefits of competition, to consumers and entering firms, is greater than the losses to incumbent firms.

11.3 Analyzing a Duopoly using Game Theory

Learning Outcomes

1. Learn to evaluate the strategic decisions of duopoly firms in a game theory context.
2. Learn the characteristics of a prisoner's dilemma game.

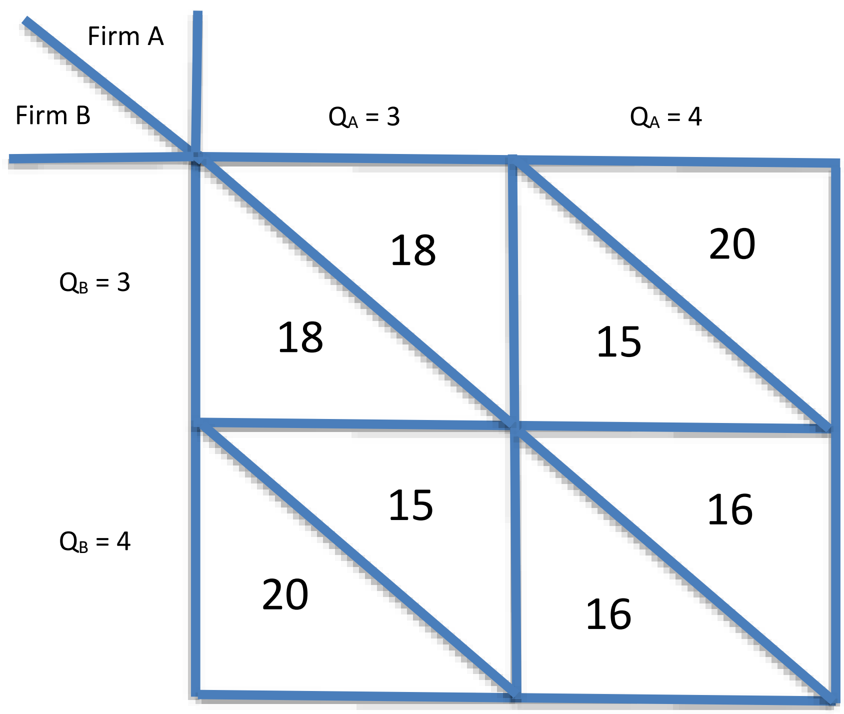
It will be useful to retell the story of strategic interaction in a duopoly in the context of an economic game. *Game theory* is a branch of economics, and social science more generally, that focuses on the study of strategic interactions between market, or political decision, makers. Playing card games, or board games, is a common activity that most everyone has some familiarity with. Playing these games is fun and challenging largely because they often involve complex decision making, or sometimes just dumb luck. All games have the feature that one's own outcome is dependent not just on one's own actions but also on the actions of others, and also on chance shocks that occur unexpectedly. Strategic behavior in a game refers to the notion that you must think not just of what actions you might take, but must also consider what opponents in the game might do and how it will affect you.

A simple game can be set up using the previous duopoly market model. It will enable us to define important terminology used in many game theory models and to describe some common outcomes, or equilibria, in the jargon of economics.

Suppose there are two firms A and B producing diamonds as in the previous model in Section 11.2. We will call these firms the *players* in the game. Let's assume for simplicity that each player has only one of two decisions they can make, either produce 3,000 diamonds or 4,000 diamonds. We will call these actions their *strategies*. Next let's assume that the objective of the players is to maximize their individual profit. In general, the value of the objective is usually called the *payoff* of the game.

These players, strategies and payoffs are shown in the 2 x 2 matrix shown in Figure 11.2. Firm A's strategies are listed at the top of the two columns of the matrix and are measured in thousands. Firm B's strategies are listed to the left of the two rows of the matrix. The profit payoffs are given in the four squares of the matrix and are measured in millions of dollars. The values are derived from the exercise presented in section 11.2, but we are ignoring the step-by-step iterations moving to the duopoly solution. The quantity values chosen correspond to the monopoly, or cartel solution, and the final duopoly solution. Finally, the values listed above the diagonal is Firm A's payoff and the value below the diagonal is Firm B's.

Figure 11.2 Duopoly using Game Theory



In this particular example, there is a dominant strategy for both players. This is not always true and depends on the particular payoffs depicted in the game. A *dominant strategy* is one that is best for the player to choose regardless of what the other player chooses. Thus, notice that if Firm B chooses $Q_B = 3$, then the best choice for Firm A is to choose $Q_A = 4$ (because Firm A gets \$20 million in profit instead of the \$18 million if $Q_A = 3$) . Also if Firm B chooses $Q_B = 4$, then again Firm A's best choice is $Q_A = 4$ (because Firm A gets \$16 million in profit instead of the \$15 million if $Q_A = 3$). Regardless of Firm B's choice, $Q_A = 4$ is the best choice for A and hence is its dominant strategy.

The same logic shows that Firm B's dominant strategy is $Q_B = 4$. The implication is that if these firms play this game against each other and seek their highest profit payoff, they will both choose to produce 4,000 diamonds. In game theory jargon, this outcome is called either the non-cooperative equilibrium, or the Nash equilibrium. It is a *non-cooperative equilibrium* because the two players and not speaking with each other or coordinating their actions in any way. They are simple doing what is in their individual self-interest. It is called a *Nash equilibrium* in honor of the originator of this equilibrium concept, John Nash, who, by-the-way, is the individual portrayed by Russell Crowe in the 2001 movie, A Beautiful Mind.

This outcome poses a curious dilemma for the two firms. Contrary to Adam Smith's suggestion that if two individuals pursue their self-interest in a market, it can lead to the improvement in welfare for both of them, in this equilibrium, both individuals are clearly worse-off than they would be had they chosen Q = 3, generating payoffs of (18,18) instead of (16,16). So, why is it that their self-interest leads them to an inferior outcome.

Before explaining further, it is worth pointing out that this puzzling outcome arises in many strategic games that have been conceived of in the social sciences. So much so, it has been given a name, a Prisoner's Dilemma. A *Prisoner's Dilemma game* is one in which self-interested non-cooperative behavior generates an inferior outcome for both players. The reason behind the name is that one of the earliest PD games developed imagined two criminals who are arrested and interrogated separately. Each criminal's individual interest leads him to confess to the crime even though had both remained silent, they would have been released due to insufficient evidence.

The prisoner's story also makes explicit something that prevents the superior outcome. Because the prisoners are separated after arrest, they do not have a chance to discuss a strategy beforehand. Had they been able to talk, they may have reached a deal promising each other they would not confess, thereby assuring the better outcome. Because this coordinated outcome is more likely to arise when the two cooperate with each other, it is called the cooperative solution or equilibrium. In more technical terms the *cooperative equilibrium* is that outcome which maximizes the joint payoffs of the players in the game.

In the Duopoly game above, the cooperative equilibrium is for each firm to produce 3,000 diamonds thereby generating the preferable outcome of $18 million in profit each. This cooperative solution involves forming a cartel agreement with each firm promising the other to restrict output in order to raise the price and profits.

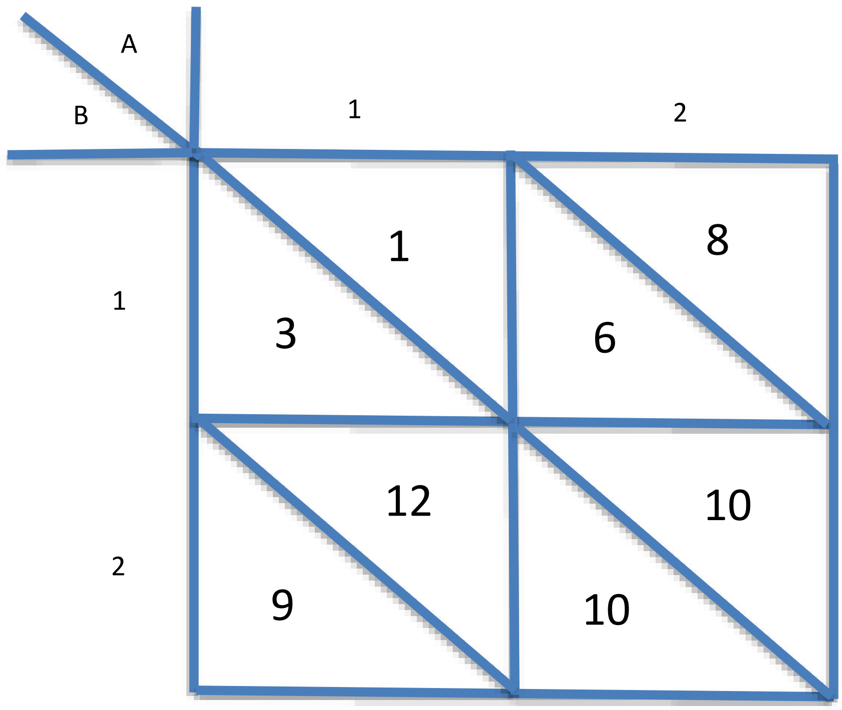
Notice something else; from the vantage point of overall market welfare, the outcome is worse when there is cooperation by the firms. One's natural inclination might be that cooperation is always better than individualized self-interest, bit that is not always true. It always depends on who's cooperating and whether they are taking account of all the effects. In this case, the firms still only care about their own well-being, not that of the larger market community.

Another lesson from this exercise is that if the firms are in some way prevented from forming a cooperative cartel, much like the prisoners are prevented from conversing, then the self-interested behavior of the firms will result in the best outcome for the market overall. Consumer benefits will outweigh the losses in firm profit and economic efficiency improves. The same is true for the prisoners. By preventing them from talking, they confess, and justice is served.

Side Note: Sometimes games have different stories, and payoffs. All games do not have dominant strategies and all are not prisoner's dilemma games. However, other games will have Nash and cooperative equilibria. For example consider the following non-descript game in

Figure 11.3. It is non-descript because we'll tell no background story. Instead only assume there are two players, A and B, with two strategies, 1 and 2, generating the payoffs listed.

Figure 11.3 Solutions for a Non-Descript Game



First, note that player A does not have a dominant strategy: if B chooses 1, A chooses 2 (because 8 > 1), but if B chooses 2, A chooses 1 (12 > 10). Player B does have a dominant strategy. If A chooses 1, B chooses 2 (because 9 > 3) and if A chooses 2, B again chooses 2 (because 10 > 6).

To find a Nash equilibrium one can always use the following method. First choose a policy for one player, then determine the best choice for the second. Next, take the choice of th second and find the best strategy of the first. Keep going until neither player switches. For example, Suppose B chooses strategy 1. Then A should choose 2 (because 8 > 1). Next, if A chooses 2, then B chooses 2 (because 10 > 6). Now, if B chooses 2, A chooses 1 (because 12 > 10). Next, if A chooses 1, B chooses 2 (because 9 > 3). The last two steps mirror each other indicating the players get stuck in the lower left box, A chooses 1 and B chooses 2. This is the Nash equilibrium. This method works for all two-person, two-strategy games.

Finally the cooperative equilibrium in this game is found by choosing the square that gives the highest total utility. In this game the lower left box is also the cooperative equilibrium because the joint payoff, (12 + 9 = 21), is greater than for any other outcome. Since the Nash equilibrium is the same as the cooperative equilibrium, there is no prisoner's dilemma.

Key Takeaways

1. An economic game is described by identifying the players, the strategies, the payoffs, and the objectives.

2. Two game theory equilibrium concepts include a non-cooperative, or Nash, equilibrium and a cooperative equilibrium.
3. In a Nash equilibrium, each player chooses a strategy that maximizes their individual payoff given the strategies other players are making, which are also individually optimal.
4. In a cooperative equilibrium, players choose an outcome that maximizes the joint welfare of all players.