OLIGOPOLY AND GAME THEORY

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Comparing market structures

<table>
<thead>
<tr>
<th>Perfectly competitive market</th>
<th>Monopolistic competition</th>
<th>Oligopoly</th>
<th>Monopoly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many sellers</td>
<td>Many sellers</td>
<td>A few sellers</td>
<td>One seller</td>
</tr>
<tr>
<td>Similar products</td>
<td>Differentiated products</td>
<td>Typically differentiated products</td>
<td>Unique product without close substitutes</td>
</tr>
<tr>
<td>No barrier to entry and exit</td>
<td>Low barriers to entry or exit</td>
<td>Barriers to entry</td>
<td>High barriers to entry</td>
</tr>
</tbody>
</table>
Measuring market power in oligopoly

• Market power is the ability of a firm to control the price of the goods sold.

• There is a negative relationship between the number of firms in an industry and the market power that each firm has.

• In other words: the fewer, the merrier

• In general, economists use concentration ratios as a gauge of market power that firms have in an oligopoly.

• The most common concentration ratio used is the four-firm concentration ratio.
Measuring market power in oligopoly (2)

• The four-firm concentration ratio expresses the sales of the four largest firms in an industry as a percentage of the industry’s total sales.

• For example, if the four largest firms in an industry are firms A, B, C and D with respective sales a, b, c and d.

• Given the total sales by all the firms in the industry is x, we can calculate the four-firm concentration ratio as:

• Four-firm concentration ratio = (a + b + c + d) / x
### Measuring market power in oligopoly (3)

<table>
<thead>
<tr>
<th>Industry</th>
<th>Four-firm concentration ratio</th>
<th>Top firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Search engines</td>
<td>98.5</td>
<td>Google, Yahoo, Microsoft</td>
</tr>
<tr>
<td>Wireless Telecommunications</td>
<td>94.7</td>
<td>Verizon, AT&amp;T, Sprint Nextel, T-Mobile</td>
</tr>
<tr>
<td>Satellite TV providers</td>
<td>94.5</td>
<td>DIRECTV, DISH Network</td>
</tr>
<tr>
<td>Soda production</td>
<td>93.7</td>
<td>Coca-Cola, PepsiCo, Dr Pepper Snapple</td>
</tr>
<tr>
<td>Sanitary paper products</td>
<td>92.7</td>
<td>Kimberly-Clark, Procter &amp; Gamble, Georgia Pacific</td>
</tr>
<tr>
<td>Lighting and bulb manufacturing</td>
<td>91.9</td>
<td>General Electric, Philips, Siemens</td>
</tr>
<tr>
<td>Tire manufacturing</td>
<td>91.3</td>
<td>Goodyear, Michelin, Cooper, Bridgestone</td>
</tr>
<tr>
<td>Major household appliances</td>
<td>90.0</td>
<td>Whirlpool, Electrolux, General Electric, LG</td>
</tr>
<tr>
<td>Automobile manufacturing</td>
<td>87.0</td>
<td>General Motors, Toyota, Ford, Daimler-Chrysler</td>
</tr>
</tbody>
</table>

Measuring market power in oligopoly (4)

• In the search engines industry, for instance, the four largest firms hold a very high percentage of the market share (close to 100%).

• At the bottom of the list, in the automobile industry, the four largest firms hold 87% of the market share, which is still very significant.

• This illustrates the fact that oligopolists have big market shares and therefore enjoy significant market power.

• They have much control over their prices.
Collusion and Cartels

• Oligopoly is neither perfect competition nor is it monopoly.
• However, oligopolists often have competitive tendencies as well as monopolistic tendencies.
• They often end up competing against each other even though they have monopolistic advantages.
• In order to understand this better, let’s use the case of a duopoly.
• A duopoly is an industry with only two firms.
Collusion and Cartels (2)

• Duopolies are hard to come by in general.
• However, we can find duopolies in small communities.
• For example, two telephone service providers could be enough in a small town of a couple of thousands people.
• Following is the demand schedule for cell phones in a small town:
<table>
<thead>
<tr>
<th>Price in $ (P)</th>
<th>Number of customers (Q)</th>
<th>Total Revenue in $ (TR = P * Q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>180</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>165</td>
<td>100</td>
<td>16500</td>
</tr>
<tr>
<td>150</td>
<td>200</td>
<td>30000</td>
</tr>
<tr>
<td>135</td>
<td>300</td>
<td>40500</td>
</tr>
<tr>
<td>120</td>
<td>400</td>
<td>48000</td>
</tr>
<tr>
<td>105</td>
<td>500</td>
<td>52500</td>
</tr>
<tr>
<td>90</td>
<td>600</td>
<td>54000</td>
</tr>
<tr>
<td>75</td>
<td>700</td>
<td>52500</td>
</tr>
<tr>
<td>60</td>
<td>800</td>
<td>48000</td>
</tr>
<tr>
<td>45</td>
<td>900</td>
<td>40500</td>
</tr>
<tr>
<td>30</td>
<td>1000</td>
<td>30000</td>
</tr>
<tr>
<td>15</td>
<td>1100</td>
<td>16500</td>
</tr>
<tr>
<td>0</td>
<td>1200</td>
<td>0</td>
</tr>
</tbody>
</table>
Collusion and Cartels (4)

• If the two firms want to operate as perfectly competitive firms:
  - The following condition must be satisfied: $P = MR = MC$
  - Duopolies usually have excess capacity, which means that the marginal cost is equal to 0.
  - For example, each cell phone service provider has a cell phone tower.
  - Therefore, the additional cost incurred when a new subscriber is added is 0.
  - Consequently, each firm will provide 1200 customers with free phones and will not get any revenues.
  - This case scenario is efficient but utterly unrealistic.
Collusion and Cartels (6)

• If the two firms want to operate as monopolies:
  - The monopolist chooses the price that maximizes his profit.
  - He faces no kind of competition.
  - According to the demand schedule, the total revenue is maximized when the price is $90.
  - Total revenue is then $54000 with 600 customers.
Collusion and Cartels (7)

• In this case scenario, it is good for the two firms to *collude* so they can earn the highest profit.
• **Collusion** is an agreement between rival firms that specifies the price that each firm charges and the quantity it produces.
• Therefore, in order for both firms to maximize their profit, each needs to charge $90 and produce 300 phones.
• Each firm will then make a profit of $27000.
• However, collusion is very often illegal and is prohibited by anti-trust laws.
• Firms that have colluded are called a cartel.
Strategic choices

• Even if collusion occurs in a duopoly, there still remains a problem.
• A firm’s sole purpose is to maximize profit.
• If both firms agree to charge $90 for their cell phones and produce 300 units each…
• ... one of the two firms may be inclined to break the deal and charge a lower price in order to get a higher revenue.
Strategic choices (2)

• Let’s suppose firm A breaks the agreement and charges $75 instead of the agreed $90.

• The total market demand rises to 700.

• Firm A will have 400 customers meanwhile firm B will keep its former 300 customers.

• The new total revenue of firm A will change to $30000, which is an increase in total revenue of $3000 compared to when it was still charging $90.
Strategic choices (3)

• Seeing that firm A is making more profit having cut its price, firm B will react too and match firm A’s price.
• Firm B revenue will come from its 300 customers at the new price of $75.
• Firm B’s revenue will fall to $22500, which is a loss of $7500.
• But at this point, there is no reason why firm B should sit still and do nothing.
• It will lower its price further down to $60, which will cause an increase in its revenue to increase to $24000.
Strategic choices (4)

• Firm A will try to react to firm B’s action by lowering its prices too.
• It would not be wise for firm A to try to increase its market share by lowering the price below $60.
• For example, if firm A charges $45, its revenue will go down to $22500, which is $1500 less than if it had just matched firm B’s price.
• Both firms will end up charging $60 for their phones and individually make a profit of $24000.
• In an oligopoly, a firm’s market share is determined by the products it offers, the price it charges and the actions of its competitors.
The Nash equilibrium

• The first kind of equilibrium we discussed earlier was the market equilibrium.
• The market equilibrium sets the price at a level that makes quantity demanded and quantity supplied equal.
• In the case of an oligopoly, price is not set the same way as we just saw.
• A Nash equilibrium is a state in which no economic agent can be better off by changing its current strategy.
The Nash equilibrium (2)

• In the cell phone oligopoly example, the Nash equilibrium occurs when each firm produces 400 phones at a price of $60 each.
• No firm can individually change this current strategy and increase its profit.
Game Theory

• So far, we have analyzed strategic decisions in a duopoly.
• Those decisions are said to be “strategic” because they depend on what others do.
• In our duopoly example, firm A broke the deal, then firm B reacted, then firm A reacted again... and they finally reached an equilibrium.
• This is an example of game theory – a branch of mathematics used in economics to analyze the strategic behavior of decision-makers.
• In general, game theory allows us to determine the level of cooperation which is most likely to occur.
A game

- A game consists of:
  - A set of players: firm A and firm B
  - A set of strategies available: cut price, increase price
  - A specification of the payoffs for each combination of strategies: more profit, less profit, same profit
- A game is usually represented by a payoff matrix.
- A payoff matrix shows the players, the available strategies and the corresponding payoffs.
A very popular game: the prisoner’s dilemma

- Two prisoners are being interrogated separately about a crime they both participated in.
- Each is offered a plea bargain to cooperate by testifying against the other.
- If both suspects refuse to cooperate, neither can be convicted of a more serious crime though they will have to spend some time in jail.
- But the police have offered full immunity if one cooperates and the other does not.
- If both confess, they will spend more time in jail than if they had both stayed quiet.
A very popular game: the prisoner’s dilemma: payoff matrix

- Two players are in this game: prisoner A and prisoner B
- Each player has two strategies: to testify or to keep quiet
- The numbers in blue are the payoffs of prisoner A.
- The numbers in red are the payoffs of prisoner B.
- If both testify, they will both spend 10 years in jail.
- If both keep quiet, they will both spend only 1 year in jail.
- If one confesses and the other stays quiet, the one who confesses will be immediately released but the prisoner who stayed quiet will spend 25 years in jail.

<table>
<thead>
<tr>
<th>Prisoner A</th>
<th>Testify</th>
<th>Keep quiet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testify</td>
<td>(10,10)</td>
<td>(0,25)</td>
</tr>
<tr>
<td>Keep quiet</td>
<td>(25,0)</td>
<td>(1,1)</td>
</tr>
</tbody>
</table>
A very popular game: the prisoner’s dilemma: payoff matrix (2)

<table>
<thead>
<tr>
<th></th>
<th>Testify</th>
<th>Keep quiet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prisoner A</strong></td>
<td>1 (10,10)</td>
<td>3 (25,0)</td>
</tr>
<tr>
<td><strong>Prisoner B</strong></td>
<td>2 (0,25)</td>
<td>4 (1,1)</td>
</tr>
</tbody>
</table>

- If both prisoners testify (quadrant 1):
  - Prisoner A gets 10 years
  - Prisoner B gets 10 years
- If both prisoners keep quiet (quadrant 4):
  - Prisoner A gets 1 year
  - Prisoner B gets 1 year
- If prisoner A testifies and prisoner B keeps quiet (quadrant 2):
  - Prisoner A goes free
  - Prisoner B gets 25 years
- If prisoner A keeps quiet and prisoner B testifies: (quadrant 3)
  - Prisoner A gets 25 years
  - Prisoner B goes free.
Analyzing the prisoner’s dilemma

• Each suspect is interrogated separately and simultaneously.
• The decisions of each prisoner is therefore made non-cooperatively, which is why they both face a dilemma.
• Dilemma faced by prisoner A if he testifies:
  - He gets 10 years if prisoner B also testifies.
  - He goes free if prisoner B keeps quiet
• Dilemma faced by prisoner A if he keeps quiet:
  - He gets 25 years if prisoner B testifies.
  - He gets 1 year if prisoner B also keeps quiet.
Analyzing the prisoner’s dilemma (2)

- No matter what choice prisoner B makes, prisoner A is always better off choosing to testify.
- In the same way, no matter what choice prisoner A makes, prisoner B is always better off choosing to testify.
- They will end up testifying both and getting a 10-year sentence even though keeping quiet has a better outcome.
- In this game, to testify is called a dominant strategy.
- A dominant strategy is a strategy whose outcome is the best irrespective of the choices of other players.
Finding the dominant strategy in a few games: Game 1

<table>
<thead>
<tr>
<th></th>
<th>Player B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left</strong></td>
<td><strong>Right</strong></td>
</tr>
<tr>
<td>1</td>
<td>(7,2)</td>
</tr>
<tr>
<td>3</td>
<td>(3,4)</td>
</tr>
</tbody>
</table>
Game 1: Player A

• The two players in this game are player A and player B.
• Player A’s strategies are Up and Down.
• Player B’s strategies are Left and Right.
• If player A chooses Up:
  - His payoff is 7 if player B chooses left.
  - His payoff is 5 if player B chooses right.
• If player A chooses Down:
  - His payoff is 3 if player B chooses left.
  - His payoff is 4 if player B chooses right.
• Player A’s dominant strategy is Up because his payoff is the highest irrespective of player B’s choice.
Game 1: Player B

- Player B’s strategies are Left and Right.
- If player B chooses Left:
  - His payoff is 2 if player A chooses Up.
  - His payoff is 4 if player A chooses Down.
- If player B chooses Right:
  - His payoff is 3 if player A chooses Up.
  - His payoff is 6 if player A chooses Down.
- Player B’s dominant strategy is Right because his payoff is the highest irrespective of player A’s choice.