University of Pacific-Economics 53
Lecture Notes #14

I. Introduction to Oligopolies

We have studied two types of industries: perfectly competitive industries and monopolies. We saw that in perfect competition there are many firms, that produce the same product and are price takers. On the other side, a monopolistic industry has just one seller that produces a unique product and can set its own price. An **oligopoly** is somewhere between. An industry is said to be an oligopoly if it is dominated by a few firms who are large enough to influence the market price. One difference between an oligopoly and perfect competition is that because there are only a small number of firms in the industry, the actions of any one of those firms will have a large effect on the other firms. Therefore, firms in an oligopolistic industry must act strategically. That is before a firm takes any action, it has to consider the possible reactions of its rivals. In this lecture, we'll develop the tools necessary to analyze this complex set of decisions for firms.

Economists use **concentration ratios** to measure the degree of concentration in a market. Concentration ratio is computed as the percentage of the market output produced by the largest firms. Some industries have just a couple large firms with a concentration ratio of 90%, with hundreds of smaller firms accounting for the rest of the market share (beer). While other industries have a four firm concentration ratio of 100% (copper).

Other Features of Oligopolies

- **Oligopolies may or may not sell unique products.** In some oligopolies the firms make all the same products, while in others the products are differentiated. The more unique the products produced by oligopolistic firms, the more their behavior will resemble that of a monopolist.
- **Barriers to entry may not be possible.** As with monopolies, oligopolies can earn above normal profits. Such profits may attract other firms to enter the industry. In some oligopolistic industries, the barriers to entry are low enough that firms could enter. These are known as **contestable markets.** The threat of entry will result in oligopolies behaving as if they were in a perfectly competitive situation.

II. Oligopoly Models

Next we turn to see how oligopolies determine the level of output and prices. There are three models that explain the behavior of oligopolistic firms. The key point that you should take from these models is that the actions of an oligopolistic firm depends on the actions of the other firms in the industry.

A. The Collusion Model

The collusion model states that if the small number of firms that make up a oligopoly were able to get together and make price and output decisions jointly the resulting outcome would

be the same as if a monopoly controlled the industry. When a group of firms gets together to make joint price and output decisions it is called a **cartel.**

The best example of a cartel is the Organization of Petroleum Exporting Countries (OPEC) which is a group of 13 countries that meet to determine oil production levels and consequently price levels.

Collusion is illegal under the anti-trust laws of the United States. Collusion is when price and quantity fixing agreements are explicitly determined. Thus we don't see cartels of firms in the United States. The potential for large profits for oligopolistic firms to collude is strong enough to find ways around this. One was is to engage in **tacit collusion** where firms may set similar prices, If there are a small number of firms it is relatively easy for one firm to raise its price and other firms to follow its lead without any formal agreement being made.

In order for cartels to be successful, there are several conditions which must hold:

- **Demand for the cartel's product must be inelastic.** The reason why OPEC can be successful is that there are few substitute for oil. If they cut production and raise the price, consumers have little option but to pay the higher prices. On the other hand if carrot producers tried to set up a cartel for carrots it would not be very successful. As soon as the carrot producers raise their prices, consumers will just switch to other vegetables.
- **Members of the Cartel must not cheat.** This is a hard condition to maintain as firms do have a strong incentive to cheat. For example, suppose that OPEC cuts production and raises prices. A member country such as Venezuela could increase its production and offer a lower price and make large profits as everyone rushes to buy Venezuelan oil. Venezuela can gain market share by cheating at the expense of other countries that follow the agreement. Other countries might have similar thoughts, and if enough of the cartel members cheat the cartel agreement will collapse.

B. Price Leadership Model

In the price leadership model there is one dominant firm and several smaller firms in the oligopoly. The dominant firm sets the price and the smaller firms follow. We assume that the smaller firms can supply as much as they want at the price set by the dominant firm. The dominant firm will produce the quantity demanded in the market net the amount supplied by the smaller firms.

The output produced under the price leadership model will be in between the level produced under a monopoly situation and a perfect competition model. Similarly the price will also be between the monopoly price and a perfectly competitive price. The dominant firm has an incentive to push the smaller firms out of the industry so it can charge a monopoly price and earn more profits. How can the dominant firm accomplish this?

1. **Mergers.** The dominant firm could just merge with the smaller firms until there is just one large firm. However, anti-trust laws prevent this from happening.

2. **Aggressive Price Setting.** Since the smaller firm will match whatever price the dominant firm charges, one strategy for the dominant firm would be to aggressively cut prices to an artificially low level in order to drive the smaller firms out of business. Such a practice is called **predatory pricing.** By charging a price below average variable cost for the smaller firm, the dominant firm can force the smaller firms out of the industry and then it can recoup its own losses by charging higher prices later on. This practice is also illegal under the anti-trust laws.

C. The Cournot Model

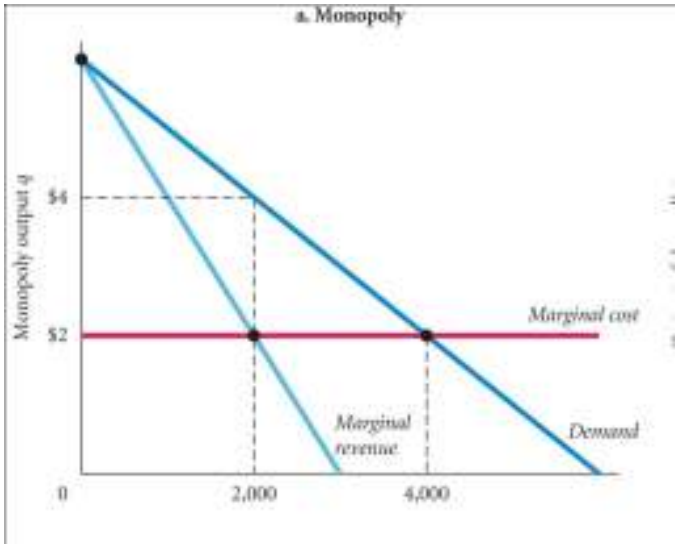
Is a simple model that takes into account that the output decision by an oligopoly firms is based on what other firms.

Cournot Model Assumptions

- **The oligopoly consists of only two firms (duopoly)**
- **The two firms produce identical products**
- **The two firms have identical cost curves**
- **The two firms cannot collude**

Before we delve into the Cournot model let us review the monopoly outcome and the perfectly competitive outcome.

Figure 1



For simplicity we're assuming that the MC=ATC is constant. Recall that under perfect competition the long-run profit will be 0. The perfectly competitive outcome will occur where the demand curve intersects the marginal cost curve. Quantity produced will be 4000 units and the price will be $2. Note that at this output total revenue will be $8000 while total cost is also $8000 leaving zero profit. The monopolist outcome will be where MR=MC. At this point the quantity produced will be 2000 units and the price will be $4.

Perfectly Competitive Outcome
Q_c = 4,000 units
P_c = $2

Monopoly Outcome
Q_M = 2,000 units
P_M = $4

The problem for the duopolist is that the firm when choosing their output levels must take into account the actions of the other firm. For example, if Firm A and Firm B are in a duopoly, Firm A's output decision will depend on how much Firm B produces. The quantity that Firm A can sell is based on the total quantity demanded in the market minus the quantity supplied by Firm B. The more that firm B produces the less Firm A can produce. The goal for a firm in a duopoly is to maximize their profits based on the market that is left.

To analyze duopoly behavior we need to examine the **reaction functions** for each firm. The **reaction function** shows the firm's optimal, profit-maximizing output decision given what the other firm has decided to produce.

Figure 2 shows the reaction function for a duopoly based on the earlier example in Figure 1.

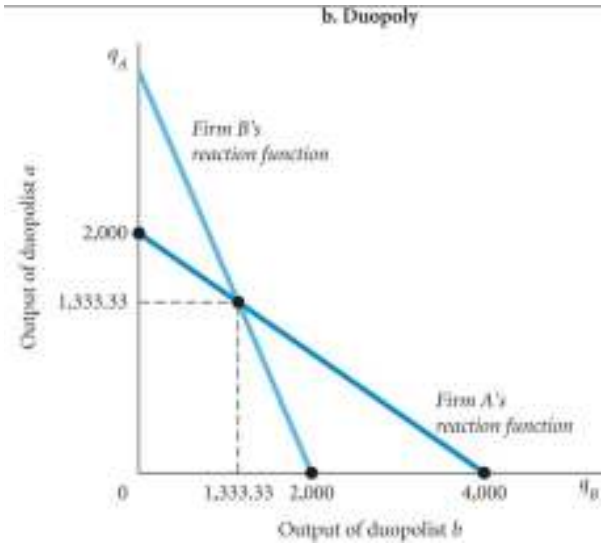


Figure 2 shows the reaction function for Firm A and for Firm B. The Y-axis measures the quantity produced by Firm A. The X-axis measures the quantity produced by Firm B. The output level for the duopoly will be determined where the two curves intersect. At that point 1,333.33 units would be produced by both Firms A and B. Total output in the duopoly will be 2,666.66.

To start with we need to learn how to draw a reaction function for a given firm.

- What is Firm A's optimal output if Firm B decides to produce nothing?

  If Firm B produces zero output, then Firm A becomes the only firm in the industry and will thus produce at the monopolist output level. That is Firm A will produce 2,000 units of output (using our example from Figure 1). Thus one point in Firm A's reaction function is (0,2000).
- What will be Firm A's optimal output level if Firm B decides to produce 4,000 units.

  If Firm B produces 4,000 units then Firm B will be producing at the perfectly competitive outcome. At that output level there will be zero economic profits. If Firm A tries to produce anything beyond that level, then MC will exceed MR and Firm A will lose money. The optimal solution will be for Firm A to produce 0 units. Another point on Firm A's reaction function will be (4,000, 0).

Connecting these two points will yield us the reaction curve for Firm A. The downward slope reveals that as Firm B produces more, Firm A will necessarily produce less.

You can easily derive for yourself the reaction function for Firm B using the same thought process.

Notice that the two reaction curves intersect. The point of intersection is called the **best response equilibrium.** Given the other firm's output production, both firms will do best to produce at the best response equilibrium. In this case both firms will produce 1333.33 units of output. The duopoly total will be 2666.66 units of output. Note that the duopoly outcome is more than the monopoly outcome of 2,000 units but less than the perfectly competitive outcome of 4,000 units.

Also notice that there can only be one best response equilibrium point. To see this suppose that Firm A assumes that Firm B will produce 0 units and will thus produce 2,000 units of output. Firm B sees that Firm A is now producing 2,000 units of good and will respond by looking at their reaction function and seeing what they should produce since A is producing 2000 units. Suppose that amount is 1,000 units. Firm B will now supply 1000 units of good. Firm A now must adjust their production level in response. Initially they had assumed B to produce 0 units, but now B is producing 1000 units, they will thus lower their production based on what their best response function tells them they should do. This will continue until both firms reach the best response equilibrium At that point both firms are doing the best they can given the behavior of the other firm.

III. Game Theory

As we saw with the Cournot Model, the oligopolist output decision is based on what they believe the other firm will do. However, when Firm A makes a decision it only guesses what Firm B's output level will be. Firm A does not take into account that Firm B's output level might change in response to whatever Firm A will do. **Game theory** is a subfield of economics that studies how decisions are made in strategic situations. Game theory provides the necessary tools to analyze how an oligopolist will develop a strategy to maximize profits while anticipating the reactions of rival firms.

A. P ayoff Matrix-The Prisoner's Dilemma

Game theory works just like a game in that there are

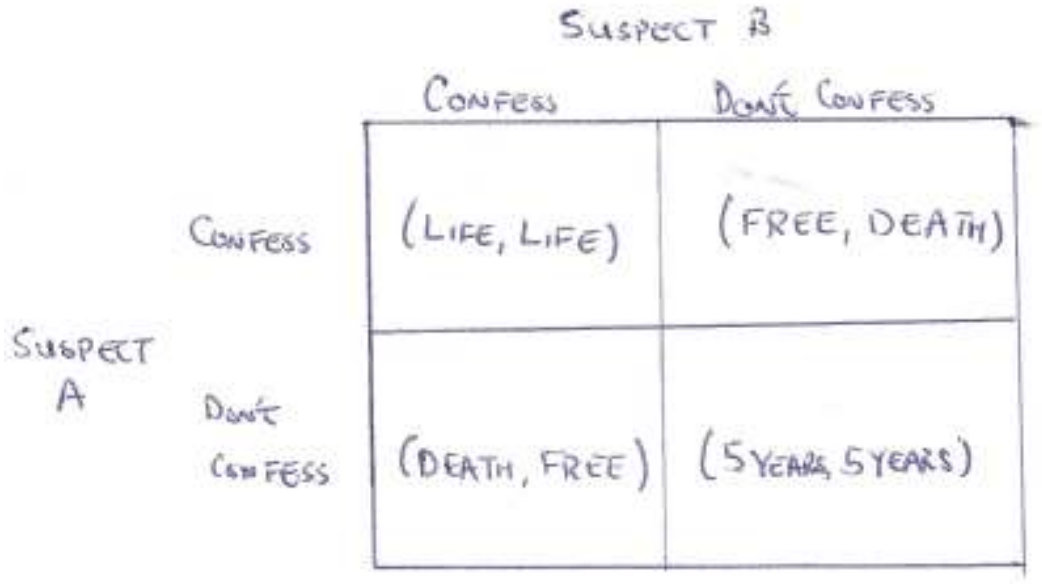
- Players
- Rules of the game
- Payoffs (prizes)

Players try to maximize their payoffs by choosing strategies without knowing what the other player will do with certainty. A common tool used in game theory is a playoff matrix. **A playoff matrix** is a table that shows for each player what the payoffs will be for each possible outcome.

Figure 3 shows the playoff matrix from a game called **the Prisoner's Dilemma.** In this game there are two suspects (Suspect A and Suspect B) that have been arrested driving a stolen car.

The two criminals are also prime suspects in a brutal murder but the District Attorney has no proof. The DA separates the two prisoners during questioning and offers each of them a deal. If one suspect confesses to the murder while the other suspect doesn't confess the one that confesses will get a plea deal and will be released from prison, while the one that doesn't confess will get the death penalty. If neither of them confesses, then both suspects will go to jail for 5 years for the stolen car charge. If both of them confess to the murder then each of them will go to jail for life.

Figure 3



In the playoff matrix, Suspect A's choices are on the left side of the diagram, while Suspect B's choice are on the top of the diagram. The consequences of the decisions made are in the boxes. The payoffs are in parentheses with the consequence for Prisoner A on the left and the outcome for Prisoner B on the right. For example the upper right outcome (FREE, DEATH) indicates that if Suspect A confesses while Suspect B doesn't confess than Suspect A will go free while Suspect B will die.

Suspect A doesn't know what Suspect B will do and vice-versa, but Suspect A can determine what his/her best choice would be depending on what Suspect B does. Suppose that Suspect A guesses that Suspect B will confess, what will be A's best strategy? If Suspect B confesses, then A can choose between confessing (getting LIFE) or not confessing (getting DEATH). Assuming that A would prefer to live rather than die, A's best strategy would be to confess.

- Suspect A's best strategy if B confesses is to **confess.**

What will be Suspect A's best strategy if Suspect B doesn't confess? If B chooses not to confess, then A can choose between confessing (and be set FREE) or not confessing and getting (5 YEARS).

- Suspect A's best strategy if B doesn't confess is to **confess.**

Note that A's best strategy is to confess no matter what B chooses to do. Thus Suspect A will always confess. The fact that A will always confess is called a **dominant strategy.** A dominant strategy is one that is best no matter what the other player chooses to do.

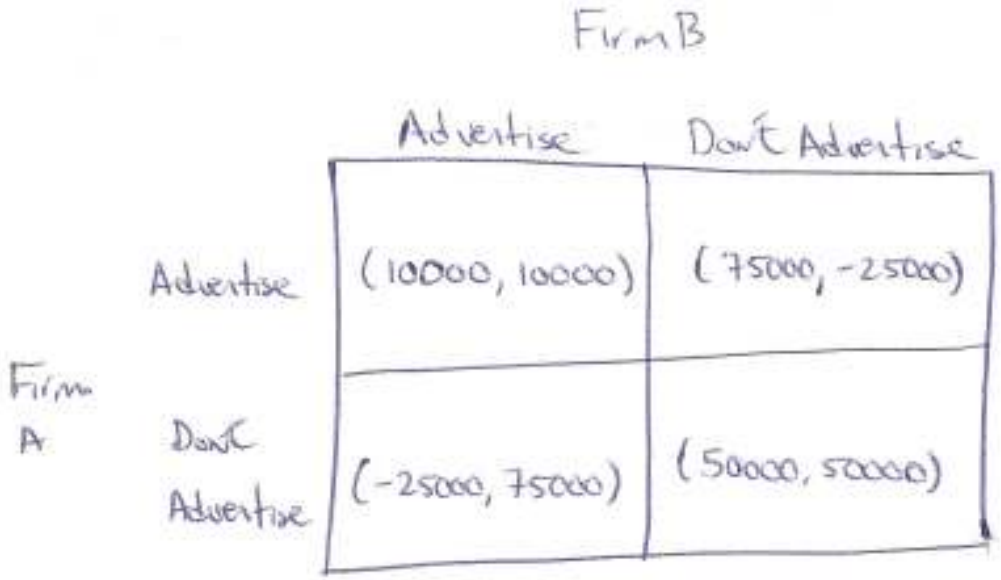
What about Suspect B? Again Suspect B will not know what Suspect A will do. If Suspect B assumes that A will confess then B's best strategy will be to confess as well. While if A chooses not to confess than B's best strategy will be to confess. Thus Suspect B also has a dominant strategy to confess.

The fact that both players have a dominant strategy to confess will result in both players confessing and thus both receiving life prison terms. Note that if they could have gotten together and talked about it they could have agreed to both not confess and have only gone to jail for 5 years. However, there is a strong incentive to go back on the agreement and get a plea deal (there is no honor among thieves) and thus both would probably confess after all.

In this above scenario, both prisoners would have been better off if they could have cooperated, but being prevented to collude, they both pursue a dominant strategy that made them worse off than if they had cooperated.

Figure 4 shows a prisoner dilemma type game when applied to firms. Suppose two firms A and B are deciding whether or not to advertise. If each firm advertises the profit to both firms will be $10,000 each. If neither firm advertises the profits will be $50,000 each. If one firm advertises while the other firm chooses not to advertise the firm that advertises will earn a $75,000 profit, while the other firm will lose $25,000.

Figure 4

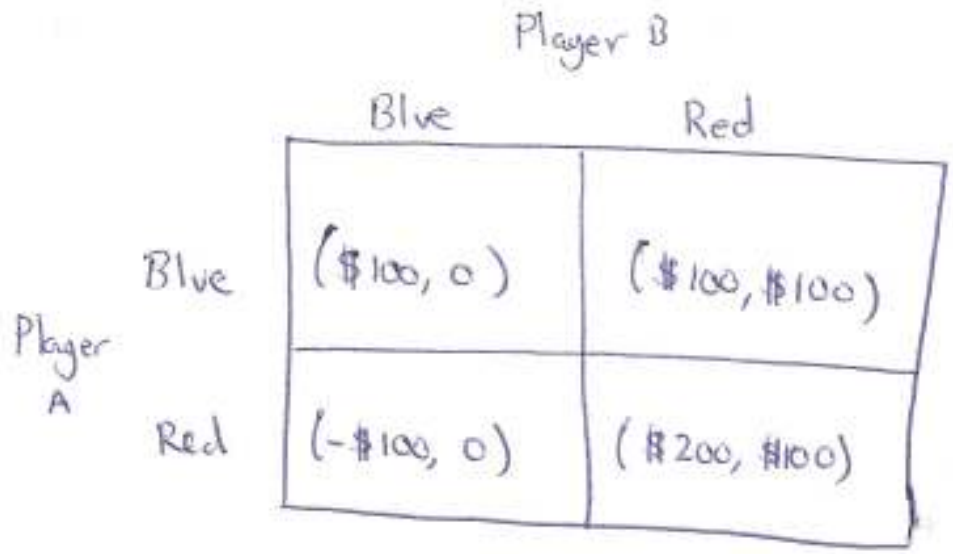


As with the prisoner dilemma game we check to see what the best strategy is for Firm A depending on what Firm B does.

If Firm B advertises, Firm A's best strategy is to advertise ($10,000 profit is better than a $25,000 loss). Similarly, if Firm B chooses not to advertise, Firm A will still choose to advertise ($75,000 is bigger than $50,000). Firm A will choose to advertise no matter what Firm B does. Firm A has a dominant strategy to advertise.
Using similar logic we can find that Firm B also has a dominant strategy to advertise no matter what Firm A does. In the end both firms will advertise and thus will both end up with $10,000 profit. Again, if they were allowed to collude, both would have agreed not to advertise and would have ended up with higher profits each.

B. Nash Equilibrium

Figure 5 shows another payoff matrix game. In this game the two players have to write "BLUE" or "RED" on a slip of paper. If both players write BLUE, then Player A will get $100, while Player B gets nothing. If on the other hand both players write RED, then Player A will get $200, while Player B will get $100. If Player A chooses BLUE, while Player B chooses RED, then both will get $100. If Player A chooses RED while Player B chooses BLUE then A will lose $100 while B will get $0.
Figure 5



What will Player's A's best strategy be in this game?
If Player B chooses BLUE, Player A's best strategy will be to also pick BLUE.
If Player B chooses RED, Player A's best strategy will be to pick RED

Here Player A has no dominant strategy. Player's A best strategy depends on what B chooses. Does that mean we won't be able to predict the outcome of this game? Well look at Player B's choices. If Player B chooses BLUE, B is guaranteed to get $0. If Player B chooses RED he's guaranteed to get $100. Player B will thus always pick RED.

Player A will know this and will thus always choose RED as well. The outcome RED, RED will be the final outcome of this game. This type of equilibrium is called **Nash Equilibrium.** A

Nash Equilibrium is one in which player's play their best strategy given what their competitors are doing.

C. Repeated Games

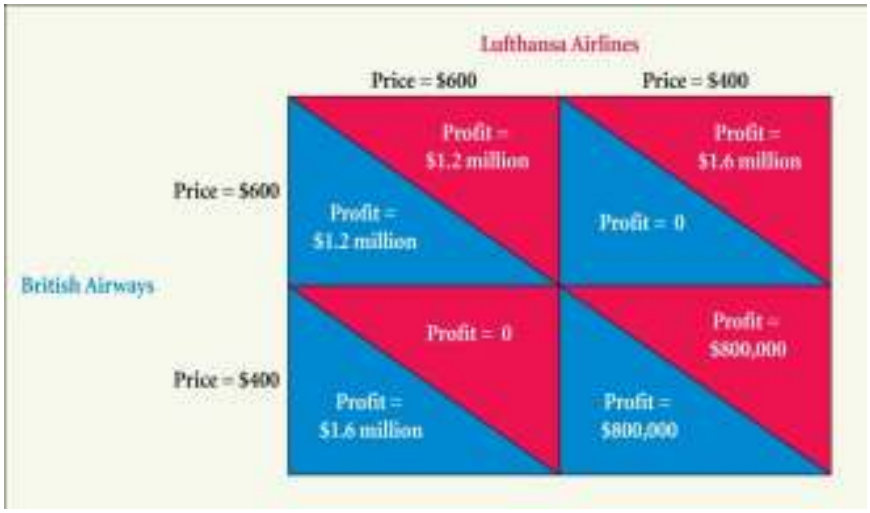


Figure 6 shows another playoff matrix for two airlines: Lufthansa and British Airways. Both are deciding what to charge for a flight from London to New York. The options are either to charge a high price ($600) or a discounted price ($400).

If both airlines charge the high price they both make $1.2 million in profit. If both charge the low price then they both will only make $800,000 in profit. If one charges a low price, while the other charges a high price, then the airline that charges a low price will gain the entire market share and will make a profit of $1.6 million.

Justify to yourself that both airlines has a dominant strategy to charge the $400 ticket. Thus the Nash Equilibrium will be where both firms earn $800,000 in profit. The equilibrium is not ideal from the perspective of the airlines because if they had coordinated they could have earned $1.2 million each in profit.

However, the Nash Equilibrium outcome applies to a game played only once. What if British Airways and Lufthansa played this same game a number of times? Suppose that after 4 months of playing this game and both firms charging $400, British Airways suddenly decides to raise its price to $600. Although Lufthansa will be inclined to keep charging $400, they will be curious as to way British Airways would raise its price knowing that their profits would go to 0. British Airways executives might be signaling to their counterparts at Lufthansa that both firms would be better off charging $600 and is signaling that Lufthansa should follow suit. This type of strategy only works in a game that is repeated and is called a **tit for tat strategy.**

If the signaling is effective then both airlines will charge $600 a ticket and earn higher profits.

IV. Oligopoly and Economic Performance

As we have seen an oligopoly outcome will result in output and prices that are somewhere between the perfectly competitive outcome and the monopoly outcome. The fact that oligopolies produce output less than the perfectly competitive situation implies that there is some social inefficiency.

However, there are some potential benefits to the oligopoly structure. One theory put forth by Joseph Schumpeter argue that oligopoly market structure is good for advancing technological change. The idea is that oligopolies can earn and keep profits that result from a new technology. Thus big firms have an incentive to conduct research and development.

V. Oligopoly and the Role of Government

Anti-trust laws prevent one single company from gaining a large market share in an industry through mergers. The government has to approve any merger proposal and will reject a merger that would lead to a too large a market share for the combined company. The **Herfindahl-Hirschman Index** is the measure of market structure the government uses to determine market concentration. The index is found by summing the square of the percentage shares of firms in the market.

For example suppose there are only 2 companies in an industry (duopoly) each with a 50% market share. The HHI for this industry would be: $HHI = 50^2 + 50^2 = 5000$

Suppose there was another industry with 4 companies each with a 25% market share. The HHI for this industry would be: $HHI = 25^2 + 25^2 + 25^2 + 25^2 = 2{,}500$

Given the HHI in the industry, the government will then calculate what effect a proposed merger would have on the HHI index.

- If the HHI < 1000: The industry is un-concentrated and the merger will be allowed to proceed.
- If 1000 < HHI < 1800: The industry is somewhat concentrated. A merger will be rejected if the HHI increases by over 100 points as a result of the merger.
- If HHI > 1800: The industry is highly concentrated. A merger will be rejected if the HHI increases by over 50 points as a result of the merger.

A recurring debate in calculating HHI is what defines an industry/market. For example the more narrowly define a market the higher the HHI index will be. For example, suppose Coca Cola wanted to merge with 7-UP is the relevant market the soda-market (in which case the merger would probably be blocked) or would it be the beverage market (Coca-Cola has less of a concentration on the overall beverage market).