Oligopoly

Under perfect competition, a firm is too small to worry about how their rivals will react to its output decision. Under monopoly, there are no rivals to react to its output decision.

Under oligopoly, before a firm can calculate its optimal strategy, it must anticipate what its rivals think its strategy will be (in order to figure out what they will do).

Game Theory is designed to address these strategic interactions.

A *game* is a set of players, a set of feasible strategies for each player, and an outcome function which specifies each player's payoff as a function of the strategies selected.

A *Nash equilibrium* of a game is a choice of strategies, one for each player, for which no player can receive a higher payoff by deviating to another strategy, holding the other players' strategies constant.

Example: Prisoner's Dilemma

		Pepsi	
		high	low
Coke	high advertising	1,1	3,0
	low advertising	0,3	2,2

Equilibrium is (high,high). No matter what the other player does, you are better off with high.

This is not purely confrontational. Both players could benefit by signing a binding contract.

There should be a match between the environment to be understood and the game you specify. The following details can be important:

1. Whether the strategic choice is price, quantity, or something in between (for example, if firms set prices but limit their quantity.

2. The timing of who moves first, or if moves are simultaneous.

3. Whether firms know their own costs or not; whether firms know the costs of other firms.

4. Whether consumers know the prices being charged before they choose a firm.

5. Do all firms produce perfect substitutes, or is there brand loyalty?

Quantity Competition vs. Price Competition

In the oil industry, competition is probably best described as choosing the quantity of oil to produce. By the time the market opens, players have largely committed to the quantity of oil they want to sell.

Firms bidding for contracts to supply the government or "downstream" firms are engaging in price competition. The lowest bid is the price, and the firm placing the lowest bid supplies whatever quantity is demanded.

Cournot (Quantity) Competition

For $i = 1, 2$, the strategic choice for firm i is its output quantity, x_i. Given the outputs of the two duopolists, the price is determined by the inverse demand curve, $p_x(x_1 + x_2)$.

Given how profits depend on x_1 and x_2, we can solve for the Nash equilibrium, where each firm's output is a best response to the other firm's output.

Example: Each firm has the cost function, $TC = 20x_i$, so average and marginal cost equals 20.

The market demand curve and inverse demand curves are

$$\begin{aligned} x &= 80 - p_x \\ p_x &= 80 - x = 80 - x_1 - x_2. \end{aligned}$$

Let us look at firm 1's optimization problem. Profits are

$$\pi_1 = (80 - x_1 - x_2)x_1 - 20x_1. \tag{1}$$

Firm 1's best response to x_2 (or what it believes will be x_2) is found by differentiating π_1 with respect to x_1.

$$\frac{\partial \pi_1}{\partial x_1} = 0 = 80 - 2x_1 - x_2 - 20.$$

Solving for x_1, we have

$$x_1 = \frac{60 - x_2}{2}. \tag{2}$$

Equation (2) is called firm 1's *reaction function*, because it shows how firm 1 optimally reacts to expectations of its rival's strategy.

Notice that if $x_2 = 0$, firm 1's best response is to produce the monopoly quantity, 30.

The same procedure allows us to calculate the reaction function for firm 2:

$$x_2 = \frac{60 - x_1}{2}. \tag{3}$$

The *Nash equilibrium* occurs when neither firm has an incentive to change its strategy, so we are on both reaction functions. Solving (2) and (3) simultaneously, we have

$$\begin{aligned} x_1 &= 20, \quad x_2 = 20, \text{ and therefore} \\ p_x &= 40, \quad \pi_1 = \pi_2 = 400. \end{aligned}$$

Notice that the price is between the monopoly price, 50, and the competitive price, 20.

Analysis of a Cartel

If the two firms could conspire, they could increase profits by reducing their output to 15 (half the monopoly output). Then we would have $p_x = 50$, $\pi_1 = \pi_2 = 450$.

However, this is not a Nash equilibrium, and there is a tendency to cheat. From (2), firm 1's best response to $x_2 = 15$ is 22.5, which would yield $\pi_1 = 506.25$.

This example illustrates why cartels are difficult to maintain. There is too much temptation to cheat, especially if it takes time for rivals to see that you are overproducing.

Repeated Quantity Competition

Oligopolies usually compete repeatedly over time, which changes the game. A strategy now specifies your output, as a function of the observed *history* of outputs. This opens the possibility of rewards and punishments.

Here is a strategy for firm 1, where $x_1(t)$ is firm 1's output in round t:

$$\begin{aligned} x_1(t) &= 15 \quad \text{if} \quad x_2(1) = \cdots = x_2(t-1) = 15 \\ x_1(t) &= 20 \quad \text{otherwise.} \end{aligned}$$

In other words, firm 1 produces the cartel output as long as firm 2 has never cheated, but reverts to the one-shot Nash equilibrium if firm 2 ever cheats.

If both firms adopt the above "trigger" strategy, that is a Nash equilibrium. A firm that deviates to an output other than 15 at best receives profits of 506.25 during the round it cheats. However, its profits are reduced from 450 to 400 every round afterwards.

Repeated play allows for *tacit collusion*, where there is no conspiracy needed. The collusive cartel outcome is self-enforcing. Thus, oligopolists can sometimes achieve cartel profits legally.

Price Competition

Now firm i's strategy is its choice of price, p_x^i. Given the prices, the firm offering the lower price supplies whatever is demanded at that price. If both firms set the same price, they split the market.

For our example, the solution is marginal cost pricing, $p_x^1 = p_x^2 = 20$. Raising your price loses all customers, and lowering your price yields negative profits. Fierce competition to undercut your rival.

If the two firms frequently bid against each other, tacit collusion is again possible.

With quasi-fixed costs, some degree of tacit collusion might be the only way to avoid monopoly (since no one wants to be the second firm in)!

Miscellaneous

1. First mover advantage–installed capacity becomes a fixed cost and can act as a threat. Now your *marginal* costs are lower than the long run marginal cost of someone who has not yet entered.

2. Second mover advantage–observe the incumbent, avoid R&D expenditures or better learn the nature of demand.

3. Weakness can be strength–the incumbent will resist cannibalizing its current profitable product. Also, a small firm may not have to worry about attack (3 person duel).

4. Raise the cost of your rivals–encouraging costly regulation could be to your advantage.