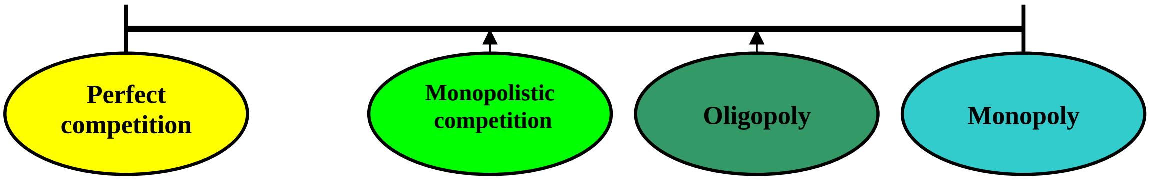
Lecture 08 – Market Structure (II)

A. Oligopoly

1. Spectrum of market structure



Most markets are neither perfectly competitive nor monopolistic but they may fall somewhere in between along the spectrum. Typical market will have more than one seller of the same or similar products, but not enough to justify the assumption that sellers simply take prices as given. Thus, each firm will have an *individual, downward sloping demand* curve and is said to have "some level" of monopoly power.

2. Oligopoly

Oligopoly is from the Greek word "*oligospolein*" meaning "*few to sell.*" And it is reflecting the *interdependence* among firms, which means oligopoly or imperfectly competitive firm must take account of its rival's actions in making its own pricing decisions. So, studies of oligopoly can give us good information about competitions among firms, strategic reaction or decision-making process and trend of market shares of firms.

The most modern approach is to model such firms as choosing "strategies" or playing "games" with one another. This approach is called game theory.

3. Early Generalized Model

<u>Assumptions</u>

- N firms producing homogeneous and standardized products.
- Input market is perfectly competitive.
- No entry is allowed.

From these assumptions, we can derive several things;

1) Inverse demand function is expressed as

$$p = f(Q) \qquad (i)$$

, where $Q = \sum_{i=1}^{N} q_i$ (market quantity).

2) Profit of each firm will be $\pi_i = p(Q)\cdot q_i - c_i(q_i),\ i = 1,\ 2,\ \cdots,\ N \qquad (ii)$

3) FOC of profit maximization is $\dfrac{d\pi_i}{dq_i} = p + q_i \dfrac{dp}{dQ}\dfrac{dQ}{dq_i} - \dfrac{dc_i(q_i)}{dq_i} = 0 \qquad (iii)$

cf) $\dfrac{dQ}{dq_i}$ means that a change in product of *i-th* firm can affect the change in total product or change in products of other firms.

4) We need to know the value of dQ/dq_i . Rewriting this, we can get

$$\frac{dQ}{dq_i} = \frac{dq_i}{dq_i} + \frac{dQ_{-i}}{dq_i} \quad \left(\because Q = \sum_{i=1}^{N} q_i = \sum_{i \neq j=1}^{N} q_j + q_i .\ Q_{-i} = \sum_{i \neq j=1}^{N} q_j \right) \quad (iv)$$

$\boxed{\frac{dQ_{-i}}{dq_i}}$: the ratio of change in products of other firms to the change in *i-th* firm.

$\Rightarrow$ ***Conjectural Variation (C.V.)***

So, equation (*iv*) is now $\boxed{\frac{dQ}{dq_i} = 1 + \lambda_i}$ (*v*)

(This is the most important factor in Oligopoly. We can figure out different types of oligopoly as λ changes)

Putting aside the discussion about λ_i, we need to derive the generalized result by assuming that c_i (cost structure) and λ_i are constant across individual firms. Therefore,

5) From (*iii*) and (*v*), we can get $p - MC_i = -q_i \frac{dp}{dQ}(1+\lambda)$

$\frac{p - MC_i}{p} = -\frac{q_i}{Q} \cdot \frac{Q}{p} \cdot \frac{dp}{dQ} \cdot (1+\lambda)$. $\boxed{\text{Lerner Index} = \frac{k_i(1+\lambda)}{\varepsilon}}$ (*vi*)

(k_i is market share of *i-th* firm. ε is price elasticity of market demand)

From (*vi*), assuming that every firm has the same size, then $k_i = 1/N$.

$$\boxed{\frac{p - MC_i}{p} = \frac{(1+\lambda)}{N \cdot \varepsilon}} \quad (vii)$$

6) So, Lerner Index or monopoly power can be determined by N, ε, and λ.

Ex) In perfect competition, $p = MC_i$ ($\because N \to \infty$ and $\varepsilon = \infty$)

In monopoly, $N = 1$, $\lambda = 0$. So, $\frac{p - MC_i}{p} = \frac{1}{\varepsilon}$

For more generalized case, we can relax the assumption that λ is constant. So, assuming that λ_i and k_i can vary among the firms, then we get

$$\boxed{\frac{p - MC_i}{p} = \frac{k_i(1+\lambda_i)}{\varepsilon}} \quad (viii)$$

7) Let's think about the industry (But, assume that $\boxed{MC = AC}$)

Rewriting equation (*ii*), we can get

$$\pi_i = p(Q) \cdot q_i - c_i'(q_i) \cdot q_i, \; i = 1, 2, \cdots, N \quad (ix)$$

Let Π denote the industry profit or aggregate profits, then

$$\Pi = \sum_{i=1}^{N} \pi_i = \sum p(Q) \cdot q_i - \sum q_i \cdot c_i'(q_i) \quad (x)$$

8) From (*viii*), multiplying by q_i on both sides and summing up from 1 through *N*, we get

$$\frac{\sum pq_i - \sum c_i' q_i}{p} = \frac{\sum k_i(1+\lambda_i)q_i}{\varepsilon}. \text{ And } \frac{\sum pq_i - \sum c_i' q_i}{pQ} = \frac{\sum k_i(1+\lambda_i)q_i}{\varepsilon \cdot Q} = \frac{\sum k_i^2(1+\lambda_i)}{\varepsilon} \quad (xi)$$

From equation (*x*) and (*xi*),

$$\frac{\Pi}{TR} = \frac{\sum k_i^2(1+\lambda_i)}{\varepsilon} = \frac{HHI(1+\lambda_i)}{\varepsilon} \qquad (xii)$$

, where $HHI = \sum_{i=1}^{N} k_i^2$ (***Herfindahl-Hirschmann Index***)

9) From (xii), $l.h.s$ is called Industrial Rate of Return, which can reflect the performance of the industry.

10) If MC_i, k_i, and λ_i are constant, $HHI = \sum_{i=1}^{N} k_i^2 = \frac{1}{N}$ (why?)

$$\frac{\Pi}{TR} = \frac{(1+\lambda)}{N\varepsilon} = \frac{(p-MC)Q}{pQ} = LI \qquad (xiii)$$

In conclusion,

1. As $N \to \infty$,
   - Conjectural variation $(\lambda_i) \to 0$
   - Negligible market share $(k_i) \to 0$
   - Low HHI $(HHI) \to 0$

Therefore, from (xii), the value on $r.h.s.$ will go to zero, which is analogous to the perfect competition with $p = MC$.

2. If monopoly, $N = 1$, $k_i = 1$ (or 100%), $HHI = 1$ (or 10000), and $\lambda_i = 0$.

$\therefore$ ***(Price-cost margin in monopoly) = (industrial rate of return)***

$$\frac{p-MC}{p} = \frac{1}{\varepsilon} = \frac{\Pi}{TR}$$

4. Cournot Duopoly (Augustine A. Cournot, 1838)

1) Assumptions

- * $\lambda_i = dQ_{-i} / dq_i = 0$
- * Each firm determines products that maximize their profits taking the products of rivals' constant.
- * Market demand is $P = a - Q$ ($a > 0$) and $Q = q_1 + q_2$ (Q is the total quantity of spring water sold in the market per unit of time).
- * For simplicity, $MC = AC = c$.

2) Model

- * Firm 2 assumes that firm 1 is producing q_1 and it produces q_2 as the best response to q_1.
- * So, the economic profit for firm 2 is as follows,

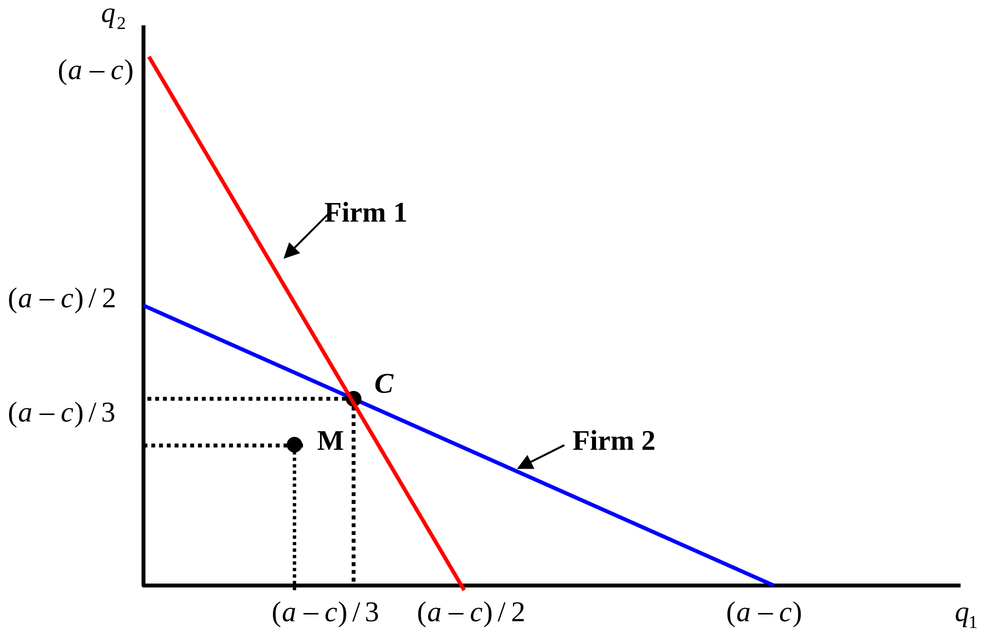
$\pi_2 = (P-c)q_2 = (a-c-q_1-q_2)q_2$.

$\frac{\Delta \pi_2}{\Delta q_2} = a - c - q_1 - 2q_2 = 0$ (i). From (i), we get the best response of firm 2 to q_1 of firm 1,

$$q_2 = \frac{a-c-q_1}{2} \quad \text{(ii): } \textbf{Reaction Curve of firm 2}$$

* In the same way, we get reaction curve of firm 1.

$$q_1 = \frac{a-c-q_2}{2} \quad \text{(iii): } \textbf{Reaction Curve of firm 1}$$



* **Cournot-Nash Equilibrium**

$$q_1^* = q_2^* = \frac{a-c}{3}$$

$$P^* = a - 2q_1^* = \frac{a+2c}{3}$$

$$\pi_c = \frac{(a-c)^2}{9} = (P^* - c)q_1^*$$

* Suppose firm 1 and firm 2 decide to make a Cartel and act as "collective monopolist."
Then what are the profits of two firms? And what is the monopolistic product? (MR = MC)
Given demand curve is $P = a - Q$. $TR = PQ = (a-Q)Q$. And $MR = a - 2Q$, and $MC = c$

$\therefore MR = a - 2Q = c = MC$. So, $Q_m = \frac{(a-c)}{2}$

If these two firms produce the same quantities, then $q_1 = q_2 = \frac{(a-c)}{4}$.

And $P_m = \frac{a+c}{2}$, $\pi_m = \frac{(a-c)^2}{8}$, which is bigger than profit at point C ($\pi_c = \frac{(a-c)^2}{9}$).

* If the two firms make a Cartel and determine their quantities cooperatively, then their economic profits are higher than those of Cournot-Nash equilibrium. Therefore, there is a good reason and motive to cartelize or to collude.

* But, why do we call C as an equilibrium point, not M? Or, why is not M an equilibrium? Because there is another motive to cheat by increasing quantity to earn more profit at point M.

* If firm 1 produces $q_1 = \frac{a-c}{4}$ and keeps the Cartel but firm 2 does not, then the profit function of firm 2 is as follows: $\pi_2 = (a - c - \frac{a-c}{4} - q_2)q_2 = (\frac{3}{4}(a-c) - q_2)q_2$.

$$\frac{\Delta \pi_2}{\Delta q_2} = \frac{3}{4}(a-c) - 2q_2 = 0.$$

$q_2 ** = \frac{3}{8}(a-c)$, which maximizes economic profit of firm 2. Hence, firm 2 breaks the cartel and produces more. Market price of firm 2's products is $P_2 = \frac{3a+5c}{8}$ and

$$\pi_2 = \frac{9}{64}(a-c)^2 > \frac{1}{8}(a-c)^2.$$

* Firm 2 has a motive to cheat firm 1. Vice versa. So, one-shot cartel is unstable.
* Cartel is easy to collapse. But, if the cartel is made among few firms for relatively long periods, then it can be sustained longer with efficient and severe punishment or penalty on the violators.

5. Generalization to Oligopoly

$$\begin{cases} P = a - Q,\ a > 0. \\ Q = \sum_{i=1}^{n} q_i \end{cases}$$

$$\pi_i = (p-c)q_i = [a - c - (q_1 + q_2 + \cdots + q_i + q_{i+1} + \cdots + q_n)]q_i$$

$$\frac{d\pi_i}{dq_i} = [a - c - q_1 - q_2 - \cdots - q_{i-1} - 2q_i - q_{i+1} - \cdots - q_n] = 0$$

$$\Rightarrow q_1 + \cdots + q_{i-1} + 2q_i + q_{i+1} + \cdots + q_n = a - c$$

Assuming that $c_i = c = MC_i = AC_i,\ \forall i\ (q_j = q^*)$

$$q^* = \frac{a-c}{n+1},\ p^* = \frac{a+nc}{n+1},\ \pi^* = \frac{(a-c)^2}{(n+1)^2}$$

If $n = 2$, we get the same results in Cournot Duopoly.

6. Bertrand's Paradox

1) Assumptions
* Each firm is assuming that the prices of other firms are constant in deciding the quantities.
* So, in this model we can think about the motive to set a lower price than any other firm.
* Price-undercutting and finally up to most competitive level.

2) Model

Unlike Cournot model, firms will determine the price. And quantity is decided in accordance with the price.

* Market Demand: $P = a - Q$ or $Q = a - P$ ($a > 0$)

Suppose there are two floppy diskette companies TDK and Maxell. Assuming that the diskettes are entirely identical in every aspect, then consumers try to purchase a cheaper one.

$$\begin{cases} \text{If } P_T < P_M,\ Q_T = a - P_T = Q \text{ and } Q_M = 0 \\ \text{If } P_T = P_M,\ Q_T = \frac{1}{2}(a - P_T) = Q_M \\ \text{If } P_T > P_M,\ Q_T = 0 \text{ and } Q_M = a - P_M = Q, \text{ where } Q = Q_M + Q_T. \end{cases}$$

The unique (Nash) equilibrium is accomplished if $P_T = P_M = c$, and at this level

$\pi_T = \pi_M = (c-c)\times\frac{1}{2}(a-c) = 0$.

* The rationale is as follows;

At $P_T = P_M = c$, no firm can set a price lower than *c*. If $P_T > c$, then Maxell can dominate the market by setting $P_M < P_T$ even slightly.

$$\begin{cases} \text{If } P_T > P_M,\ \pi_T = (P_T - c)\times 0 = 0 \\ \text{If } P_T = P_M,\ \pi_T = (P_T - c)\times\frac{1}{2}(a - P_T) \\ \text{If } P_T < P_M,\ \pi_T = (P_T - c)\times(a - P_T) \end{cases}$$

* For example, if TDK sets $P_T = P_M - \varepsilon$ ($\varepsilon > 0$), then its profit will be $(P_M - \varepsilon - c)(a - P_M + \varepsilon)$. Simply, as ε approaches to zero, its profit will go to $(P_M - c)(a - P_M)$. If TDK sets $P_T = P_M$, profit is $\frac{1}{2}(P_M - c)(a - P_M)$, which is about half of $(P_M - \varepsilon - c)(a - P_M + \varepsilon)$.

Ex) Suppose $a = 2000$, $c = 800$, $P_M = 1000$, and $P_T = 999$, $\varepsilon = 1$.

Maxell earns 0, and TDK earns $(999-800)\times(2000-999) = 199{,}199$.

If $P_T = P_M = 1000$, $\pi_T = \frac{1}{2}(1000-800)(2000-1000) = 100{,}000$

7. Product Differentiation

1) Model

* Small Car Market (Oligopoly)

Two Firms: Ford (Firm 1) and Toyota (Firm 2) with Focus and Echo, respectively.

* For simplicity, assume that $MC_F = AC_F = c = AC_T = MC_T$.

Demand facing Ford is assumed to be $\boxed{Q_F = a - P_F + \beta\cdot P_T}$ (*i*).

* If $\beta > 0$, the increase in P_T will increase Q_F. It means Focus and Echo are substitutes.

* If $\beta < 0$, two products are complements.

2) Analysis

Let's get best response of Ford to P_T.

$\pi_F = (P_F - c)Q_F = (P_F - c)(a - P_F + \beta\cdot P_T)$ (*ii*)

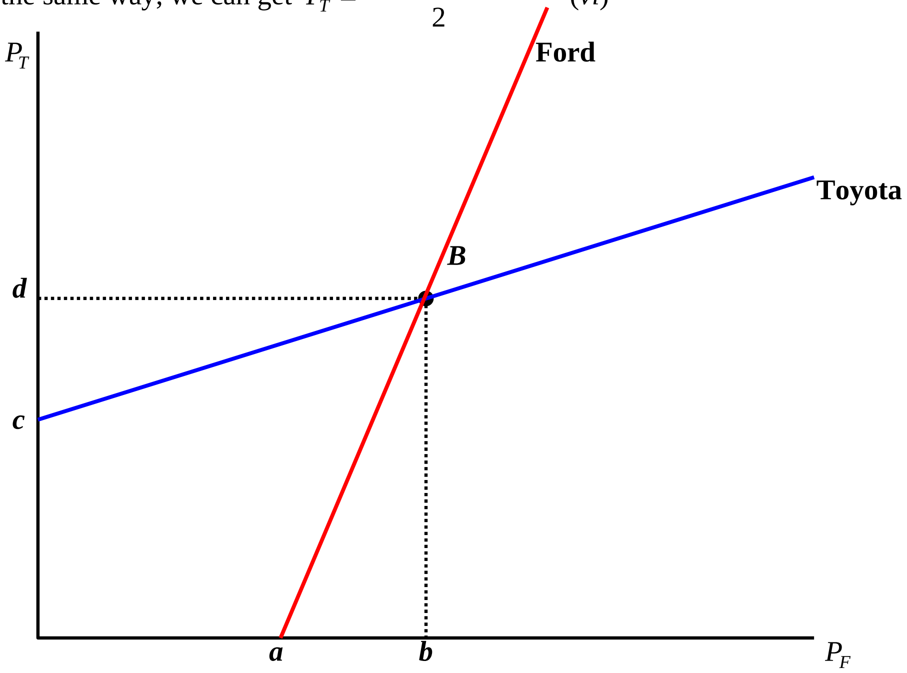
$\frac{d\pi_F}{dP_F} = a + c - 2P_F + \beta\cdot P_T = 0$ (*iii*)

The reasonable price P_F is $P_F = \dfrac{a + c + \beta \cdot P_T}{2}$ (*iv*) (Ford's reaction curve to Toyota's price)

For example, if Toyota sells Echo at $P_T = c$, then Ford's best way to maximize its profit is to sell Focus at $P_F = \dfrac{a + c + \beta c}{2}$.

Suppose the demand facing Toyota is $\boxed{Q_T = a - P_T + \beta \cdot P_F}$ (*v*)

In the same way, we can get $P_T = \dfrac{a + c + \beta \cdot P_F}{2}$ (*vi*)



Point *a* and *c*: $\dfrac{a + c}{2}$

Point *b* and *d*: $\dfrac{a + c}{2 - \beta}$

If $0 < \beta < 2$, then Focus and Echo have substitutability in some degree.

At **B**, $\boxed{P_F{*} = P_T{*} = \dfrac{a + c}{2 - \beta}}$, $0 < \beta < 2$. And $\boxed{Q_F{*} = Q_T{*} = \dfrac{a + (\beta - 1)c}{2 - \beta}}$

If $\beta < 0$, we get the same results. But reaction curves are downward sloping.

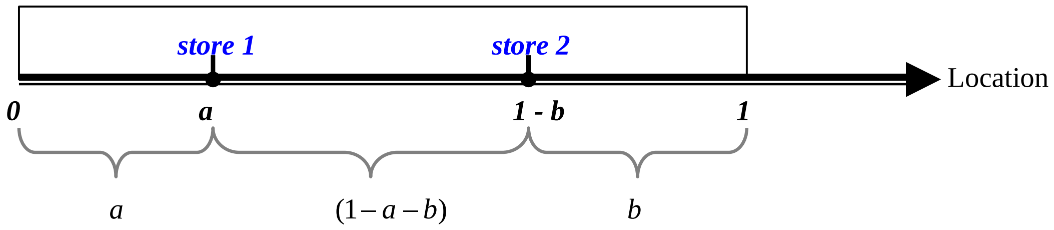
If $\beta > 2$, $P_F{*}, P_T{*} < 0$. In practice, $P_F{*} = P_T{*} = c$

As β goes up, the substitutability will go up, which means there are almost identical products. So, it is same in the perfect competition pricing.

8. Location Game

Brands compete more vigorously with brands that are close substitutes than with those that consumers view as less close substitutes. Consumers view certain brands as closer substitutes than others. Simply, certain brands have particular common characteristics that other lack. That is, each brand is "located" at a particular point in product characteristic space. Or, products sold at nearby stores are close substitutes. That is, each firm is located at a particular address or point in geographic space.

1) Hotelling's Model (1929)
* Consider a long, narrow city with only one street which is 1 mile long.
* Consumers are uniformly distributed between 0 and 1.
* Each has to purchase one unit of product.
* Two stores are selling almost identical product at the same price and try to maximize profits.
* Consumers will purchase at the nearest store because they have to incur transaction cost (travel, time, waiting, …).



* Suppose two stores have to locate at the same time before they start to sell. Consumers living on the left of store 1and half of consumers living between store 1 and 2 will choose store 1.
* Store 1's market share $= a + 0.5(1 - a - b) = 0.5(1 + a - b)$
  Store 2's market share $= b + 0.5(1 - a - b) = 0.5(1 - a + b)$
* The equilibrium in this location game is where two stores are located in the center of this linear city. $\boxed{a = 0.5 = (1 - b)}$
* Intuitively, if store 1 is at $a = 0.5$, then the best response of store 2 is to locate at $b = 0.5$ to maximize its share. But, if store 2 is at $(1 - b) > 0.5$, then it has less 50% of total share. If store is at $a = 0.3$, store 2 can maximize its share by locating at $(1 - b) = 0.3$, right next to store 1.

The equilibrium when there are two firms suggested to Hotelling that "Buyers are confronted everywhere with an excessive sameness" (1929). The result that two firms in either product or geographic space will locate in the middle is often referred to as the principle of minimum differentiation (K. Boulding, 1966). The principle does not hold strictly when there are more than two firms. However, even when there are more than two firms, the equilibrium market configuration is characterized by "bunching."

* ***Economic Implication: Adopting this model to product Differentiation***
  Two competitive firms in duopoly will have a strategy for medium consumers as main target in design, character or quality. And the degree of differentiation is trivial.
  Ex) Even in political science, U.S. has two party politics system. Democrats and Republican. They take public pledge or commitments which are so similar or vague which are not easily distinguishable.

9. Stackelberg's Duopoly (Leader-Follower Model)

In Cournot's duopoly, we assumed that $\lambda = 0$. But, if the decision on production is sequential or if there is a gap in competitive power, then one firm acts as a leader and the others as followers. Stackelberg showed another duopoly model with leader and followers. In his model, leader acts as if the other firm's output is constant, and followers, however, choose optimal products in response to leader's output.

1) <u>If leader/follower are predetermined</u>
* Firm 1 (leader) and Firm 2 (follower). Identical in almost every aspect.

* Market demand: $P = a - (q_1 + q_2)$, same demand in Cournot model.
* $MC_1 = AC_1 = c = AC_2 = MC_2$
* If q_1 is determined, q_2 that maximizes π_2 will be: $q_2 = \frac{a-c-q_1}{2}$ (i)
* And, Firm 1 (leader) can expect that Firm 2 will produce $q_2 = \frac{a-c-q_1}{2}$ if Firm 1 produces q_1.

So, plugging the reaction curve of Firm 2 into π_1,

$$\pi_1 = (p-c)q_1 = (a-c-q_1-q_2)q_1 = \frac{a-c-q_1}{2} \times q_1 = \frac{a-c}{2}q_1 - \frac{1}{2}q_1^{\,2} \qquad (ii)$$

$$\frac{d\pi_1}{dq_1} = \frac{a-c}{2} - q_1 = 0, \; q_1{*} = \frac{a-c}{2} \qquad (iii)$$

* By the way, the Firm 2 (follower) will produce q_2 in response to $q_1{*} = \frac{a-c}{2}$.

$$q_2{*} = \frac{a-c-\frac{a-c}{2}}{2} = \frac{a-c}{4} \qquad (iv)$$

* So, market product $Q = q_1{*} + q_2{*} = \frac{3(a-c)}{4}$ (v)
* Market price is $P{*} = a - \frac{3(a-c)}{4} = \frac{a+3c}{4}$ (vi)
* $\pi_1^* = (P^* - c)q_1^* = \left(\frac{a+3c}{4} - c\right) \cdot \frac{(a-c)}{2} = \frac{(a-c)^2}{8}$ (vii)
* $\pi_2^* = (P^* - c)q_2^* = \left(\frac{a+3c}{4} - c\right) \cdot \frac{(a-c)}{4} = \frac{(a-c)^2}{16}$ $(viii)$

2) <u>If leader/followers are not certain</u>

We know every firm wants to be a leader because the leader's profit is always bigger than that of follower. So, if the leader and follower are not determined before they start game, we might expect different results.
Each firm has two strategies; Lead and Follow.

* If two firm act as leaders ad produce q_1 and q_2,

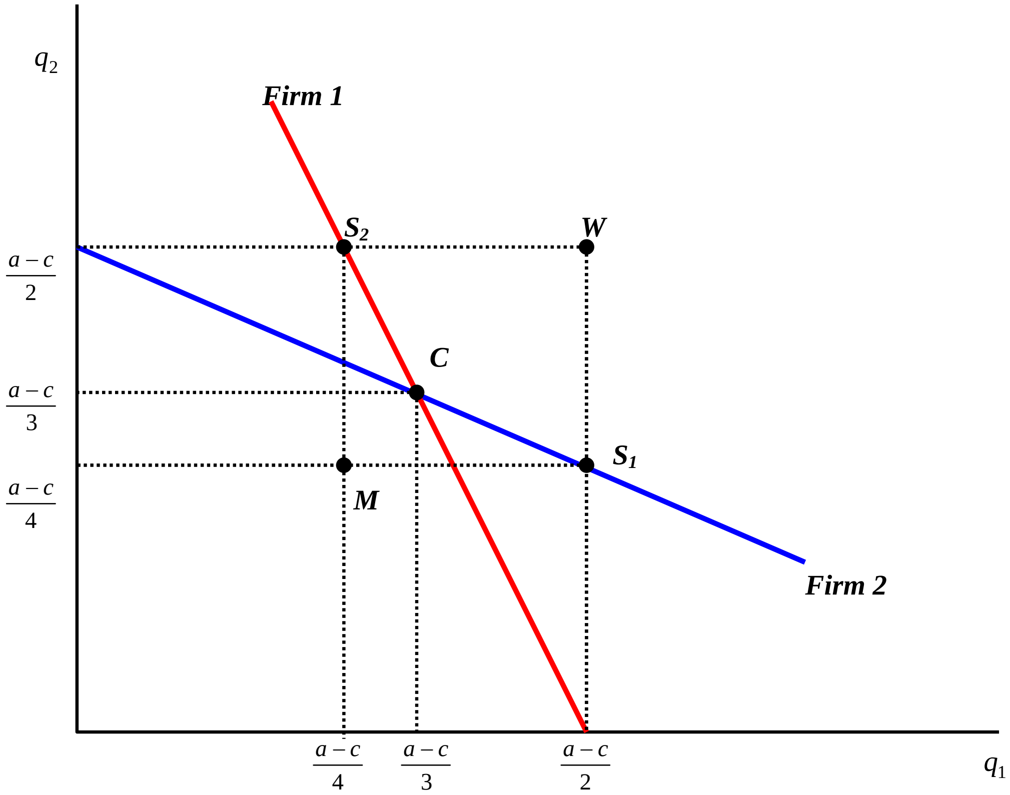
$$q_1{*} = q_2{*} = \frac{a-c}{2}, \; P = a - (q_1 + q_2) = c, \; \pi_1 = (P-c)q_1 = (P-c)q_2 = \pi_2 = 0$$

Identical to Perfect Competition (**Stackelberg Warfare**)

* If two firms act as followers and produce q_1 and q_2,

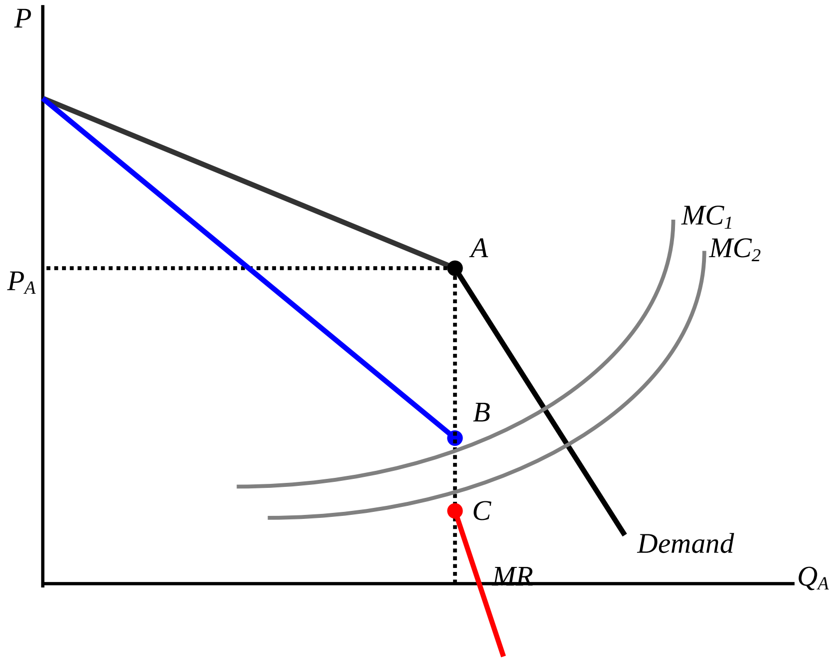
$$q_1{'} = q_2{'} = \frac{a-c}{3}, \; P' = \frac{a+2c}{3}, \pi_1{'} = \pi_2{'} = \frac{1}{9}(a-c)^2$$

It is **Cournot Duopoly**



C: Cournot-Nash Equilibrium Point
S_1: If Firm 1 is a leader
S_2: If Firm 2 is a leader
W: Stackelberg Warfare

10. Kinked Demand Curves (by Paul Sweezy)



Another hypothesis about how oligopolistic rivals may respond says that rivals match price cuts but do not respond to price increases. In this situation, an oligopolist believes that it will not gain much in sales if it lowers its price, because rivals will match the price cuts, but it will lose considerably if it raises its price, since it will be undersold by rivals who do not change their prices. The demand curve facing such an oligopolist appears kinked. The curve is very steep below the current price, p_1, reflecting the fact that few sales are gained as price is lowered. But it is relatively flat above that price, indicating that the firm loses many customers to its rivals, who refuse to match the price increases.

The figure also presents the MR curve, which has a sharp drop at the output level corresponding to the kink. Why does the MR curve have this shape, and what are the consequences? Consider what happens if the firm wants to increase output by one unit. It must lower its price by a considerable amount since, as it does so, its rivals will match that price. Accordingly, the MR it garners is small. If the firm contemplates cutting back on production by one unit, it needs to raise its price only a little since rivals will not change their price. Thus, the loss in revenue from cutting back output by a unit is much greater than the gain in revenue from increasing output by a unit. With a flat demand curve, price and MR are close together.
The drop in MR means that at the output at which the drop occurs, extra revenue lost from cutting back production is much greater than the extra revenue gained from increasing production. This has one important implication. Small changes in MC, from MC1 to MC2, have no effect on output or price. Thus, firms that believe they face a kinked demand curve have good reason to hesitate before changing their price.

11. Advertising (Non-price competition)

1) Types of Advertising

- *Persuasive* advertising of *experience goods*: focusing on image making for the company
- *Informational* advertising of *search goods*: focusing on information of products

2) Optimal Advertising Model

$TR = TR(Q,\ \alpha)$, where $\alpha \geq 0$ (advertising expenses)

$\pi = TR(Q,\ \alpha) - TC(Q) - \alpha$. To solve for Q^* and α^* that can maximize profit, FOCs will be

$$\begin{cases} \dfrac{\partial \pi}{\partial Q} = \dfrac{\partial TR}{\partial Q} - \dfrac{dTC}{dQ} = TR_Q - MC = 0 \\ \dfrac{\partial \pi}{\partial \alpha} = \dfrac{\partial TR}{\partial \alpha} - 1 = TR_\alpha - 1 = 0 \end{cases}$$

Can you interpret the result?