Econ 510 Collusion I

Collusive Agreements

- Collusive agreements can take different forms:
  - Agreements on sale prices;
  - Agreements on allocation of production, market segregation;
    - Geographical segregation (Ex.: Carlsberg-Heineken)
    - Customer class segregation
  - Investment in advertising, quality;
    - Ex: air transport

- Collusive agreements can be organized in different ways:
  - Cartel-like structure;
    - Ex: OPEC
  - (Secret) communication to coordinate behaviour;
  - Tacit collusion.

Plan of the lectures

- Functioning of a collusive agreement.
- Structural factors that facilitate collusion:
  - Concentration
  - Entry barriers
  - Frequency of orders
  - Evolution of demand
  - Symmetry
  - Market transparency ……
- Facilitating practices
  - Exchange of information
  - RPM
  - Meeting-competition clause …..
- R&D agreements

Functioning of a collusive agreement

- Example

- Incentive to **deviate** intrinsic to any collusive agreement

- In order to sustain a collusive agreement it is crucial:
  - to **punish** deviators;

  (note the importance of repeated interaction)
  - to **detect** deviations (in a timely way);

Basic model

- n (identical) firms
- Homogeneous product
  - Demand:

$$D_i(p_i) = \begin{cases} D(p_i) & if \ \ p_i < p_j \ \ for\, any\, i \neq j \\ \dfrac{D(p)}{n} & if \ \ p_i = p_j = p \ \ for \ any\, i, j \\ 0 & if \ \ there \ exists \ a \ k \ such \ that \ \ p_i > p_k \end{cases}$$

- Marginal cost = *c*
- Same discount factor = δ = 1/(1+r)
- No capacity constraint
- Infinitely repeated interaction:
  - In each period $t=1,2,\ldots\ldots$firms simultaneously fix prices

- Equilibrium strategy (trigger strategy):

$$\begin{cases} t=1 \quad p_i = p^m \qquad \pi_i = \dfrac{\pi^m}{n} \\ t>1 \quad se \;\; p_{j,t-1} = p^m \; for \; any \; j, \quad p_{i,t} = p^m \\ \qquad\quad se \;\; p_{j,t-1} < p^m \; for \; at \; least \; one \; j, \quad p_{i,t} = p_{i,t+1} = \ldots = c \end{cases}$$

where p^m is the price that max industry profits and π^m the corresponding maximum profit

- Payoff from following the candidate equilibrium strategy:

$$\frac{\pi^m}{n} + \delta\frac{\pi^m}{n} + \delta^2\frac{\pi^m}{n} + \delta^3\frac{\pi^m}{n} + \dots\dots = \frac{\pi^m}{n}\sum_{i=0}^{\infty}\delta^i = \frac{\pi^m}{n}\frac{1}{1-\delta}$$

- Payoff from deviating:

$$\pi^m + \delta(0) + \delta^2(0) + \delta^3(0) + \dots\dots = \pi^m$$

- Following the equilibrium strategy is more profitable than deviating if:

$$\frac{\pi^m}{n}\frac{1}{1-\delta} > \pi^m$$

- The previous inequality can be written as follows:

$$\underbrace{\pi^m - \frac{\pi^m}{n}}_{\substack{immediate \\ gain\ \ from \\ deviation}} < \underbrace{\delta\left(\frac{\pi^m}{n} - 0\right) + \delta^2\left(\frac{\pi^m}{n} - 0\right) + \delta^3\left(\frac{\pi^m}{n} - 0\right) + \delta^4\left(\frac{\pi^m}{n} - 0\right) + \ldots\ldots}_{long\ \ term\ \ cost\ \ of\ \ deviation}$$

$$\pi^m - \frac{\pi^m}{n} < \delta \frac{\pi^m}{n}\left[1 + \delta + \delta^2 + \delta^3 + \ldots\ldots\right] = \frac{\delta}{1-\delta}\frac{\pi^m}{n}$$

$$\delta > 1 - \frac{1}{n} \equiv \delta^*$$

⇨ Collusion is sustainable if the profits that the firm gives up in the future by deviating are sufficiently important

- The discount factor can also be written as

$$d=\phi\delta$$

where ϕ is the probability that the market exists in the following period

⇨ Collusion more difficult in markets where products become obsolete very rapidly, where the turn-over is very high, etc

Other points

- Multiplicity of equilibria:
  - If $\delta > \delta^*$, any agreement based on a price $p \in [c, p^m]$ is sustainable.

- In principle, no need to communicate to sustain collusion (**tacit collusion**): result of purely non-cooperative behaviour.

- However communication is essential:
  - Coordinate on the collusive price
  - Adjust prices to shocks without triggering price wars

Structural factors affecting collusion

- **<u>Number of competitors</u>**

  ceteris paribus, the lower the number of competitors, the easier to sustain collusion:

$$\delta^* = 1 - \frac{1}{n} \downarrow \quad if \quad n \downarrow$$

$$\underbrace{\pi^m - \frac{\pi^m}{n}}_{\substack{the\ immediate \\ gain\ of\ deviation\ \downarrow}} < \underbrace{\frac{\delta}{1-\delta}\frac{\pi^m}{n}}_{\substack{the\ cost \\ of\ deviation\ \uparrow}}$$

- In this sense, higher degree of concentration makes collusion more likely

- Moreover,
  - Reciprocal monitoring easier and detection of deviations quicker.
  - Easier to coordinate behaviour.

- **<u>Entry barriers</u>**

  collusion cannot be sustained in the absence of entry barriers and it is more difficult to sustain the lower the entry barriers.

  - Stream of future collusive profits ↓

  - Cost of deviation ↓ (punishment less effective)

- Imagine that in in each future period a firm enters with some probability μ and charges the competitive price *p=c.*

$$\frac{\pi^m}{n}+\delta\left(\frac{\pi^m}{n}(1-\mu)+0\mu\right)+\delta^2\left(\frac{\pi^m}{n}(1-\mu)+0\mu\right)+\delta^3\left(\frac{\pi^m}{n}(1-\mu)+0\mu\right)+\ldots>\pi^m+\delta 0+\delta^2 0+\ldots..$$

- Equivalently,

$$\pi^m-\frac{\pi^m}{n}<(1-\mu)\frac{\pi^m}{n}\frac{\delta}{1-\delta}$$

  - The immediate gain from deviation =
  - As μ ↑, the cost of deviation ↓
  - The critical discount factor is increasing in μ:

$$\delta>\delta^*(\mu)\equiv\frac{n-1}{n-\mu}>\delta*$$

- **Frequency of orders**

  Collusion more difficult if firms interact less frequently

  – Cost of deviation ↓ (Punishment less effective).

- Imagine orders arrive every T periods (at time 1, T+1, 2T+1, ….)

$$\frac{\pi^m}{n} + \delta^T \frac{\pi^m}{n} + \delta^{2T} \frac{\pi^m}{n} + \delta^{3T} \frac{\pi^m}{n} + ... > \pi^m + 0$$

- Equivalently,

$$\underbrace{\pi^m - \frac{\pi^m}{n}}_{\substack{immediate \\ gain\ of \\ deviation\ =}} < \underbrace{\delta^T \frac{\pi^m}{n} + \delta^{2T} \frac{\pi^m}{n} + ...}_{cost\ of\ deviation\ \downarrow}$$

- The critical discount factor ↑ as T ↑ : $\delta^*(T) = \left(1 - \frac{1}{n}\right)^{\frac{1}{T}}$

- **Frequency of price adjustments**

  Collusion more difficult if prices adjust less frequently

  - Punishment will start later in the future:
    - Benefit of deviation enjoyed for a longer period
    - Cost of deviation decreases

- Imagine prices adjust every T periods:

$$\frac{\pi^m}{n} + \delta \frac{\pi^m}{n} + \delta^2 \frac{\pi^m}{n} + \ldots\ldots > \pi^m + \delta \pi^m + \delta^2 \pi^m + \ldots\ldots \delta^T 0$$

- Equivalently, $\underbrace{\left(\pi^m - \frac{\pi^m}{n}\right)\left(1 + \delta + \delta^2 + \ldots\ldots + \delta^{T-1}\right)}_{benefit\ \ of\ \ deviation\ \uparrow} \leq \underbrace{\left(\frac{\pi^m}{n} - 0\right)\left(\delta^T + \delta^{T+1} + \ldots\ldots\right)}_{\cos t\ \ of\ \ deviation\ \downarrow}$

- The critical discount factor: $\delta^*(T) = \left(1 - \frac{1}{n}\right)^{\frac{1}{T}}$

- <u>**Evolution of demand**</u>

1. **Demand fluctuations hinder collusion.**

Rotemberg e Saloner, (1986)

- In each period demand can be either high or low.
  - Shocks are independently and identically distributed across periods.
  - Firms observe present demand. Present demand does not provide information on future demand.

Collusion more difficult when demand is high:

- Immediate gain of deviation is higher
- Cost of deviation is the same (based on average demand)

- With probability ½: $D^L=(1-\varepsilon)D(p)$; $D^H=(1+\varepsilon)D(p)$
- Average demand: D(p)

- IC when demand is high:

$$\underbrace{(1+\varepsilon)\left(\pi^m - \frac{\pi^m}{n}\right)}_{immediate \quad gain \quad \uparrow} < \underbrace{\frac{\delta}{1-\delta}\frac{\pi^m}{n}}_{\substack{\text{cost of} \\ deviation \quad =}}$$

- IC when demand is low:

$$\underbrace{(1-\varepsilon)\left(\pi^m - \frac{\pi^m}{n}\right)}_{immediate \quad gain \quad \downarrow} < \frac{\delta}{1-\delta}\frac{\pi^m}{n}$$

- The critical discount factor increases with ε.

$$\delta > \delta^*(\varepsilon) \equiv \frac{(1+\varepsilon)(n-1)}{n+\varepsilon(n-1)}$$

- When demand especially high, firms collude "less" (on prices lower than the monopoly price) or even abandon any agreement.

⇨ Collusive prices are **anti-cyclical.**

A similar analysis applies to more deterministic fluctuations (ex. Seasonal/business cycles).

- In the US, the government uses to buy vaccines in bulk in order to make procurement auctions less frequent.

2. Demand growth

For a fixed number of firms, collusion is easier in growing markets; it is more difficult in declining markets.

- Cost of deviation larger (lower).

- Imagine demand varies steadily at a rate g:

$D^t(p)=(1+g)^t D(p)$ with t=0,1,2,3,4……

$$\frac{\pi^m}{n}+\delta\frac{\pi^m(1+g)}{n}+\delta^2\frac{\pi^m(1+g)^2}{n}+\delta^3\frac{\pi^m(1+g)^3}{n}+\ldots\ldots>\pi^m$$

- Equivalently,

$$\underbrace{\pi^m-\frac{\pi^m}{n}}_{\substack{immediate\\ gain\ =}}<\underbrace{\frac{\delta(1+g)}{1-\delta(1+g)}\frac{\pi^m}{n}}_{\substack{\cos t\ of\ deviation\ \uparrow\\ (when\ g>0)}}$$

- The critical discount factor decreases with g (if positive)

$$\delta > \delta^*(g) \equiv \left(1 - \frac{1}{n}\right)\frac{1}{1+g}$$

In practice, demand growth is often interpreted as a factor hindering collusion.

Why? Entry is easier in growing markets.

The **direct** and the **indirect** effect must be assessed.

- **Symmetry**

  The general idea is that **symmetry helps collusion**.

  Symmetry can concern several dimensions:

  - Market shares
  - Production capacity
  - Costs
  - Number of varieties

a) **Market shares**

Collusion more difficult, the more asymmetric firms' market shares.

- The smaller firm has stronger incentive to deviate

- Imagine 2 firms, one with share α>1/2.
  - IC of the large firm:

$$\underbrace{\pi^m - \alpha\pi^m}_{\substack{immediate \\ gain\ smaller}} < \underbrace{\frac{\delta}{1-\delta}\alpha\pi^m}_{\substack{\text{cost of deviation} \\ \text{larger}}}$$

  - IC of the small firm:

$$\underbrace{\pi^m - (1-\alpha)\pi^m}_{\substack{immediate \\ gain\ larger}} < \underbrace{\frac{\delta}{1-\delta}(1-\alpha)\pi^m}_{\substack{\text{cost of deviation} \\ smaller}}$$

- Concentration indexes may be misleading
  - Ex. Herfindahl Index: ↑ as asymmetries of market shares ↑.

Asymmetry in market shares is endogenous and reflects deeper differences across firms.

b) Production capacities

In general, the existence of capacity constraints has an ambiguous effect on collusion:

- Gain from deviation (undercutting rivals) ↓.
- Capacity constraints limit punishment effectiveness: cost of deviation ↓ : payoff of the deviator during punishment phase >0.

Instead, the impact of asymmetry in capacity is less ambiguous: collusion more difficult with an asymmetric distribution of capacities.

(Compte, Jenny, Rey, 2002)

- Imagine one firm has large capacity and the other small.
  - The large-capacity firm gains more from deviation.
  - The cost deviation is lower for the large-capacity firm (the small firm is not a tough punisher).

- Example: Nestlè-Perrier.

⇨ To induce the large-capacity firm to abide to collusion, it will be necessary to give it a higher market share.

d) Cost asymmetries

There is less scope for collusion with an asymmetric cost structure.

- More difficult to coordinate behaviour.
- More difficult to agree on sharing collusive profits.

- More efficient firms more tempted to deviate:
  - Gain more from a deviation.
  - Cost of deviation smaller (the high-cost firm is not a tough punisher).

- Consider 2 firms:$c_H > c_L$; Rigid demand: D if $p \leq v$;
- Equal market shares

- <u>IC of high-cost firm</u>:

$$(v-c_H)\left(D-\frac{D}{2}\right) < \frac{\delta}{1-\delta}(v-c_H)\frac{D}{2} \qquad \delta > \frac{1}{2}$$

- <u>IC of low-cost firm</u>:

$$\underbrace{(v-c_L)\left(D-\frac{D}{2}\right)}_{\substack{larger\ gain \\ from\ deviation}} < \frac{\delta}{1-\delta}\left[(v-c_L)\frac{D}{2}-(c_H-c_L)D\right] = \underbrace{\frac{\delta}{1-\delta}\left[(v-c_H)\frac{D}{2}-(c_H-c_L)\frac{D}{2}\right]}_{smaller\ cost\ of\ deviation}$$

$$\delta > \frac{1}{2-\gamma} \qquad where \quad \gamma = \frac{2(c_H-c_L)}{v-c_L}$$

➡ To better induce the low-cost firm to stick to the collusive conduct, firms may grant a larger market share to the more efficient firm.

c) <u>Discount factors</u>

The firm with the smaller discount factor (for instance, in financial distress) more tempted to deviate.