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:
    \[ D_i(p_i) = \begin{cases} 
    D(p_i) & \text{if } p_i < p_j \text{ for any } i \neq j \\
    \frac{D(p)}{n} & \text{if } p_i = p_j = p \text{ for any } i, j \\
    0 & \text{if there exists a } k \text{ such that } p_i > p_k 
    \end{cases} \]
- Marginal cost = c
- Same discount factor = \( \delta = 1/(1+r) \)
- No capacity constraint
- Infinitely repeated interaction:
  - In each period \( t=1,2,\ldots \) firms simultaneously fix prices
• Equilibrium strategy (trigger strategy):

\[
\begin{cases}
  t = 1 & p_i = p^m \quad \pi_i = \frac{\pi^m}{n} \\
  t > 1 & \text{se } p_{j,t-1} = p^m \text{ for any } j, \quad p_{i,t} = p^m \\
  & \text{se } p_{j,t-1} < p^m \text{ for at least one } j, \quad p_{i,t} = p_{i,t+1} = \ldots = c
\end{cases}
\]

where \( p^m \) is the price that max industry profits and \( \pi^m \) the corresponding maximum profit
• Payoff from following the candidate equilibrium strategy:

\[ \frac{\pi^m}{n} + \delta \frac{\pi^m}{n} + \delta^2 \frac{\pi^m}{n} + \delta^3 \frac{\pi^m}{n} + \ldots = \frac{\pi^m}{n} \sum_{i=0}^{\infty} \delta^i = \frac{\pi^m}{n} \frac{1}{1-\delta} \]

• Payoff from deviating:

\[ \pi^m + \delta(0) + \delta^2(0) + \delta^3(0) + \ldots = \pi^m \]

• 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:

\[
\pi^m - \frac{\pi^m}{n} < \delta \left( \frac{\pi^m}{n} - 0 \right) + \delta^2 \left( \frac{\pi^m}{n} - 0 \right) + \delta^3 \left( \frac{\pi^m}{n} - 0 \right) + \delta^4 \left( \frac{\pi^m}{n} - 0 \right) + \ldots
\]

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

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

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 \( \phi \) 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

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

  \[
  \delta^* = 1 - \frac{1}{n} \quad \text{if} \quad n \downarrow
  \]

  \[
  \pi^m - \frac{\pi^m}{n} < \frac{\delta \pi^m}{1 - \delta n}
  \]

  - the immediate gain of deviation \(\downarrow\)
  - 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.
• **Entry barriers**

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 each future period a firm enters with some probability $\mu$ 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 $\mu \uparrow$, the cost of deviation $\downarrow$
– The critical discount factor is increasing in $\mu$:

\[
\delta > \delta^*(\mu) \equiv \frac{n-1}{n-\mu} > \delta^*
\]
• **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,

\[
\frac{\pi^m}{n} - \frac{\pi^m}{n} < \delta^T \frac{\pi^m}{n} + \delta^{2T} \frac{\pi^m}{n} + .......
\]

`immediate gain of deviation = cost of deviation ↓`
• The critical discount factor \( \uparrow \) as \( T \uparrow \): \[ \delta^* (T) = \left(1 - \frac{1}{n}\right)^{\frac{1}{T}} \]
• **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:

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

• Equivalently,

\[
\left(\pi^m - \frac{\pi^m}{n}\right)(1 + \delta + \delta^2 + \ldots + \delta^{T-1}) \leq \left(\frac{\pi^m}{n} - 0\right)\left(\delta^T + \delta^{T+1} + \ldots\right)
\]

benefit of deviation \uparrow

\[\text{cost of deviation} \downarrow\]

• The critical discount factor:

\[
\delta^*(T) = \left(1 - \frac{1}{n}\right)^{\frac{1}{T}}
\]
• **Evolution of demand**

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 $\frac{1}{2}$: $D^L = (1-\varepsilon)D(p)$; $D^H = (1+\varepsilon)D(p)$
- Average demand: $D(p)$

- IC when demand is high:

\[
(1+\varepsilon)\left(\pi^m - \frac{\pi^m}{n}\right) < \frac{\delta}{1-\delta} \frac{\pi^m}{n}
\]

- IC when demand is low:

\[
(1-\varepsilon)\left(\pi^m - \frac{\pi^m}{n}\right) < \frac{\delta}{1-\delta} \frac{\pi^m}{n}
\]
• The critical discount factor increases with $\varepsilon$.

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

• 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 $g$:

$$D^t(p) = (1 + g)^t D(p) \text{ with } t = 0,1,2,3,4......$$

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

• Equivalently,

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

Immediate gain $= \frac{\pi^m}{n}$
Cost of deviation (when $g > 0$) $\uparrow$
• 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 $\alpha > 1/2$.
  - **IC of the large firm:**
    \[
    \frac{\pi^m - \alpha \pi^m}{\text{immediate gain smaller}} < \frac{\delta}{1 - \delta} \frac{\alpha \pi^m}{\text{cost of deviation larger}}
    \]
  - **IC of the small firm:**
    \[
    \frac{\pi^m - (1 - \alpha) \pi^m}{\text{immediate gain larger}} < \frac{\delta}{1 - \delta} \frac{(1 - \alpha) \pi^m}{\text{cost of deviation smaller}}
    \]
• Concentration indexes may be misleading
  – Ex. Herfindahl Index: \textup{\textup{\textup{↑}}} as asymmetries of market shares \textup{\textup{\textup{↑}}}.

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: Nestlé-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

**IC of high-cost firm:**

\[
(v - c_H) \left( D - \frac{D}{2} \right) < \frac{\delta}{1 - \delta} (v - c_H) \frac{D}{2} \quad \delta > \frac{1}{2}
\]

**IC of low-cost firm:**

\[
(v - c_L) \left( D - \frac{D}{2} \right) < \frac{\delta}{1 - \delta} \left[ (v - c_L) \frac{D}{2} - (c_H - c_L)D \right] = \frac{\delta}{1 - \delta} \left[ (v - c_H) \frac{D}{2} - (c_H - c_L) \frac{D}{2} \right]
\]

\[
\delta > \frac{1}{2 - \gamma}
\]

where \( \gamma = \frac{2(c_H - c_L)}{v - c_L} \)
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) **Discount factors**

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