# Collusion

Sotiris Georganas

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# Outline

*People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices. It is impossible indeed to prevent such meetings, by any law which either could be executed, or would be consistent with liberty and justice.*

Adam Smith, The Wealth of Nations, 1776

# Cartels

**Definition**

*A cartel is a formal (explicit) agreement among competing firms.*

- Anticompetitive agreements are observed to exist since ancient times
  - First named "cartels" in Germany around 1880 for "alliances of enterprises"
  - The name was imported into the Anglophone world during the 1930s
- Found to decrease welfare of consumers
  - Outlawed in the USA by the Sherman Act (1890) although Adam Smith thought it impossible
- Public cartels permitted in the United States during the Great Depression in the 1930s
  - Continued to exist for some time after World War II in industries such as coal mining and oil production

# Cartels

- Cartels also played an extensive role in the German economy during the inter-war period.
  - The word cartel got Anti-German bias in the '40s, as they were used by the enemy
- Illegal now in most countries (except international cartels)
  - More frequent when there was no law against them (e.g. Rockefeller's *Standard Oil*)
  - Some complicated forms survive, such as the Salary Cap in the NBA
- Pattern: some industries are more prone to cartel formation than others.

# The incentive for cartel formation

- It's the money, stupid!
- Market demand functions are *downward sloping*.
- A firm that increases output imposes a *negative externality* on the other firms in that market by causing the price to drop.

**Implication**

Uncoordinated firm behavior leads to *lower total profits* than can be achieved through coordinated behavior.

# The scope for collusion in the Cournot model

- Recall the Cournot model with two firms producing quantities $q_i$, $i = 1, 2$.
- Product demand is represented by the inverse demand function $p(q_1 + q_2)$.
- Firm 1's profits are given by

$$\pi_1(q_1, q_2) \equiv p(q_1 + q_2)\, q_1 - C_1(q_1) \qquad (1)$$

**Insight**

When firm 2 increases its output, it reduces firm 1's profits through the effect on the market price

$$\frac{\partial \pi_1}{\partial q_2} = p'(q_1 + q_2)\, q_1 < 0 \qquad (2)$$

## Recall

At the Cournot equilibrium, each firm maximizes its **own** profits, given the other firm's output; hence in equilibrium

$$\frac{\partial \pi_i}{\partial q_i} = 0, \qquad i = 1, 2. \tag{3}$$

- Let $\Pi$ denote total joint profits: $\Pi \equiv \pi_1 + \pi_2$

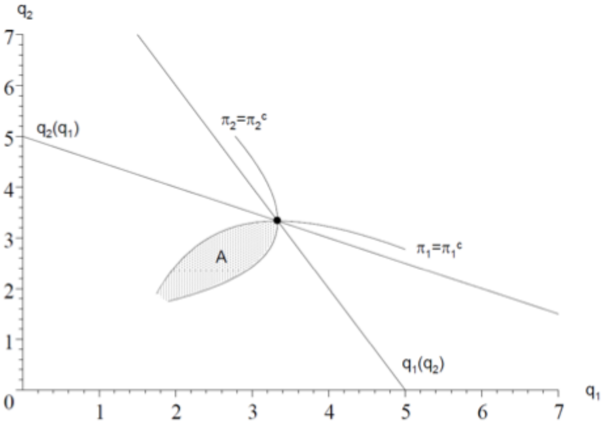
## Insight

At the Cournot equilibrium the effect of an output increase by firm 2 (say) on **total profits** $\Pi$ is therefore negative:

$$\left.\frac{\partial \Pi}{\partial q_2}\right|_{\text{Cournot eq.}} = \frac{\partial \pi_1}{\partial q_2} + \frac{\partial \pi_2}{\partial q_2} = p'\left(q_1 + q_2\right) q_1 + 0 < 0. \tag{4}$$

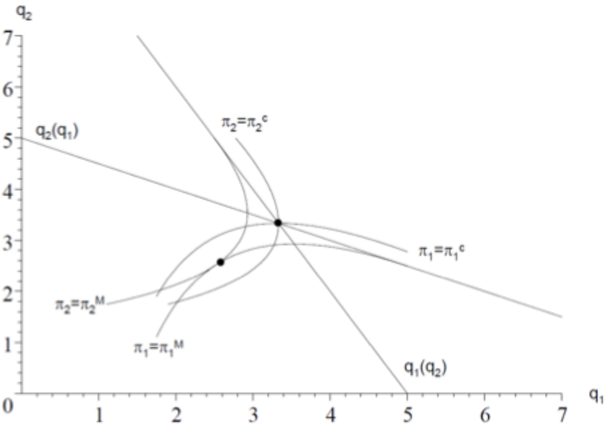
- Illustrated in **Fig 1.**

Fig 1




- Total joint profits $\Pi$ are maximized by the two firms reducing their output levels. **Fig 2.**

Fig 2




- But on the other hand, if the firms do coordinate and reduce their output levels, then each firm will have an incentive to cheat on the agreement by increasing its output: at the coordinated cartel optimum $\partial \pi_i / \partial q_i > 0$, for $i = 1, 2$.

# Game theoretic analysis of self-enforcing collusion

- Start from the Cournot duopoly model. Two firms in a market.
- They compete in quantities.
  - Firm 1's quantity: $q_1$.
  - Firm 2's quantity: $q_2$.
- The firms' profits:

$$\pi_1(q_1, q_2) = p(q_1 + q_2)\, q_1 - C_1(q_1),$$

$$\pi_2(q_1, q_2) = p(q_1 + q_2)\, q_2 - C_2(q_2).$$

- A **Cournot-Nash equilibrium**:
  - $(q_1^c, q_2^c)$ is a Cournot-Nash equilibrium if neither firm can increase its profits by deviating unilaterally:

$$\pi_1(q_1^c, q_2^c) \geq \pi_1(q_1, q_2^c) \qquad \text{for every } q_1,$$

$$\pi_2(q_1^c, q_2^c) \geq \pi_2(q_1^c, q_2) \qquad \text{for every } q_2.$$

- In contrast, the **collusive outcome**, $(q_1^m, q_2^m)$, maximizes total profits (denoted $\Pi$ above)

$$\max_{q_1, q_2} \{\pi_1(q_1, q_2) + \pi_2(q_1, q_2)\}.$$

  and we use $\pi_i^m$ to denote the profit obtained by firm $i$ in the collusive outcome.

- The collusive outcome cannot be sustained as a Cournot-Nash equilibrium in a one-shot game.
  - Suppose Firm 1 expects Firm 2 to produce its share of the optimal cartel output, $q_2^m$. Then Firm 1's best response would be the solution to

$$\max_{q_1} \pi_1 \left( q_1, q_2^m \right).$$

    - Denote the solution to this problem by $q_1^r$.
    - And denote Firm 1's profit if deviating to $q_1^r$ by $\pi_1^r$ [$=\pi_1 \left( q_1^r, q_2^m \right)$].
  - We have $q_1^r > q_1^m$ and **importantly**

$$\pi_1^r > \pi_1^m > \pi_1^c.$$

# Infinitely repeated games

- "Infinitely repeated games" are also called "supergames."
- Suppose there is an infinite sequence of time periods: $t = 1, 2, 3, \ldots$
- In each period, the duopolists simultaneously choose their quantities $q_1^t$ and $q_2^t$.
- They then get the profits $\pi_1\left(q_1^t, q_2^t\right)$ and $\pi_2\left(q_1^t, q_2^t\right)$.
- This is repeated in every period, and both players know all previously chosen quantities.
- The list of all chosen quantities prior to period $t$ is called the **period** $t$ **history of the game** [=everything that has happened previously in the game].

- Each firm maximizes the **discounted sum** of all its future profits. For Firm 1:

$$
\begin{aligned}
V_1 &= \pi_1\left(q_1^1, q_2^1\right) + \delta\pi_1\left(q_1^2, q_2^2\right) \\
&\quad + \delta^2\pi_1\left(q_1^3, q_2^3\right) + \delta^3\pi_1\left(q_1^4, q_2^4\right) + \cdots \\
&= \sum_{t=1}^{\infty} \delta^{t-1}\pi_1\left(q_1^t, q_2^t\right),
\end{aligned}
$$

  where $\delta$ is a **discount factor** [recall that $\delta^0 = 1$].
- Assumption: $0 < \delta < 1$.
- Interpretation:
  - $\delta = \frac{1}{1+r}$, where $r$ is an interest rate.
  - $\delta$ could also reflect the possibility that, with some probability, the game ends after the current period.

# Grim trigger strategies

- A **strategy** in a repeated game is a *function*.
  - This function specifies, for any possible history of the game, which quantity a player chooses.
- Consider the following "grim trigger strategy" for Firm 1 in period $t$:
  - If both firms have played the collusive output ($q_i^m$) in all previous periods, play the collusive output in this period too.
  - If at least one firm did not play the collusive output (some $q_i \neq q_i^m$) in at least one previous period, play the Cournot-Nash output ($q_i^c$).

- Check if it is an SPNE for the firms to use this strategy:
  - First we check that no firm has an incentive to deviate unilaterally along the equilibrium path. (Requirement for having a Nash equilibrium.)
  - Then we check the same thing off the equilibrium path. (Requirement for subgame perfection.)

**Reminder**

The sum of an infinite geometric series:

$$1 + \delta + \delta^2 + \delta^3 + \cdots = \frac{1}{1-\delta}$$

# Checking the equilibrium

- Player 1's payoff if both players play the grim trigger strategy (from $t = 1$ onwards):

$$\begin{aligned} V_1^e &= \sum_{t=1}^{\infty} \delta^{t-1} \pi_1^m = \pi_1^m \sum_{t=1}^{\infty} \delta^{t-1} \\ &= \pi_1^m \left(1 + \delta + \delta^2 + \delta^3 + \cdots\right) \\ &= \frac{\pi_1^m}{1-\delta}. \end{aligned}$$

- Payoff if deviating (from the equilibrium path) at $t = 1$:

$$\begin{aligned} V_1^d &= \pi_1^r + \sum_{t=2}^{\infty} \delta^{t-1} \pi_1^c = \pi_1^r + \pi_1^c \sum_{t=2}^{\infty} \delta^{t-1} \\ &= \pi_1^r + \pi_1^c \left(\delta + \delta^2 + \delta^3 + \cdots\right) \\ &= \pi_1^r + \delta \pi_1^c \left(1 + \delta + \delta^2 + \cdots\right) \\ &= \pi_1^r + \frac{\delta \pi_1^c}{1-\delta}. \end{aligned}$$

- That is, no incentive to deviate if

$$V_1^e \geq V_1^d \Leftrightarrow \frac{\pi_1^m}{1-\delta} \geq \pi_1^r + \frac{\delta \pi_1^c}{1-\delta}.$$

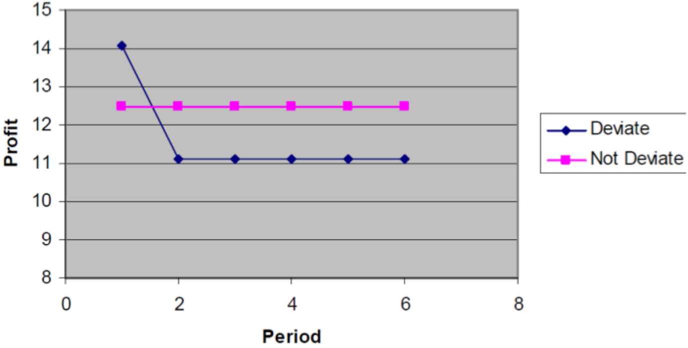
i.e. if one period deviation payoff $\left(\pi_1^r - \pi_1^m\right)$ does not exceed long term reward from cooperation:

$$\pi_1^r - \pi_1^m \leq \frac{\delta\left(\pi_1^m - \pi_1^c\right)}{1-\delta}.$$

- Solving this inequality for $\delta$ yields

$$\delta \geq \frac{\pi_1^r - \pi_1^m}{\pi_1^r - \pi_1^c}.$$

- Interpretation:
  - By deviating, you make a short-term gain but get a lower profit in all future periods. So if you're patient enough (sufficiently large $\delta$), then you resist the temptation to deviate.



- Checking subgame perfection
  - Any deviation is effectively punished by the competitor.
  - Is carrying out this punishment credible?
  - Imagine that we are in a subgame where at least one firm has previously chosen some quantity differing from the collusive output (some $q_i \neq q_i^m$).
  - The grim trigger strategy prescribes that then each firm should choose the Cournot output ($q_i = q_i^c$).
  - We must verify that this is a Nash equilibrium. Clearly it is!

# Result: Summary and Theory Discussion

- Conclusion: We can sustain the outcome $(q_1^m, q_2^m)$ (in every period) as an SPNE of the infinitely repeated game if the players care sufficiently much about the future (or, the interest rate $r$ low enough).
- However, some potential issues with this equilibrium can be raised.
- Equilibrium multiplicity
  - There are (many) other equilibria: For example, always playing the Cournot-Nash quantity is also a SPNE. Multiplicity of equilibria a problem with this theory — no obvious prediction.
  - The typical approach among IO economists: Assume the firms are able to coordinate on a collusive equilibrium whenever such exists.
- Renegotiation when collusion has broken down - Commitment problem
  - The SPNE where the firms collude is not renegotiation proof: After a defection the firms are supposed to play Cournot-Nash forever. But both would be better off if they renegotiated and agreed to forget about the deviation and instead start to collude again.

# Cartels: where, when and how?

- Effective cartels form when:
  1. group action can raise price and profits;
  2. enforcing an agreement is relatively easy;
  3. the expected punishment is low relative to the gains;
  4. the fluctuation in demand is low.

- Inelastic market demand
- Inelastic supply response from non-cartel members and from producers of close substitutes.

- When there are few firms in the cartel.
- When there is high industry concentration; e.g. a dominant firm can take the lead.
- The product is relatively homogenous: easier to agree price and to monitor.
- There are preexisting inter-firm ties, e.g. **trade associations** which can facilitate information exchange.
- Prices are highly visible: e.g. depending on the type of the product.
- Players can use violence, e.g. guns (the Sicilian mafia tends to be an internationally successful cartel)

- Expected punishment $=$ probability of detection $\times$ punishment.
- More strict legislation appears to have had some effect.

- A decrease in the market price may be due to cheating or due to a drop in demand.
- Reduces the risk of being detected when cheating.

# Cartel techniques

- Some techniques are well-known:
  - Geographic- or quota sharing
  - Most-favored-customer clause. Contractual commitment by a seller that all customers will pay the lowest price charged any customer.
    - Makes it more costly for a firm to deviate from a collusive agreement (since it has to charge the lower price to all customers).
    - Gives the customers a stronger incentive to watch out for (secret) price cuts, which then also the competitors can find out about.
  - Meeting competition clauses (Never knowingly undersold): A way of obtaining information.

# Cartel techniques

## OPEC example

- OPEC is a quite powerful cartel. How does it work?
- Why is the cartel sometimes unstable?

# Issues we did (and will) not discuss

- Tacit collusion (read Tirole, Chapter 6)
- General antitrust issues
- What is the relevant market?

# What to remember from this lecture

- What is collusion and why is there scope for collusion in the standard (Cournot-Nash) duopoly model.
- The logic behind how repeated interaction can make collusion self-enforcing when the firms are patient.
- Differences between cartel models and real life cartels
- Circumstances and practices that facilitate the sustainability of cartels.