OI: competição e colusão

Aula 2 – 1ª Parte

Baseado nos slides de Paul Belleflamme e Martin Peitz

Agenda

- Positive vs. normative approach
- Incentives to collude: cartel formation
- How collusion can be sustained

OI approaches

- Positive approach
  - Describe, explain workings of imperfectly competitive markets
- Normative approach
  - Guidance for competitive policy
    - Basic postulate: competition is desirable as it promotes economic efficiency
    - Problem: firms might be tempted to reduce competition
    - Consequence: set of rules aiming at maintaining competition $\rightarrow$ competition (antitrust) policy

- **Case**. The vitamin cartels
  - Worldwide market for bulk vitamins
  - In Europe, sales of bulk vitamins were 800m € in 1998
  - Production of vitamins is highly concentrated
    - Largest firm is Hoffmann-La Roche: market share of 40-50%
    - BASF: 20-30%
    - Aventis: 5-15%
  - Concentration on the production side
    - Slow and costly plant construction
    - Economies of scale in the production technology
  - Buyer side is more fragmented.
  - November 2001: European Commission imposes a fine of 855.22 m € to 8 companies for participating to secret market-sharing and price-fixing cartels.

Formation and stability of cartels

- Simple market structure
  - n symmetric firms produce a homogeneous good
  - Constant marginal cost c
  - Competition à la Cournot
  - Firms face an inverse demand given by $P(q) = a - q$, where q is the total quantity produced
- 3 alternative procedures
  - Firms decide **simultaneously** whether or not to participate in a single industry-wide cartel.
  - Endogenous formation of cartels in a **sequential** way
  - Bilateral **market-sharing agreements** ("I stay out of your market if you stay out of mine")

Simultaneous cartel formation

- A cartel of k firms is formed, with $1 < k \leq n$.
- The Cournot game is thus played among the other $(n-k)$ independent firms and the cartel.
- All $(n-k+1)$ players are symmetric.
  - Assumption: inside the cartel the division of profits is equitable.
- For a given cartel size, profits for firms inside and outside the cartel are

$$\pi^{in}(k) = \frac{(a-c)^2}{k(n-k+2)^2} \quad \text{and} \quad \pi^{out}(k) = \frac{(a-c)^2}{(n-k+2)^2}$$

Cartel stability (1)

- No cartel member has an incentive to unilaterally leave the cartel,

$$\pi^{in}(k) \geq \pi^{out}(k-1) \Leftrightarrow \frac{(a-c)^2}{k(n-k+2)^2} \geq \frac{(a-c)^2}{(n-k+3)^2}$$

- **Lesson**: Consider the formation of a single cartel on a Cournot market with homogeneous goods and constant marginal costs. If there are at least three firms in the industry, all firms remain independent. If there are just 2 firms in the industry, the 2 firms form a cartel.

Cartel stability (2)

- **Intuition** for this result:
  - Formation of the cartel induces positive externalities on the firms outside the cartel (higher market price).
  - All firms prefer to free-ride on the public good provided by cartel members.
- Result changes if firms produce **horizontally differentiated goods**
  - Competition and free-riding incentive are relaxed.
  - $\rightarrow$ It is possible to find stable cartels comprising not all firms but a strict subset of them (if goods are sufficiently differentiated).

Example: stable partial cartels (1)

- Recall:
  - Cournot market with homogeneous good, constant marginal cost
  - Simultaneous formation of a single cartel
  - All firms remain independent if at least 3 firms.
- However, if firms produce **horizontally differentiated goods** competition and free-riding incentive are relaxed.
- Consider the following inverse demand functions

$$p_i = a - q_i - \gamma \sum_{j \neq i} q_j, \text{ where } \gamma \in [0,1]$$

measures the strength of product substitutability

Example: stable partial cartels (2)

- Suppose $n = 3$, $\gamma = 1/2$ and $a - c = 1$.
- Nash equilibrium in which 2 firms form a cartel while the 3rd remains independent
  - Cartel firms choose q_1 and q_2 to maximize their joint profits

$$\Pi_{12} = \left((1 - q_1 - \frac{1}{2}(q_2 + q_3) \right) q_1 + \left((1 - q_2 - \frac{1}{2}(q_1 + q_3) \right) q_2$$

  - Symmetry leads to $q_1 = q_2 = q_{12}$ and joint profits

$$\Pi_{12} = 2\left(1 - \frac{3}{2} q_{12} - \frac{1}{2} q_3 \right) q_{12}$$

  - FOC: Derive the cartel's reaction function

$$q_{12}(q_3) = \frac{1}{6}(2 - q_3)$$

Example: stable partial cartels (3)

- Independent firm chooses q_3 to maximize

$$\pi_3 = \left(1 - q_3 - \frac{1}{2}(q_{12} + q_{12})\right) q_3$$

- Reaction function (from FOC)

$$q_3(q_{12}) = \frac{1}{2}(1 - q_{12})$$

- Equilibrium quantities $q_{12} = 3/11$ and $q_3 = 4/11$

- Equilibrium profits $\pi_1 = \pi_2 = \pi^{in}(2) = 27/242$ and $\pi_3 = \pi^{out}(2) = 32/242$

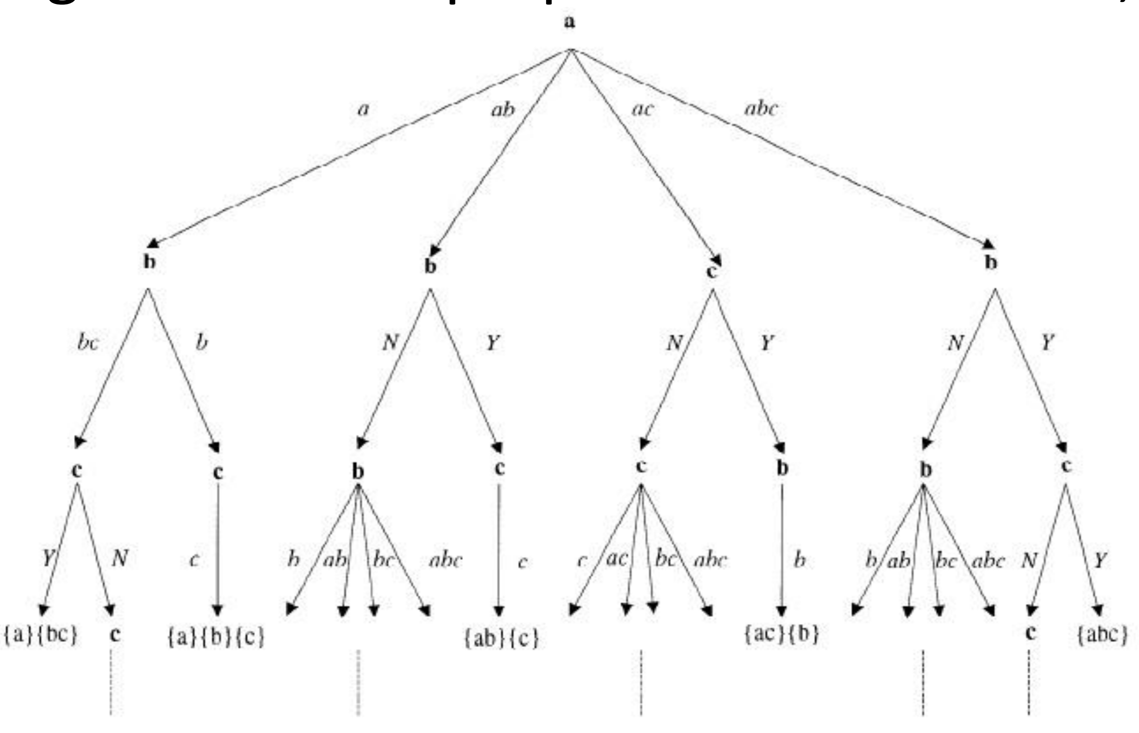
- Free-riding effect is still present as $\pi^{out}(2) > \pi^{in}(2)$

Example: stable partial cartels (4)

- Two requirements for the cartel to be stable
  - Internal stability (no leaving)
    - If firms leave the cartel, 3 firms would be independent.
    - Stability as long as $\pi^{in}(2) \geq \pi^{out}(1)$ which is true as $27/242 \approx 0.1116 > 1/9 \approx 0.1111$
  - External stability (no entry into the cartel)
    - Compute the profits firm 3 would obtain by joining firms 1 and 2 in the cartel.
    - No incentive to join as long as $\pi^{out}(2) \geq \pi^{in}(3)$ which is true as $32/242 \approx 0.132 > 1/8 \approx 0.125$

Sequential cartel formation (1)

- Game where multiple cartels can be formed
  - Exogenous specification of the ordering of the firms; 1st firm proposes a cartel; if all prospective members accept, cartel is formed; otherwise, 1st firm in the ordering that refuses proposes another cartel; etc.



Source: Bloch, 1995

Sequential cartel formation (2)

- Sequentiality entails important differences
  - Firms can commit to stay out of the cartel.
  - At equilibrium, first firms remain independent and free-ride on cartel that last firms will eventually form.
  - Firms prefer to form a cartel of size k than to remain independent if

$$\pi^{in}(k) \geq \pi^{out}(1) \Leftrightarrow \frac{(a-c)^2}{k(n-k+2)^2} \geq \frac{(a-c)^2}{(n+1)^2}$$

$$\Leftrightarrow (k-1)(-k^2+(2n-3)k-(n+1)^2) \geq 0$$

$$\Leftrightarrow k > \tfrac{1}{2}\left(2n+3-\sqrt{4n+5}\right) > 0.8n$$

Sequential cartel formation (3)

- **Lesson**: Consider a Cournot market with homogenous goods. The first $(n - k^*)$ firms remain independent while the last k^* firms form a cartel, with k^* being larger than 80% of the firms in the industry.

- **Intuition**
  - **Simultaneous** cartel formation: each firm has an incentive to leave the cartel.
  - **Sequential** cartel formation: first firms can commit to stay out and cartel can then form

Network of market-sharing agreements

- **Bilateral** collusive agreements
- Market-sharing agreements
  - 2 firms are active on different geographical markets or serve distinct consumer segments
  - Refraining from competing on the other firm's territory
  - Constitute a collusive structure, a **collusive network**
- Network stability if
  - No pair of firms has an incentive to form a new link.
  - No firm has an incentive to unilaterally destroy an existing link.
- **Lesson**: If collusive network are negotiated bilaterally, they may lead to full collusion, with every firm a monopoly on its own market.

Tacit collusion

- 'Meeting of the minds' between colluding firms
- Analysis of 'tacit agreements' is also highly relevant for explicit agreements
  - Sustainability necessary for cartels as long as punishments cannot be legally binding
- Considering 2 firms
  - Offer perfect substitutes at constant marginal costs c
  - Compete over time (each period $t = 1,2, \ldots T$, firms repeat the 'static' game)
- **Lesson**: If competition is repeated over a **finite** number of periods, firms play according to the (unique) Nash equilibrium of the static game in each period. Tacit collusion cannot emerge.

Tacit collusion: infinite horizon

- Infinite time horizon (no known end to the game)
- Tacit collusion may emerge.
- Consider the **grim trigger strategy**
  - Firm i starts by choosing the action that maximizes total profits.
  - Firm i keeps on choosing this action as long as both firms have done so in all previous periods.
    $\rightarrow$ **cooperation phase**
  - If one firm deviates, deviation 'triggers' the start of the **punishment phase**.
    - Firms choose the action that corresponds to the Nash equilibrium of the static game.

Grim trigger strategy (1)

- Cooperative action: both obtain $\pi^c = \pi^m/2$
- If one plays the cooperative action and the other optimally deviates, the deviating firm obtains π^d
- At the Nash equilibrium of the static game, both firms obtain π^n, with $\pi^d > \pi^c > \pi^n$.
- Trade-off between
  - immediate gain from deviation
  - future losses resulting from the other firm's punishment
- Trade-off depends on
  - magnitude of the deviation and the punishment profits with respect to the collusive profits
  - the firms' discount factor

Grim trigger strategy (2)

- Cooperative phase: present discounted value

$$V^C = \pi^c + \delta\pi^c + \delta^2\pi^c + \ldots = \frac{1}{1-\delta}\pi^c$$

- If firm 1 deviates, it will obtain π^d in the current period and π^n in all subsequent periods

$$V^D = \pi^d + \delta\pi^n + \delta^2\pi^n + \ldots = \pi^d + \frac{\delta}{(1-\delta)}\pi^n$$

- Follow the grim trigger strategy if and only if

$$V^C \geq V^D \Leftrightarrow \frac{1}{1-\delta}\pi^c \geq \pi^d + \frac{\delta}{1-\delta}\pi^n$$

Discounted long term losses

Short term gain

$$\Leftrightarrow \boxed{\frac{\delta}{1-\delta}\left(\pi^c - \pi^n\right)} \geq \boxed{\pi^d - \pi^c}$$

$$\Leftrightarrow \quad \delta \geq \frac{\pi^d - \pi^c}{\pi^d - \pi^n} \equiv \delta_{\min}$$

Application to price competition (1)

- Bertrand competition model with constant and identical marginal costs
  - If both firms collude, they make a profit of $\pi^c = \pi^m/2$
  - Undercutting the rival‘s price leads to deviation profits of $\pi^d = \pi^m - \varepsilon$
  - After deviation has occurred, $\pi^n = 0$
  - Minimum discount factor

$$\delta_{\min}^{Bert} \geq \frac{\pi^d - \pi^c}{\pi^d - \pi^n} = \frac{\pi^m - (\pi^m / 2)}{\pi^m - 0} = \frac{1}{2}$$

- **Lesson**: In the infinitely repeated Bertrand duopoly game, any profit level between zero and the monopoly profit can be supported in a subgame perfect equilibrium if the discount factor is sufficiently large, $\delta \geq 1/2$.

Application to price competition (2)

- Suppose n firms operate in the market
  - Total collusive profits have to be shared among n firms: $\pi^c = \pi^m/n$

$$V^C \geq V^D \Leftrightarrow \frac{1}{1-\delta}\frac{\pi^m}{n} \geq \pi^m \Leftrightarrow \delta \geq 1 - \frac{1}{n} \equiv \delta_{\min}^{Bert}(n)$$

  - Critical discount factor $\delta_{\min}^{Bert}(n)$ is increasing in n
- **Lesson**: In the infinitely repeated Bertrand price-setting game, the set of discount factors that can support collusion is larger the smaller the number of firms in the market.

Application to quantity competition (1)

- n-firm Cournot model with constant and identical marginal costs
  - Inverse demand $P(q) = a - q$
  - Resulting collusive profits:

$$\pi^c = \frac{\pi^m}{n} = \frac{1}{4n}(a-c)^2$$

  - Recalling Cournot Nash equilibrium profits:

$$\pi^n = \frac{1}{(n+1)^2}(a-c)^2$$

  - If other firms play the collusive quantity q^m/n, then

$$\pi^d = \frac{(n+1)^2}{16n^2}(a-c)^2$$

Application to quantity competition (2)

- Minimum discount factor to allow firms to sustain the monopoly outcome:

$$\delta_{\min}^{Cour}(n) \equiv \frac{\pi^d - \pi^c}{\pi^d - \pi^n} = \frac{\dfrac{(n+1)^2(a-c)^2}{16n^2} - \dfrac{(a-c)^2}{4n}}{\dfrac{(n+1)^2(a-c)^2}{16n^2} - \dfrac{(a-c)^2}{(n+1)^2}} = \frac{(n+1)^2}{n^2+6n+1}$$

- $\delta_{\min}^{Cour}(n)$ increases with n
- as $n \longrightarrow \infty$, the critical discount factor converges to 1

Collusion and frequency of interaction

- Suppose
  - n firms, Bertrand competition, grim-trigger strategy
  - **Scenario 1**: firms compete only every k periods

$$V_1^C = \frac{\pi^m}{n} + \delta^k \frac{\pi^m}{n} + \delta^{2k} \frac{\pi^m}{n} + \ldots = \frac{1}{1-\delta^k} \frac{\pi^m}{n} \text{ and } V_1^D = \pi^m$$

  - **Scenario 2**: price are set for k periods

$$V_2^C = \frac{1}{1-\delta} \frac{\pi^m}{n} \text{ and } V_2^D = \pi^m (1 + \delta + \cdots + \delta^{k-1}) + \delta^k \times 0 = \frac{1-\delta^k}{1-\delta} \pi^m$$

  - **In both cases**, cooperation is preferable if $\delta \geq \left(1 - \frac{1}{n}\right)^{1/k}$
    - Threshold $\uparrow$ with k
- **Lesson**: Firms find it harder to sustain collusion when they interact less frequently or when price adjustments are less frequent.

Collusion and multimarket contact

- What if firms face same competitors on several markets? Does this facilitate tacit collusion?
- 2 effects
  - **Deviation more profitable** $\rightarrow$ it can take place on all markets at the same time
  - **Deviation more costly** $\rightarrow$ deviators can be punished on all markets
- The 2 effects cancel out if identical markets, identical firms and constant return to scale.
- Otherwise, 2^{nd} effect dominates
  - **Collusion easier to sustain with multimarket contacts**
  - Applications
    - Differing markets
    - Differing firms

Application: differing markets (1)

- Different frequency of interaction
  - Suppose that firms can change prices more frequently in market 1 than in market 2
  - Multimarket contact opens up the possibility that a deviation in market 2 can be (immediately) punished in market 1
  - Pooling of incentive constraints across the two markets facilitates collusion
- Different number of firms
  - Suppose that firms A and B are both present in markets 1 and 2, firms C is only present on market 2
  - Idea: to induce firm C to collude by
    - leaving it a larger market share on market 2
    - Using the interaction on market 1 as a disciplining device

Application: differing markets (2)

- Firms A and B are able to sustain collusion in both markets although they would not be able to collude on market 2 were they only active on that market

- **Lesson**: With multimarket contact on different markets, collusion may become sustainable in several markets, even though deviations would be profitable if firms were active only in one of the markets.

Application: Differing firms

- 2 markets (1 and 2)
- 2 firms (A and B)
  - firm A is installed in market 1
  - firm B is installed in market 2
- Each firm
  - produces a homogenous good at constant marginal cost c
  - faces a transportation costs of τ to move one unit of output from its 'home‘ to the 'foreign‘ market
- Demand on both markets is given by $Q(p) = a - p$
- Monopoly price for home firm is $p^m(c) = (a - c)/2$
- To ensure competition, we assure marginal cost of the foreign firm is smaller than the monopoly price

$$c + \tau < (a + c)/2 \text{ or } 2\tau < a - c$$

Benchmark: market-sharing agreements in one market (1)

- As a benchmark, we first examine the optimal collusive outcome that would prevail if firms were only competing in one market.
- Assuming Bertrand competition, the optimal punishment consists for both firms in setting their price equal to c in every future period following a deviation
- Let $s_h + s_f$ denote the respective market shares of the home and the foreign firm (by definition, $s_h + s_f = 1$)

Benchmark: market-sharing agreements in one market (2)

- If the collusive price is $p \geq c + \tau$
- A deviating firm with cost c_i will slightly undercut and achieve immediate profit equal to

$$\pi^d(p, c_i) = (p - c_i)(a - p)$$

with $c_i = c$ for the home firm and $c_i = c + \tau$

- Hence both firms abide by the collusive agreement as long as

$$\begin{cases} \dfrac{1}{1-\delta} s_h (p-c)(a-p) \geq (p-c)(a-p) \quad \Leftrightarrow \quad s_h \geq 1-\delta \\ \dfrac{1}{1-\delta} s_f (p-c-\tau)(a-p) \geq (p-c-\tau)(a-p) \quad \Leftrightarrow \quad s_f \geq 1-\delta \end{cases}$$

Benchmark: market-sharing agreements in one market (3)

- We can sum the two conditions and conclude that only if $\delta \geq 1/2$ the firms can sustain collusive prices above $c + \tau$
- But a large enough market share must be allocated to the inefficient foreign firm to keep it from deviating
- It must be that $s_f \geq 1 - \delta$

Market-sharing agreements in two markets (1)

- Focus on symmetric collusive outcomes
  - Both firms set the same price p on both markets
  - The home firm receives a share s_h
- For a given $p \geq c + \tau$, the best collusive outcome involves $s_h = 1$ which implies that each firm completely withdraws from the foreign market.
- Best collusive price is $p^m(c) = (a + c)/2$
- Present value of abiding by the market-sharing agreement

$$V^c = \frac{1}{1-\delta}\frac{(a-c)^2}{4}$$

Market-sharing agreements in two markets (2)

- The best deviation consists in entering the foreign market and undercutting the home firm.
  - immediate profit of $(p^m(c) - c - \tau)(a - p^m(c))$
  - Meanwhile, in this period, the firm is keeping the monopoly profit on its home market.
- As before the punishment that follows the deviation yields a continuation profit of zero.
- So the present discounted value of deviation is

$$V^D = \frac{(a-c)^2}{4} + \frac{(a-c)(a-c-2\tau)}{4}$$

- Therefore a market-sharing agreement can be sustained if $V^c \geq V^d$ *or*

$$\frac{\delta}{1-\delta}\frac{(a-c)^2}{4} \geq \frac{(a-c)(a-c-2\tau)}{4} \Leftrightarrow \delta \geq \frac{1}{2}\frac{a-c-2\tau}{a-c-\tau}$$

Market-sharing agreements with differing firms

- **Lesson**: The optimal market-sharing agreement can be sustained over a larger set of discount factors than the most profitable collusive outcome that firms can achieve when they are present on one market only.

Referências

- BELLEFLAMME, P.; PEITZ, M. Industrial Organization: Markets and Strategies, 2 ed. Cambridge (UK): Cambridge University, 2015.
- TIROLE, J. The Theory of Industrial Organization. Cambridge (MA): MIT, 1988.