Collusion and cartels

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Section 1

Cartel

What is a cartel?

An association of firms that reduces competition by coordinating actions:

- setting prices
- allocating market shares
- creating exclusive territories

Cartel

- Cartels are fairly common but hidden since collusion is illegal in the US, the European Union, and other countries
- But some cartels are explicit
  - Phoebus cartel (太阳神卡特尔): light bulbs
  - OPEC/Organization of the Petroleum Exporting Countries (欧佩克/石油输出国组织): oil
  - De Beers (戴比尔斯): diamonds

Cartel (cont.)

- Evidence shows that cartels raise prices by a substantial amount $\Rightarrow$ Connor and Lande (2005) found that the median cartel price increase was 22%
- Governments have agencies to combat collusion
    - United States Department of Justice Antitrust Division (美国司法部反托拉斯司)
    - European Commission (欧洲联盟委员会)
- Fines and jail sentences are used as punishment
- Antitrust authorities have been reasonably successfully in recent years

Cartel (cont.)

- Cournot competition induces firms to overproduce
- Bertrand competition induces low prices
- Firms would be better off if they coordinated their activities

⇒ *e.g.*, restricting their outputs increases the market price and profits

Cartel (cont.)

- In a one-shot game, each firm finds it profitable to cheat

$\Rightarrow$ firms can't commit (they can't exactly sign contracts agreeing to price fix)

$\Rightarrow$ prisoner's dilemma

- But firms typically interact repeatedly so they may have an incentive to coordinate activities

$\Rightarrow$ look for strategies that will sustain cooperation

Section 2

One-shot game

One-shot Cournot competition

- Two firms
- Demand: $p = a - Q$
- Marginal cost: c
- NE:

$$q^c = \frac{a - c}{3}$$

- Profit:

$$\pi^c = \frac{(a - c)^2}{9}$$

One-shot Cournot competition (cont.)

- If they are able to coordinate and behave as a monopoly
  $\Rightarrow Q^* = \frac{a-c}{2}$
- The firms split the output
  $\Rightarrow$ Output:
$$q^* = \frac{a-c}{4}$$
  $\Rightarrow$ Profit:
$$\pi^* = \frac{(a-c)^2}{8} > \pi^c$$

One-shot Cournot competition (cont.)

- There is an incentive to cheat
- If firm j sticks to the agreement and produces $\frac{a-c}{4}$
  $\Rightarrow$ Optimal output for firm i:

$$q^d = \frac{3(a-c)}{8}$$

$\Rightarrow$ Profit:

$$\pi^d = \frac{9(a-c)^2}{64}$$

$\Rightarrow$ Firm j's profit:

$$\pi' = \frac{3(a-c)^2}{32}$$

One-shot Cournot competition (cont.)

- $$\pi^d = \frac{9(a-c)^2}{64} > \pi^* = \frac{(a-c)^2}{8} > \pi^c = \frac{(a-c)^2}{9} > \pi' = \frac{3(a-c)^2}{32}$$
- Prisoner's dilemma

	Cooperate	Non-cooperate
Cooperate	π^*, π^*	π', π^d
Non-cooperate	π^d, π'	π^c, π^c

One-shot Bertrand competition

- NE:

$$p^b = c \text{ and } \pi^b = 0$$

- If they are able to coordinate and behave as a monopoly

⇒ $\max_p (a - p)(p - c)$

⇒ Price:

$$p^* = \frac{a + c}{2}$$

⇒ Profit:

$$\pi^* = \frac{(a - c)^2}{8}$$

One-shot Bertrand competition (cont.)

- There is an incentive to cheat
- If firm j sticks to the agreement and sets price $\frac{a+c}{2}$

$\Rightarrow$ firm i can increases its profit by choosing a price $p^d < \frac{a+c}{2}$, but as close as possible to $\frac{a+c}{2}$, and is almost equal to monopoly profit

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

One-shot Bertrand competition (cont.)

- $$\pi^m = \frac{(a-c)^2}{4} > \pi^* = \frac{(a-c)^2}{8} > \pi^b = 0$$
- Prisoner's dilemma

	Cooperate	Non-cooperate
Cooperate	π^*, π^*	π', π^m
Non-cooperate	π^m, π'	π^b, π^b

Section 3

Repeated game

Repeated game

- In a repeated game cooperation may make sense
- The (discounted) profits from colluding over time may be greater than the profits from deviating today
- This may allow a regular and punishment action
  - player *i* plays the cooperative action if no one has played the uncooperative action in the past
  - otherwise, plays the uncooperative action

Repeated game (cont.)

Trigger strategy:

- cooperate in period 1
- maintain cooperation in period t if no firm has played the uncooperative action in the past, otherwise plays the uncooperative action

Subsection 1

Finitely repeated game

Finitely repeated game

- T periods
- Trigger strategy is not subgame perfect
- In period T (last period), firm 1's dominant strategy is to not cooperate
- Moving backwards, period $T-1$ is now effectively the "last period", given that cooperation is not possible in period T
  $\Rightarrow$ firm 1 will not cooperate in period $T-1$
  $\Rightarrow$ collusion cannot happen

Selten's Theorem

Selten's Theorem: If a game with a unique equilibrium is played finitely many times, its solution (SPE) is that equilibrium played each and every time
Finitely repeated play of a unique NE is the equilibrium of the repeated game

Subsection 2

Infinitely repeated game

Infinitely repeated game

- In most situations the assumption of infinitely repeated games makes more sense than finitely repeated games
  - firms are usually regarded as having an indefinite life
  - the firm may not last forever but players do not know when the game will end
- In an infinitely repeated game
  - Good behavior can be credibly rewarded
  - Bad behavior can be credibly punished

Infinitely repeated game (cont.)

- The discount factor is $\delta \in (0,1)$
- The discounted payoff

$$\pi^1 + \delta\pi^2 + \cdots + \delta^n\pi^{n-1} + \cdots = \sum_{t=1}^{\infty} \delta^{t-1}\pi^t$$

  π^t is the profit in period t
- The normalized discounted payoff

$$(1-\delta)(\pi^1 + \delta\pi^2 + \cdots + \delta^n\pi^{n-1} + \cdots) = (1-\delta)\sum_{t=1}^{\infty} \delta^{t-1}\pi^t$$

Infinitely repeated Cournot competition

- If firm 2 uses trigger strategy, firm 1 follows trigger strategy at period t, then firm 1's payoff from period t onwards is

$$\sum_{t=1}^{\infty} \delta^{t-1}\pi^* = \frac{1}{1-\delta}\pi^*$$

- If firm 2 uses trigger strategy, firm 1 deviates at period t, then firm 1's payoff from period t onwards is

$$\pi^d + \delta\pi^c + \cdots + \delta^t\pi^c + \cdots = \pi^d + \frac{\delta}{1-\delta}\pi^c$$

Here we consider only one-shot deviation

Infinitely repeated Cournot competition (cont.)

- Trigger strategy is better at period t iff

$$\pi^* \geq (1-\delta)\pi^d + \delta\pi^c$$

- $\pi^d > \pi^* > \pi^c$
  $\Rightarrow$ there exists $\underline{\delta}$ such that trigger strategy is better iff $\delta \geq \underline{\delta}$
- In this case, one-shot deviation principle guarantees trigger strategy profile to be a SPE

Infinitely repeated Bertrand competition

- Trigger strategy
  - In period 1, choose price p^*
  - In period t, choose p^* if no firm deviates t^* in the previous periods; otherwise, choose price p^b
- If firm 2 uses trigger strategy, firm 1 follows trigger strategy at period t, then firm 1's payoff from period t onwards is

$$(1-\delta)\sum_{t=1}^{\infty}\delta^{t-1}\pi^* = \pi^*$$

Infinitely repeated Bertrand competition (cont.)

- If firm 2 uses trigger strategy, firm 1 deviates at period t, then firm 1's payoff from period t onwards is

$$(1-\delta)(\pi^m + \delta\pi^b + \cdots + \delta^t\pi^b + \cdots) = (1-\delta)\pi^m + \delta\pi^b$$

- Trigger strategy is better iff $\pi^* \geq (1-\delta)\pi^m + \delta\pi^b$
$\Rightarrow$ there exists $\underline{\delta}$ such that trigger strategy is better iff $\delta \geq \underline{\delta}$
- In this case, one-shot deviation principle guarantees trigger strategy profile to be a SPE

Remark

Collusion is sustainable if:

- Short-term gains from cheating are low relative to long-run losses
- Cartel members value future profits (high discount factor)
- this model explains why we see collusion in practice

Remark (cont.)

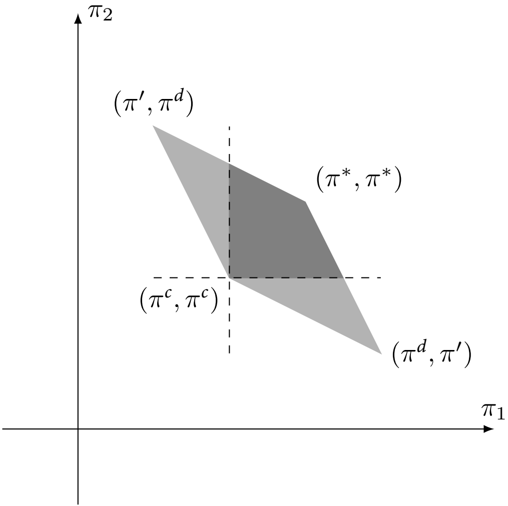
- The strategies are based on the assumption that cheating on the cartel agreement is detected quickly and that punishment is swift
  $\Rightarrow$ What if there is a delay?
  $\Rightarrow$ collusion is still possible but the discount rate has to be higher
- The punishment is harsh and unforgiving because it does not permit mistakes
  - if there is a decrease in sales and profit is it because the other firm is cheating or is because there was a decrease in demand?
  - modified trigger strategy based on a range of prices or outputs
  - punish for a limited number of periods

Folk theorem

- There are many different trigger strategies that allow a cartel agreement to be sustained in an infinitely repeated game
- Friedman (1971): Suppose that an infinitely repeated game (with finite players) has a set of payoffs that exceed the one-shot Nash equilibrium payoffs for each and every firm. Then any set of feasible payoffs that are preferred by all firms to the Nash equilibrium payoffs can be supported as a SPE for the repeated game for some discount rate sufficiently close to unity

$\Rightarrow$ Construct a trigger strategy profile

Folk theorem (cont.)



Antitrust policy

- A group of perfectly symmetric firms (an industry) which consider colluding taking into account the enforcement activity of the Antitrust Authority
- In each period, firms are reviewed by AA with probability p
- In each period, AA successfully finds the evidence that firms have collusion with probability q
- Firm will be fined F if it has been found the collusion evidence
- Discount factor δ

Antitrust policy (cont.)

- Let Π be the utility when there is an antitrust policy
- At period 1, if there is no review, the utility is

$$(1-p)(\pi^* + \delta\Pi)$$

- At period 1, if there is a review, but AA does not find evidence, the utility is

$$p(1-q)(\pi^* + \delta\Pi)$$

- At period 1, if there is a review and AA finds evidence, the utility is

$$pq\left(\pi^* - F + \frac{\delta}{1-\delta}\pi^c\right)$$

Antitrust policy (cont.)

- Thus

$$\Pi = (1-p)(\pi^* + \delta\Pi) + p(1-q)(\pi^* + \delta\Pi) + pq(\pi^c - F + \tfrac{\delta}{1-\delta}\pi^c)$$

- $$\Pi = \frac{1}{1-\delta(1-pq)}\left(\pi^* - pqF + \frac{pq\delta}{1-\delta}\pi^c\right)$$

- Recall the utility without antitrust policy is

$$\frac{1}{1-\delta}\pi^*$$

Antitrust policy (cont.)

Two approaches

- Fine F
- Probabilities of reviewing and finding evidence pq