EC481: เศรษฐศาสตร์ อุตสาหกรรม

Dynamic Oligopoly Models

ผศ.ดร. พรเทพ เบญญาอภิกุล

คณะเศรษฐศาสตร์ มหาวิทยาลัยธรรมศาสตร์

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Your Background

- Have already learned all the main static models
  - Monopoly
  - Duopoly
  - Oligopoly
    - Cournot
    - Bertrand
    - Stakelberg
  - Cartel
- For a quick review, see Pindyck & Rubinfeld.

Your Background

The basic (mostly static) models are useful benchmarks

- Non-cooperative games
  - Cournot $\rightarrow$ firms use ``quantity'' as strategic variable.
  - Bertrand $\rightarrow$ firms use ``price'' as strategic variable.
  - Stakelberg $\rightarrow$ firms can use ``quantity'' or ``price'' as strategic variable. But, there is a leader who moves first.
- Cooperative games
  - Joint-monopoly (or cartel)

Dynamic Oligopoly

The basic (mostly static) models are useful benckmarks, but not realistic.

- In the real world, firms usually meet more than 1 period
- They play dynamic games
    - repeated
    - sequential
- We introduce a dynamic oligopoly model (repeated oligopoly for this class).

Some Questions

1. Now, suppose every pineapple-grower in Thailand has to obtain a license from the government (no free entry). Do you think collusion (price-setting) might be possible?
2. Suppose you are in debt and your lender would come take away all your money (and set fire on your pineapple field) if you are unable to pay back the loan. Cheating now would give you enough money to pay back the loan. Would you cheat?
3. Suppose you are one of the pineapple growers and you (only you) plan to quit at the end of next year. Would collusion until next year be optimal for you?

The above problems imply that the value of your discount factor matters!

A Model of Repeated Oligopoly

- Repeated game is also called ``supergame'' in game theory.
- Suppose firms compete infinitely
- The present value (PV or V) of the profit for firm i is

$$PV = \pi_0 + \delta \pi_1 + \delta^2 \pi_2 + \ldots$$

$$\delta = \text{discount factor} \quad 0 \leq \delta \leq 1$$

where

<u>Example</u> : Profit = $\bar{\pi}$ every year

$\delta = 0.8$

$$PV = \bar{\pi} + 0.8\,\bar{\pi} + 0.8^2\,\bar{\pi} + 0.8^3\,\bar{\pi} + \cdots$$

$$= \bar{\pi} + 0.8\,\bar{\pi} + 0.64\,\bar{\pi} + 0.512\,\bar{\pi}$$

If π is constant in every period

$$PV = \bar{\pi} + \delta\bar{\pi} + \delta^2\bar{\pi} + \delta^3\bar{\pi} + \cdots$$

$$= \bar{\pi}\,(\underbrace{1 + \delta + \delta^2 + \cdots}_{x}) = \frac{\bar{\pi}}{1-\delta}$$

$$x = 1 + \delta + \delta^2 + \cdots$$

$$x - 1 = \delta + \delta^2 + \cdots$$

$$x - 1 = \delta\,(\underbrace{1 + \delta + \delta^2 + \cdots}_{x})$$

$$x - 1 = \delta x$$

$$x - \delta x = 1 \quad \Rightarrow \quad x = \frac{1}{1-\delta}$$

$$PV = \frac{\pi}{1-\delta}$$

A Model of Repeated Oligopoly

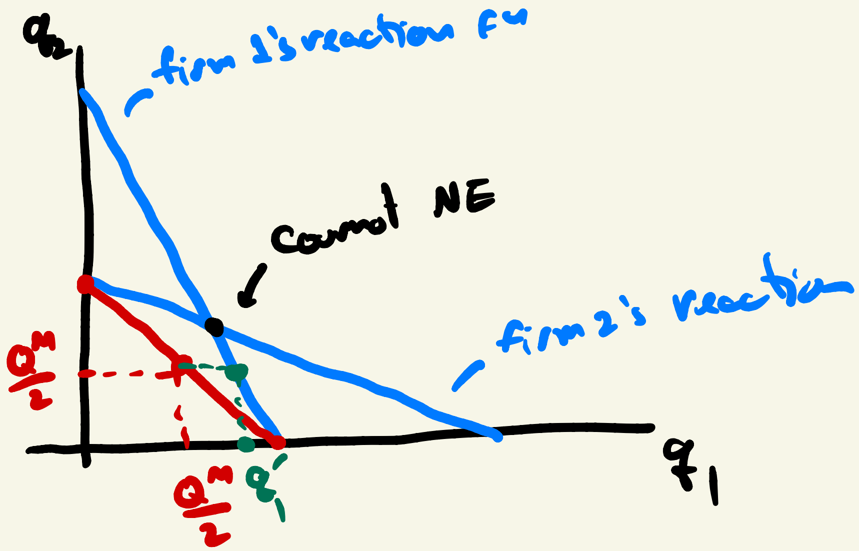
- Firm $i's$ profit can take the following 3 values:
  - $\pi_{it} = \pi^*$or profit from collude and everyone else collude
  - $\pi_{it} = \pi^r$or profit from cheating and everyone else collude
  - $\pi_{it} = \pi^c$ or profit when collusion is not possible. Here, everyone plays a Cournot game. (why?)

red dot

at green dot

at black dot

$$\pi^r > \pi^* > \pi^c$$



Can cooperation (cartel or profit from red dot) be sustained in repeated oligopoly

Condition to sustain collusion

- For collusion to be possible, each firm has to expect the total profit from collusion to be greater than cheating!

$$V_i^* > V_i^r \Rightarrow$$

PV cooperation > PV cheat

- Suppose firms play a grim strategy
  - Collude until one firm cheats. Then, not collude (play cournot) forever.

Condition to sustain collusion

- So, PV from colluding

$$PV_{colluding} = \pi^* + \delta\pi^* + \delta^2\pi^* + \dots,$$

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

- and PV from cheating

$$PV_{cheating} = \pi^r + \underbrace{\delta\pi^c + \delta^2\pi^c + \delta^3\pi^c + \dots}_{\frac{\delta\pi^c}{1-\delta}}$$

$$= \pi^r + \delta\left(\underbrace{\pi^c + \delta\pi^c + \delta^2\pi^c + \cdots}\right)$$

$$= \pi^r + \delta \frac{\pi^c}{1-\delta}$$

Firm will collude if

$$\boxed{\frac{\pi^*}{1-\delta} \geq \pi^r + \frac{\delta \pi^c}{1-\delta}}$$

There is δ^* in which if $\delta > \delta^*$ the firms will collude

$$\pi^r > \pi^* > \pi^c$$

Infinitely repeated Bertrand Model

Assume : 1. There are 2 firms (symmetric (or identical)

2. $MC = c$

$\Rightarrow$ Static game equilibrium or Nash equilibrium is $P_1 = P_2 = c$

$\pi_1 = \pi_2 = 0$

If the firms play this game repeatedly

Consider GRIM strategy

=> Firms start the game by cooperation (collusion)

- every firm sets price at monopoly level

$$P_1 = P_2 = P^M > C.$$

- This gives highest joint profit $= \pi^M$

- If they divide the profit equally

$$\pi_1 = \pi_2 = \pi^M/2$$

- The payoff from cooperating forever

$$= \frac{\pi^M}{2} + \delta \frac{\pi^M}{2} + \delta^2 \frac{\pi^M}{2} + \dots$$

$$\boxed{PV_{cooperation} = \frac{\pi^M}{2(1-\delta)}}$$

$\Rightarrow$ If firm i choose to defect from the collusion agreement

$$P_i = P^M - \varepsilon$$

very very small

$\varepsilon \to 0$

$$\pi_i = \pi^M$$

$$PV_{defection} = \pi^M + \delta 0 + \delta^2 0 + \delta^3 0 + \cdots$$

$$\boxed{PV_{defection} = \pi^M}$$

Firms will cooperate as long as

$$PV_{cooperation} \geq PV_{defection}$$

$$\frac{\pi^M}{2(1-\delta)} \geq \pi^M$$

$$\delta \geq 1/2$$

We can extend the results to n firms case

$\Rightarrow$ Assume: There are n firms in the market

$\Rightarrow$ NE of static game

$$p_1 = p_2 = \ldots = p_n = c$$

$$\pi_1 = \pi_2 = \ldots = \pi_n = 0$$

$\Rightarrow$ If all n firms cooperate: $p_1 = p_2 = \ldots = p_n = p^M$

this maximises joint profit $= \pi^M$

⇒ Every firm will share the profit equally

$$\pi_1 = \pi_2 = \ldots = \pi_n = \frac{\pi^M}{n}$$

$$PV_{cooperation} = \frac{\pi^M}{n} + \delta \frac{\pi^M}{n} + \delta^2 \frac{\pi^M}{n} + \ldots$$

$$\boxed{PV_{cooperation} = \frac{\pi^M}{n(1-\delta)}}$$

If firm i wants to defect $P_i = P^M - \varepsilon$

very small
$\varepsilon \to 0$

by doing so, $\pi_i = \pi^M$

$$PV_{defection} = \pi^M + 0\delta + 0\delta^2 + \dots$$

$$\boxed{PV_{defection} = \pi^M}$$

Firm will cooperate as long as

$$PV_{cooperation} \geq PV_{defection}$$

$$\frac{\pi^M}{n(1-\delta)} \geq \pi^M$$

$$\delta \geq 1 - \frac{1}{n} = \frac{n-1}{n}$$

If $n = 2 \Rightarrow \delta \geq 1/2$

$n = 3 \Rightarrow \delta \geq 2/3$

$n = 4 \Rightarrow \delta \geq 3/4$

$n = 100 \Rightarrow \delta \geq 99/100$

$n \to \infty \Rightarrow \delta \to 1$

Example: Imperfect monitoring

$\Rightarrow$ Assume that defection needs 1 more period to detect.

$$PV_{cooperation} = \frac{\pi^M}{n(1-\delta)}$$

$$PV_{defection} = \pi^M + \underline{\underline{\delta \pi^M}} + \delta^2 0 + \delta^3 0 + \ldots$$

$$PV_{cooperation} \geq PV_{defection} \quad \text{if}$$

$$\frac{\pi^M}{n(1-\delta)} \geq \pi^M(1+\delta)$$

$$\delta \geq \sqrt{\frac{n-1}{n}} > \frac{n-1}{n}$$

Perfect monitoring case

Imperfect monitoring makes cooperation much more difficult

Therefore, for firm i not to cheat

- If δ is large enough (meaning that firms puts enough value on their future profits), collusion can be sustained.

Example: the exact value of δ

Suppose there are 5 firms in the market. Each firm's marginal cost is 10 and the market demand curve is $P = 130 - Q$. Find the value of δ that makes collusion sustained in this case.
from

We need to find$\pi_i^r, \pi_i^*, \pi_i^c$ for each firm.

Example: the exact value of δ (cont.)

Example: the exact value of δ (cont.)

Reference and Further Reading I

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