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Lecture 10

Repeated interaction & price wars

Industrial
Economics

Course news / discussion

* Labs progress
* Homework structure
* UoL exam preparation
* Lecture on Saturday at 12:10 (auditorium K9)

Nash vs. collusion

* Previously, in our ***example*** with differentiated products:
  * If both firms charge 4, they make a profit of 18 each
  * If both firms charge 5.5 they make a profit of 20.25 each
  * If one firm charges 5.5 but the other charges 4 they make 13.5 and 22.5!

Firm 2

Firm 1	Compete $p_2 = 4$	Collude $p_2 = 5.5$
Compete $p_1 = 4$	18, 18	22.5, 13.5
Collude $p_1 = 5.5$	13.5, 22.5	20.25, 20.25

* Charging 5.5 and waiting leaves you ***"open"*** to your rival

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The prospect of collusion

Player 2

Player 1	Undercut	Collude
Undercut	Competition	Cheating
Collude	Cheating	Collusion

* ***Why not*** set profit maximizing collusion price and ***hope*** others follow?
  * Collusion is ***not a NE***
  * Collusion level of price (or output) is ***never on the optimal response*** curve

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Repeated interaction

* In the ***Bertrand*** setting, firms tend to ***undercut*** till $p = MC$

  this may not be the case if interaction has ***time depth***
* In repeated games, players can develop ***reputations*** and there is opportunity to ***retaliate*** the cheaters
* Consider the ***original Bertrand*** setting

  firms i and j ***simultaneously*** set prices for a ***homogeneous*** good they produce at ***cost*** c
* Additionally, ***assume*** that
  * The interaction is ***repeated*** T times
  * The complete ***history*** of actions is ***common knowledge***
  * Firms have a ***discount factor*** δ

Strategies

* Firms may presume each-other well-intended and adopt ***trigger strategies***

  in the beginning, everyone trusts everyone else ***until*** someone "pushes the trigger"
* Once the trigger is ***pushed*** we ***revert*** to NE
  * The cheater is ***penalized***
  * The straight player ***bears a cost*** for punishing the cheater
* We will seek the ***equilibrium*** for T ***finite*** or ***infinite***

Finite horizon

- Assume that T is ***finite*** and the game is repeated a ***predetermined*** number of times
- Using ***backward induction***
  - In the terminal period there is no possibility of punishment, thus, ***everyone will cheat***
  - The ***same*** is true for the second to last period
  - So, there is ***no possibility*** of punishment in any period
- With T finite, there is ***no credible threat of retaliation***, thus collusion is ***not sustainable***

Infinite horizon

Suppose j adopts the trigger strategy

a) If i ***adopts*** it too, cooperation never breaks down
  - Firm i ***makes*** $0.5 \cdot \Pi_M$ in every period
  - The ***NPV*** of its ***infinite stream*** of payoffs is:

$$\sum_{t=0}^{\infty} \delta^t \cdot 0.5 \cdot \Pi_M = (1 + \delta + \delta^2 + \cdots) \cdot 0.5 \cdot \Pi_M = \frac{\Pi_M}{2(1-\delta)}$$

b) If i ***defects*** in period 0
  - That is, firm j ***sets*** p_M and i sets $p_M - \varepsilon$
  - The ***NPV*** of its ***infinite stream*** of payoffs is:

$$\Pi_M + 0 \cdot \delta + 0 \cdot \delta^2 + 0 \cdot \delta^3 + \cdots = \Pi_M$$

Infinite horizon (cont'd)

c) If firm i finds itself in a period where all the ***preceding*** strategies have ***not*** been (p_M, p_M)
  - Best response is to ***set*** $p_i = c$, forever
  - This is so ***because*** firm j will also set $p_j = c$, forever

- Firm i will ***adopt*** the trigger strategy ***iff***

$$\frac{\Pi_M}{2(1-\delta)} \geq \Pi_M \quad \Rightarrow \quad \delta \geq \frac{1}{2}$$

there is ***no incentive for deviation*** from the trigger in the repeated game iff $\delta \geq 1/2$

- Thus, trigger strategies are ***Nash*** for the game starting at period 0

Infinite horizon – SPNE

- All repeated rounds or sets of rounds are ***identical*** sub-games of the ***supergame***
- Thus, the trigger strategies will also be a SPNE for the game starting at ***any period***
- ***Collusion can be sustained*** in a repeated prisoner's dilemma type of game if
  1. Termination is ***unknown***, ***random*** or ***never***; and
  2. Firms play ***trigger*** strategies; and
  3. Firms care sufficiently for their ***future*** profits

Verification lag

- Suppose now that it takes 2 periods to ***verify defection***
- NPV from ***cooperation*** is still $\frac{\Pi_M}{2(1-\delta)}$
- NPV from ***defection*** is $\Pi_M + \delta\Pi_M$

  cheater ***gets away*** with monopoly profit for ***two periods***
- Collusion is ***sustainable*** iff $\delta \geq 1/\sqrt{2}$
  - The ***critical value*** of δ is now higher
  - Collusion is ***harder*** when firms ***observe rival's prices*** with lag
  - Indeed, in reality, firms ***rarely collude on 'long-run' variables*** like capacity or R&D
  - Long-term decisions take ***more time*** to implement than just fixing the price

The folk theorem

- In the game we just analyzed there are ***multiple equilibria*** provided that δ is sufficiently high

  replace p_M with ***any price*** between c and p_M
- **Folk theorem:** *For δ sufficiently close to 1, **there exist** strategies that form a SPNE such that:*
  1. *Strategies are **IR**: payoffs per period are weakly positive*
  2. *Strategies are **feasible**: sum of payoffs does not exceed Π_M*
- ***Anything*** between static Bertrand and monopoly ***goes***
- These results can be ***generalized*** to N firms

Some facts on repetition

- The game has an ***infinite number*** of equilibria
- Collusion is ***sustainable***, but ***not necessary***
- This theory is silent as to ***how firms coordinate***
  or ***which equilibrium*** will be chosen
- Similar results can be obtained for strategies that involve punishments lasting only for a ***finite number of periods***
- Collusion can also be sustained with ***indefinite repetition***
- We also need to cover the case of ***renegotiation***
  after defection has occurred

Renegotiation

- Once defection occurs, the ***penalty phase*** begins
- Firms cheated upon play their ***Nash*** strategy
- The market equilibrates at the ***(sub-optimal) NE***
- At this point there is an ***incentive to renegotiate*** to avoid punishment for everybody
- The cheater can come up with an ***offer***:
  "I know that I cheated at t, but I promise to not do it again. We will both be better off if we leave this behind us and start over again. Let's reinstate our relationship from $t+1$"

Renegotiation Proofness

- The straight party has an ***incentive to accept*** the offer
- But, if renegotiation is ***allowed***, collusion ***cannot be sustained*** in the first place
  - Sub-game perfection ***requires*** that threats be credible
  - If an ***IC offer*** can be made, the threat is ***not credible***
- ***There are models*** where collusion is sustainable even with renegotiation
- Alternatively, we may require that strategies be ***renegotiation proof*** for collusion to prevail
  - ***Threats*** for punishment are ***credible***
  - ***No opportunity*** for Pareto improvement with renegotiation

Costs of renegotiation

- Under renegotiation proofness, firms actually ***prefer punishment to renegotiation***
  - ***Trust*** cannot be regained
  - Renegotiation is (or intentionally made) ***costly***
  - There is sufficient ***asymmetry*** in payoffs from punishment
- ***High cost*** of renegotiation may constitute the threat for punishment ***credible***, thus ***discouraging defection***
- McCutcheon (1997) argues that one of the effects of ***antitrust laws*** is to raise the costs of renegotiation, thereby making collusion easier to sustain

Price rigidity

- In some oligopoly markets, pricing behavior creates a ***predictable pricing pattern in time***
  implicit collusion may occur
- In other oligopoly markets, firms are ***aggressive*** and collusion is ***not easy***
  - This creates ***high tension***
  - A change in price may give the ***wrong signal*** to rivals
  - Firms become ***reluctant*** to lower the price even when this is ***economically necessary***
  - In this case, prices tend to be relatively ***rigid***

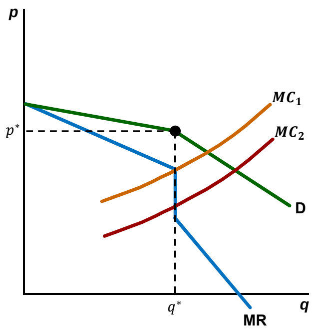
Reluctance

- Firms have strong ***desire for stability***
- Managers might be ***worried*** that a price cut may send a ***signal of price war*** to competitors
  - Even when <u>cost</u> or <u>demand</u> change, managers might be reluctant to ***adjust prices downwards***
  - They ***give up*** proper profit maximization to ***avoid the risk*** of causing a price war
- This is an ***one-way behavior***, though
  <u>increasing price</u> does not carry a risk of starting a price war – competitors ***may or may not*** follow

Demand under price rigidity

- Each firm faces a demand curve ***kinked*** at the current ***prevailing*** price, p^*
- The ***response*** of rivals to a price change is ***asymmetric***
- Above p^*, demand is ***more elastic***
  - if the firm increases price above p^*, other firms ***may not follow***
- Below p^*, demand is ***less elastic***
  - if the firm decreases price below p^*, other firms ***will follow*** suit
- With a ***kinked demand*** curve, marginal revenue curve is ***discontinuous***

Decrease in MC



- ***MC*** can change without resulting to ***price*** change
  - yet, MR = MC is ***still*** the equilibrium condition
- Change in MC must be ***significant*** to cause $\Delta p > 0$
- Kinked demand is a description of price rigidity
  - ***does not really explain*** oligopolistic pricing

Price wars

- Repetition ***explains collusion***, but ***not price wars***
  - price wars ***may occur*** in more complicated repeated games
- There is a series of models that provide ***structural explanations*** on price wars
  1. Green & Porter (1984)
  2. Rotemberg and Saloner (1986)
  3. Slade (1989)

1. Green & Porter

- Assumptions:
  1. Uncertainty about demand when firms choose p or q
  2. Imperfect info: Firms ignore past or present choices of rivals
  3. Collusion is established
- A firm that has a bad period ***cannot distinguish*** if this is due to a demand shock, or due to defection by a rival
- At the SPNE:
  - Firms ***collude***
  - Every now and then a negative ***demand shock*** occurs and triggers a price war
  - After a number of periods firms ***revert*** to collusion

Features of the model

- At equilibrium of the game ***no firm ever cheats***
  - this means that price wars are ***accidents***
- In some versions of the model firms do not achieve the ***joint monopoly payoff*** during a collusive period
  - an instance of Folk theorem
- The main testable prediction of the model is that price wars ***occur during recessions***

2. Rotemberg & Saloner

- Assumptions:
  1. Demand ***fluctuates randomly*** every period, but shocks are ***not serially correlated***
  2. Firms can observe the ***current state*** of demand before setting p in each period
  3. Firms can observe their rivals' past actions but ***not their current actions***
- ***Tendency for cheating*** is higher during a boom
  - because the ***gain from cheating*** is bigger
- During a ***boom*** firms may need to ***reduce*** the collusive price below p_M to ***ensure the stability*** of collusion

Features

* This is ***not actually a price war model***
  collusion never breaks down (!)
* The main prediction of the model is that ***prices may move counter-cyclically***
  this is the ***opposite of the Green–Porter*** result
* Note that counter-cyclicality is quite ***sensitive*** to the assumption on serial non-correlation of demand shocks

3. Slade

* Assumptions:
  1. Firms have ***imperfect information*** about ***demand shocks***
  2. Firms ignore their rivals' ***costs***
* By cutting the price, a firm ***signals its rivals*** about new cost or demand conditions
* A phase of ***price adjustment*** by all firms follows
* Ultimately collusion is ***re-established***
* Again there is no actual price war (!)
  * Decrease in prices is a ***signal*** through which firms ***obtain information*** about the ***new conditions*** in the industry
  * Price adjustment goes ***along*** with the economy ***cycle***

Empirical evidence

* Each of the three theories is a good description of collusive behavior in ***certain industries***
* Support for Green & Porter
  US railroad cartel
* Support for Rotemberg & Saloner:
  US cement industry
* Support for Slade:
  gasoline retail in Canada

Thank you!

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