Lectures 15, 16: Resolving the PD: Repetition and Reputation

Topics (over two lectures)
1. A Pricing Rivalry Duopoly Game
2. Dynamic Pricing Rivalry
3. How to Achieve Cooperation
4. Detection of Cheating
5. Punishment of Cheaters
6. Repetition: The Folk Theorem
7. Punishment
8. Evidence
9. Real-World Dilemmas
A Real-Life Telephone Conversation

H.P.: Do you have a suggestion for me?
R.C.: Yes, I have a suggestion for you. Raise your goddamn fares 20 percent. I’ll raise mine the next morning.

H.P.: Robert, we ...
R.C.: You’ll make money, and I will too.
H.P.: We can’t talk about pricing.
R.C.: Oh, bullshit, Howard. We can talk about any goddamn thing we want to talk about.

In 1982 Robert Crandall (MBA, Wharton, ’60) was the CEO of American Airlines, Howard Putnam the chairman of Braniff International Airways. (U.S. District Court, CA383-0325D)
Newspaper Wars in Sydney

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But for 3½ years News kept the *Mirror*’s price below; its share rose from 50% to 53%, and it increased its advertising rates, which increased its annual profit by nearly $1.6m, while the Sun’s fell by $1.3 m.
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Then Fairfax surrendered and henceforth the *Mirror* has been price leader.

(See the New York episode in Lecture 1 above: the *NY Post* didn’t know Rupert’s history of strategic gaming.)
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➤ If both sellers charge the same price, then the two sellers split the market.

➤ If one seller charges a lower price, then that seller gets all the sales.
Demand For The Product

The industry demand for the product is as follows:

<table>
<thead>
<tr>
<th>Industry Demand</th>
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**Profits and Costs**

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  \[ \pi = 20 - (5 \times 2) = 10 \]

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- There is a prize for the seller with the highest total profit in the room at the end.
The Game

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- Total profits will be calculated at the conclusion of the game.
- Your aim is to maximise your profits.
- You don’t know how many rounds there will be.
Game Debrief

Questions:

➢ How did your game evolve?

➢ What signals did you send? How? Were they effective? Consequences?

➢ What did the other seller do? Why — what did they mean? Your response?

➢ What patterns of play can you see across the score sheet?
**A POM for the Duopoly Game**

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<td>0, 0</td>
<td>0, 6</td>
<td>0, 10</td>
<td>0, 12</td>
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What is the N.E.?

So why I do call this lecture “solving the repeated P.D.”?
2. Dynamic Pricing Rivalry

➤ What should pricing rivalry mean in practice?
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   — or should you keep prices high, and take a share of (monopoly) profits?
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➢ Why is it important to consider the dynamics?
  — Because most interactions in most markets are repeated.
More Questions.

1. What conditions influence the *intensity of price competition* in a market?

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Price competition is a dynamic, strategic process: a firm’s decisions will affect how rivals and the firm itself behave in the future.
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Price competition is a dynamic, strategic process: a firm’s decisions will affect how rivals and the firm itself behave in the future.

What if Fairfax had understood Rupert Murdoch’s News’ intentions better in the example above, p.3, (or the New York interaction several years later)?
Dynamic Pricing Rivalry

Firms compete again and again: it’s not just once off.
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A price cut today to steal market share from rivals may result in matching price cuts tomorrow by the rivals, leading eventually to no changes in market shares, but lower profits all round: *a price war.*
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A price cut today to steal market share from rivals may result in matching price cuts tomorrow by the rivals, leading eventually to no changes in market shares, but lower profits all round: \textit{a price war}.

This interaction is very similar to a \textit{repeated or iterated PD}.

(See Rao et al. on avoiding a price war, Reading 32.)
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Q: How can such cheating be detected?

Q: What prospect of punishment will deter cheating?
Iran v. Iraq in 1990. (Cournot)

Consider Iran and Iraq supplying oil:

- “Lo” = 2 million bbl/day, “Hi” = 4 million bbl/day.
- A Cooperative solution of \{Lo,Lo\} = total production of 4 m bbl/day, @ $25/bbl.
- A Competitive solution of \{Hi,Hi\} = total production of 8 m bbl/day, @ $10/bbl.
- An Off-diagonal solution of \{Hi, Lo\} or \{Lo,Hi\} = 6 m bbl/day, @ $15/bbl.

If Iran’s extraction costs are $2/bbl, and Iraq’s are $4/bbl, then the following payoff matrix is their net returns (in $million/day).
# The Prisoner's Dilemma (Oil cartel)

<table>
<thead>
<tr>
<th>Iran’s output</th>
<th>Lo</th>
<th>Hi</th>
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</thead>
<tbody>
<tr>
<td>Lo</td>
<td>46,42</td>
<td>26,44</td>
</tr>
<tr>
<td>Hi</td>
<td>52,22</td>
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*Iraq’s output*
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Iran’s output
### The Prisoner’s Dilemma (Oil cartel)

The payoff matrix for the Prisoner’s Dilemma with Iraq and Iran as the players is shown below.

<table>
<thead>
<tr>
<th></th>
<th>Low Output</th>
<th>High Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low</strong></td>
<td>46,42</td>
<td>26,44</td>
</tr>
<tr>
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*Note:* The payoffs represent the profit for both countries, where higher numbers indicate higher profits.
The Prisoner’s Dilemma (Oil cartel)

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<th>Hi</th>
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The Prisoner’s Dilemma (Oil cartel)

The payoff matrix (Iran, Iraq) in 1990. A non-cooperative, positive-sum game, with no dominant strategy/ies.
The Payoffs Plotted

Iran’s payoffs

Iraq’s payoffs

Iran: Hi, Iraq: Hi
Lo, Hi
Lo, Lo
Hi, Lo

Iran: output; Iraq: output.
Higher outputs → lower payoffs

Individually rational payoffs: no worse than \{Hi, Hi\}. 
4. Detection Of Cheating

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What if it’s not simple price competition? e.g., quality, not so easily monitored (although even prices actually paid may not be easy to monitor).

Collusion may focus on the more transparent dimensions of choice (such as price).

Competition may move to the less observable dimensions of choice (such as quality)
— D&N’s *Law of Increasing Opaqueness.*

Cheating may be passive (e.g. not moving to increase taxes).

*n*-person games: Who’s the cheat?
5. Punishment of Cheaters

➢ A prisoner who turns informer may fear for life and limb. (What of Gotti’s jury members? What is cooperation in their case?)

➢ Police may scare drug dealers into confessing with the threat of (what?)

Threatened loss of reputation may be used.
Or threatened loss of income:
Iran v. Iraq (Cournot)

Consider Iran & Iraq’s oil production game.

- Iran’s temptation to cheat is $52 - 46 = $6 if it pumps Hi instead of Lo; and Iraq’s is $44 - 42 = $2.
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Without side-payments or contracts, there is no way to ensure cooperation in the one-shot game. Only in a repeated game does there exist the ability to punish. Collapse of the agreed {Lo, Lo} → the high cost of lower future profits.
6. Repetition: The Folk Theorem

The Folk Theorem of game theory says that for sufficiently low discount rates, any price between the monopoly (or joint-profit-maximising) price \((C,C=Lo,Lo \rightarrow 46,42)\) and the break-even or competitive price \((D,D=Hi,Hi \rightarrow 32, 24)\) can be sustained as an equilibrium in the infinitely repeated PD. (See payoffs in the graph.)

A low discount rate is equivalent to low impatience.

**Folk Theorem**: For the two-person PD, any *individually rational outcome* (shaded area) can be supported for sufficiently low discount rates.
To D(efect) or not to D(efect)

Need to consider more than just one period’s profits

— Look forward and reason backwards
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Need to consider more than just one period’s profits
   — *Look forward and reason backwards*

Depends on:
   — each firm’s pricing *strategy* (what to do, how to respond)
   — each firm’s *expectations* of its rivals’ strategies
   — the *discount rate* and the time horizon
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Some general concerns:
   — How quickly can my rivals respond?
   — What is the difference between my defection profits and my shared monopoly profits?
6.1 Coordinating on an equilibrium

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6.1 Coordinating on an equilibrium

The Folk Theorem doesn’t guarantee an equilibrium, and achieving a desired equilibrium, one amongst many, is a coordination problem, such as the Battle of the Sexes (Lecture 2).

To price cooperatively, firms must coordinate on a strategy, such as Tit for Tat:

- a variation of the “eye-for-an-eye” rule of behaviour
- cooperation in the first period (nice), then mimic your rival’s action from the previous period

A collusive agreement could attain this — but collusion is illegal.
Focal points.

Without an agreement or overt communication, the firms must find a focal point — a strategy so compelling that it would be natural for all firms to expect others to adopt it.
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Especially difficult to coordinate in competitive markets that are turbulent and changing rapidly.

Sometimes facilitated by traditions and conventions that make rivals’ moves easier to follow or their intentions easier to interpret.
Four Attributes for an Effective Strategy:

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∴ Not easily exploited!
An Ideal Strategy in a Repeated Game?

- *Tit For Tat* manages to encourage cooperation wherever possible, but avoids exploitation.
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- Tit For Tat manages to encourage cooperation wherever possible, but avoids exploitation.

- But are there flaws in Tit for Tat?
  - Misperceptions can be costly: mistakes “echo” back and forth
  - No way of saying “enough is enough”
  - And what if there is more than one other player?
  - Not sub-game perfect. (Because it’s supported by non-credible threats.)
Other Possible Strategies?

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- *Always Defect*: you bastard!
An alternative strategy?

How about:

1. begin cooperating
2. continue cooperating even if the other side defects
3. keep count of how many times the other side appears to have defected while you have cooperated
4. when this count becomes “too high”, then TtF (as punishment, that is)

The question remains of defining “too high”.
Case: Price wars.

Case: David Jones
A Matching Price Pledge

Without price matching:

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
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<tbody>
<tr>
<td>Kmart</td>
<td>2000, 2000</td>
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<td>0, 4000</td>
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High is weakly dominated by Match, and Low is weakly dominated by Match, \( \therefore \) Match emerges from the PD.
Case: How misunderstanding can lead to price wars

It may be that many real-life price wars are not started by deliberate attempts by one firm to steal business from its competitors, but instead flow from misreads and misunderstanding of rivals’ behaviour.

Such as Besanko’s tyre manufacturers’ price war (Reading 31).
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Facilitates cooperation. Why?
Conditions for collusion.

Four reasons why a firm’s response to its rivals’ actions might be delayed:

1. infrequent interactions,
2. lags in confirming rivals’ prices
3. ambiguities in identifying exactly who (among a group, e.g. OPEC) is cutting price, or increasing production
4. difficulties in separating falls in sales due to rivals’ stealing from those due to unanticipated contractions in market demand.

All of these uncertainties slow the firm’s reaction time, and so the effectiveness of any retaliatory price cuts (or production increases) against defecting firms.
Five Moderating Influences:

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5. **Volatility of demand and cost conditions.**
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Beware end-game behaviour:

If players know when the game will end (how many rounds to go), then there may be unravelling of any cooperation/collusion: near the known end, no long-term gains from not cheating.
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But cooperation is observed anyway, perhaps because:

a. no fixed end, or
b. “nice” players initially, waiting to defect, or
c. low discounting of the future, so cheating is deterred by the prospect of cut-throat competition.

One good turn deserves another. You scratch my back and I’ll scratch yours.
Case: The 1992 U.S. Airlines Fare War

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Cutting prices has an effect not emphasised above: if the industry prices fall, total demand will rise.

(Besanko et al., Reading 31.)
Why the price war started...

So two benefits to NWA:

1. with price-sensitive vacationers, NWA’s competitive disadvantages minimised,

2. a disproportionate share of additional traffic with NWA.

So if NWA could fill its planes only by stimulating market demand, it should do so when demand is most elastic, during the summer.

Low-quality or low-share firms may gain more from defection (i.e. pricing low), even if the higher-quality rivals immediately match.

(See Besanko et al., Reading 31 )
Case: Price discipline in the U.S. tobacco industry

Until the 1990s the U.S. cigarette industry had a high degree of concentration and pricing cooperation.

Dominant firms (PM and RJR) would announce the list price rises twice a year, and the others would follow: much above the inflation rate, and highly profitable (40% margins).
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L&M then introduced “deep discounts” 30% below discounts, and their rivals followed: in 1992 three segments — a premium ($69/1000), a discount ($49/1000), and a d-d ($31/1000).

(See Besanko et al., Reading 31.)
Collapse of discipline.

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Since then return of market discipline? Price increases in all segments in 1993, 1994, 1995: premium prices down 26%, discount up 8%, d-d up 48%, and Marlboro’s share up to 30% by mid-1995.

(See Besanko et al., Reading 31.)
## Sustaining Cooperative Pricing — Summary

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</tr>
<tr>
<td>Firm asymmetries</td>
<td>N</td>
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<td>High buyer concentration</td>
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<td>Lumpy orders</td>
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Y = sustains cooperative pricing  
N = doesn’t sustain such pricing
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- Uniform delivered prices
- Strategic use of inventories and order backlogs

(See Besanko et al., Reading 31)
7. Punishment is Guaranteed

Examples of enforcing price collusion through a punishment guarantee — all in the name of “competition.”

Crazy Eddie (since convicted of fraud in New York) and Newmark & Lewis and their implicit cartel:

N&L will refund 100% of the difference, plus another 25%, or more in kind (asymmetric, detection of cheating, punishment of cheaters)

A *most-favoured-customer* (MFC) guarantee.

Du Pont and its “most-favoured-customer” clause: the seller will offer to those most favoured customers the best price he offers to anyone, which made expanding market share more costly.
A Choice of Punishment

Want:

➢ simplicity & clarity
➢ certainty: defection punished & cooperation rewarded
A Choice of Punishment

Want:

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Question: how severe? to fit the crime? higher? (is it a punishment or a deterrent?) what if there are mistakes in detection?
Other Repeated PD Solutions

Changing the Penalties (for Defectors) and Rewards (for Cooperators) of the Repeated PD game.

One player takes Leadership:

such as the swing producer in OPEC, Saudi Arabia.
**Experimental Evidence**

In lab experiments, Cooperation does occur, right up until the end, or just before.

See the results of our Duopoly Game in class.

When should you defect (even when you know how many more rounds to go)?

Axelrod: “Don’t be envious, Don’t be the first to defect. Echo both cooperation and defection. Don’t be too clever.”
Real-World Dilemmas

➤ State governments compete to attract business. Offer excessive inducements.

➤ Unions v. employers. Employ lawyers

➤ Biology: The ♀ bowerbird’s dilemma: build his own bower, or destroy others’

➤ Price matching (DJ’s pledge).