OLIGOPOLY – PART 2

PRISONER'S DILEMMA

Example from P-R p. 455; also 476-7, 481-2
Price-setting (Bertrand) duopoly
Demand functions

$$X_1 = 12 - 2\,P_1 + P_2\,,\; X_2 = 12 - 2\,P_2 + P_1$$

Fixed cost 20, marginal cost 0 for each firm
Try just two price choices, 6 and 4 for each

Table shows profits of the two

		Firm 2	
		4	6
Firm 1	4	12 12	20 4
	6	4 20	16 16

Game theory jargon – players Row, Column
Players' objectives – payoffs
In each cell, Row's payoff shown first

Nash equilibrium – If both choose price 4, neither can gain by deviating unilaterally
Stronger argument – 4 is "dominant strategy" for each: each does better choosing 4 than choosing 6, no matter what the other does
But both would do better if **both** choose 6
Payoffs 16 each instead of 12 each
This is the prisoner's dilemma

Dilemma in oligopoly – collusion (cartel) is better for both than competition
But each is tempted to cheat (and would only lose by conforming if the other cheats)
Question for firms – Can they overcome this temptation and maintain cartel / high prices?
Need ways to detect and punish cheaters
Question for society – How to deter cartels and ensure competition (P closer to MC)?
But both need understanding of the game and its possible equilibria

REPEATED INTERACTION   (P-R pp. 484-8)

Above game played each period. From one period to the next, payoffs grow at rate g,
  and money values are discounted at the interest rate r
  Also, probability p that for some outside reason, interaction will discontinue
Tacit collusion can be sustained by various strategies that make it costly to cheat.
Simplest example here: "Grim trigger strategies" – both start by playing the collusive actions,
    but if anyone ever cheats, the collusion collapses in all future periods
    and the game is thereafter played to its competitive or dilemma equilibrium
Cheater gains 20 - 16 = 4 in one period, but loses (opportunity sense) 16 - 12 = 4 ever after
The future loss has expected present discounted value

$$4\,\frac{(1-p)(1+g)}{1+r}+4\left[\frac{(1-p)(1+g)}{1+r}\right]^2+4\left[\frac{(1-p)(1+g)}{1+r}\right]^3+\cdots=4\,\frac{k}{1-k}$$

where k = (1-p)(1+g)/(1+r) . Example: If p = 0.2, g = 0.05, r = 0.1, then k = 0.76, RHS = 12.1 > 4
    But if p = 0.4, g = – 0.02, r = 0.2, then k = 0.49, RHS = 3.84 < 4
So collusion more likely if [1] interest rate r at which future money flows are discounted is low,
    [2] interaction is likely to persist (low p), [3] industry is growing or stable (high g)
All these are conditions ensuring that the future is important relative to the present
Implicit in this – length of the period. Interpretation – how long it takes to detect cheating
    Therefore speed and accuracy of cheating important for successful cartelization
In practice, firms' demands and costs are asymmetric. Price wars are more costly for large firms,
    so small firms may hope to get away with cheating
P-R pp. 457-67 for other practical issues – signaling collusive price and allocating market shares
    as demand and cost conditions change, deterring or responding to outside competition, ...

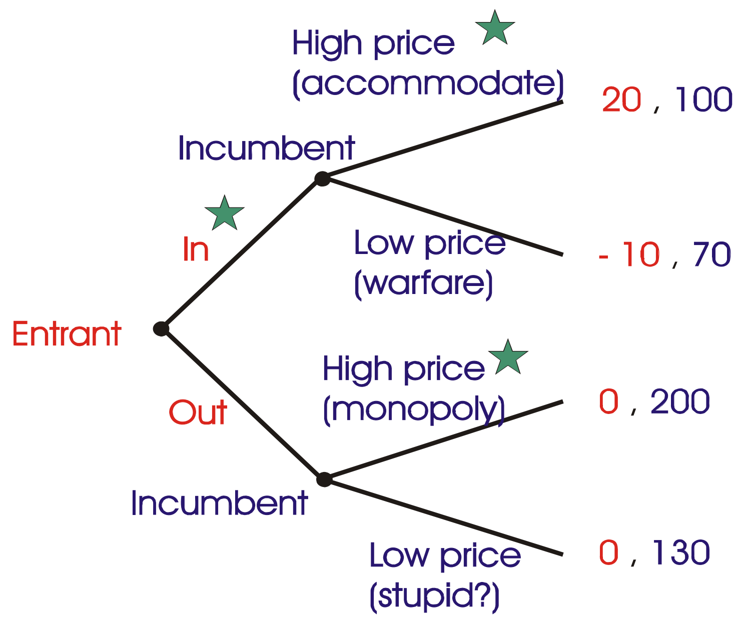
ENTRY DETERRENCE (P-R pp. 491-502, specific example from p. 497-8)

Existing firm (incumbent) trying to deter potential entrant by threat –
Says "I will charge low price (start a price war) if you enter"
Problem – threat may not be credible; potential entrant may believe that if it comes in and puts the matter to the test, the incumbent will back off and accommodate the new firm

Game "tree" shown on right. Consists of "nodes" and "branches"
Each node shows the player who takes action there; emerging branches are available actions
At final or terminal nodes, show resulting "payoffs" if that path is followed in play of game
Asterisks show the optimal action of each player at each node

With these numbers, if Entrant chooses In,
Incumbent's optimal strategy is High Price
Therefore threat of price war is not credible

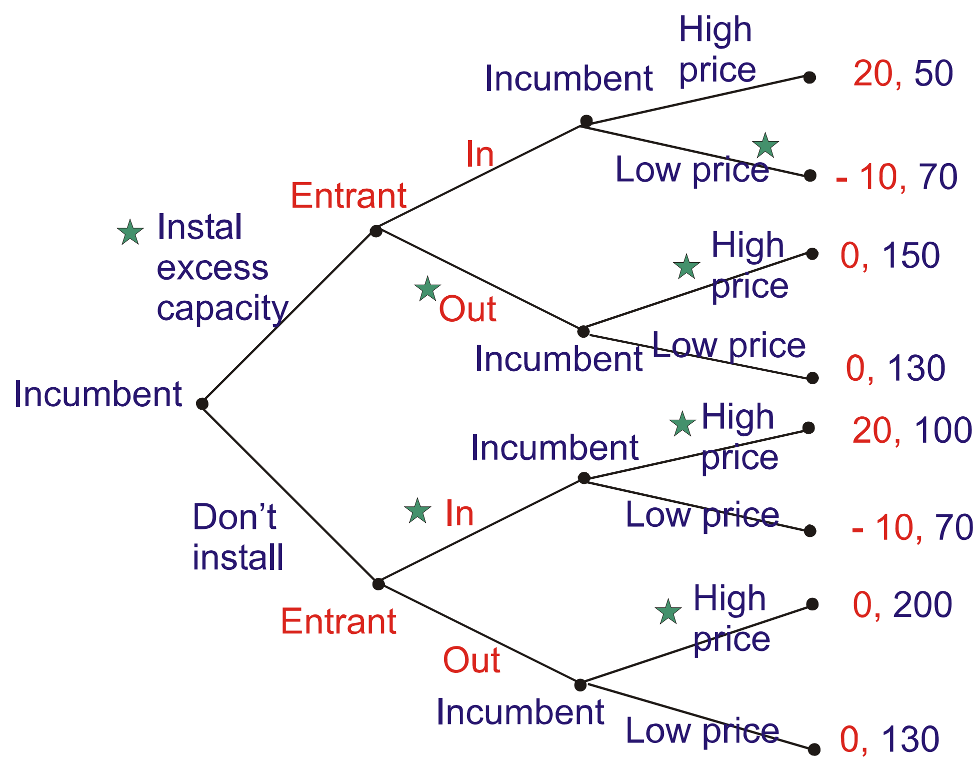
Equilibrium of game found by rollback:
Start at last decision nodes and work back
Find optimal choice at each node,
looking ahead and folding in
all optimal choices at later nodes
Resulting path of play - continuous sequence
of asterisks from the initial to a final node



Incumbent would like to make threat credible
One method – install (sink) capacity ahead of time, enough to meet demand at the low price

The extra capacity costs 50
If high price is charged, quantity is low, capacity goes unused, but its cost is sunk
Profits lower than if capacity was not sunk
If low price is charged, capacity is used. Profits no different than non-sunk case
where the same capacity would have to be acquired later to meet demand at the low price

Bigger game tree with new initial node
for incumbent's capacity choice
Lower half same as old tree
In upper half, if entrant In,
Low price becomes optimal
for incumbent – threat of
price war becomes credible



In rollback equilibrium play
Incumbent instals capacity
Entrant stays Out
Incumbent prices High
Excess capacity stays idle
Incumbent's profit 150
(200 monopoly - 50 capacity cost)
Not as good as 200, but better than
the 130 that comes without the
capacity strategy that makes threat credible

Other paths to credibility – reputation in repeated play, irrationality, ...

STACKELBERG LEADERSHIP (P-R pp. 447-8, 452)

Quantity-setting as in Cournot, but firm 1 moves first, firm 2 moves second
Numbers as in November 17 Oligopoly handout; pp. 3-4
Firm 2's reaction curve is $Q_2 = 75 - 0.75\,Q_1$; this will be its choice at its second move
Firm 1 will recognize this, so at its first move will choose Q_1 to maximize its profit

$$\Pi_1 = (200 - Q_1 - Q_2)\,Q_1 - 100\,Q_1 = (200 - Q_1 - 75 + 0.75Q_1)\,Q_1 - 100\,Q_1 = 25Q_1 - 0.25(Q_1)^2$$

To maximize this, $d\Pi_1 / dQ_1 = 25 - 0.5Q_1 = 0$, or $Q_1 = 50$
Have not drawn game tree, but this is rollback equilibrium of the sequential-move game
Then can solve for other magnitudes. Table shows comparison

Type of oligopoly	Q_1	Q_2	P	π_1	π_2
Cournot	20	60	120	400	2400
Stackelberg (firm 1 leads)	50	37.5	112.5	625	937.5

Quantity-leadership is better for firm 1 and for society than simultaneous play. Reason –
by increasing Q_1 above its Cournot level, firm 1 can get firm 2 to produce less Q_2
But firm 2'a backing off is less than 1-for-1, so total Q increases, P decreases closer to MC
So consumers gain. Total industry profit declines, but firm 1 gains at the expense of firm 2

With price-setting, leadership is often disadvantageous when products are substitutes –
the other firm moving second can see your price and then just undercut you

MONOPOLISTIC COMPETITION (P-R pp. 436-41)

Case where several firms sell close but not perfect substitutes

Free entry / exit yields (approximately) zero profit for each firm

Examples – many consumer products, supermarkets in large town, global auto industry?

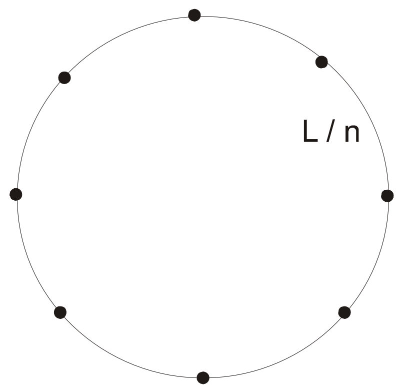
Multi-firm model of location differentiation. Consider n firms along a circle of circumference L

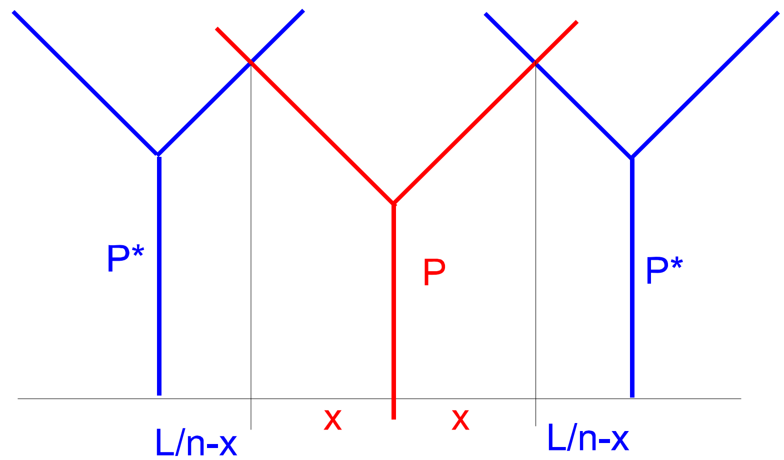
Each firm has fixed cost F and constant marginal cost c

If firm charges P, effective price at distance x is P + k x

Consider symmetric equilibrium where each firm charges price P* (more complex cases exist)

Left figure shows circle with 8 firms; right, just 3 neighbors, with prices and effective prices





If one firm deviates to charge P, it sells to distance x either side, defined by

$$P + k\,x = P^* + k\,(L/n - x)\,, \quad \text{or} \quad x = L/(2n) + (P^*-P)/(2k)$$

So total quantity it sells is $Q = 2\,x = L/n + (P^*-P)/k$

This firm's profit $\Pi = (P-c)\,Q - F = (P-c)\left[\frac{L}{n} + \frac{P^* - P}{k}\right] - F$

This firm treats others' P* as given, and chooses P to maximize its own profit

$$\frac{\partial \Pi}{\partial P} = \left[\frac{L}{n} + \frac{P^* - P}{k}\right] - (P-c)\,\frac{1}{k} = 0$$

We want a symmetric equilibrium where P = P*, so (P-c) / k = L / n, or P = c + k L / n

Then each firm sells to x = L/(2n) either side of its location, for total quantity Q = L/n

Profit of each firm is $\pi = (P\text{-}c)\ Q - F = k\ (L/n)^2 - F$

Entry / exit will reduce this to zero, so $k\ (L/n)^2 = F$, or $n = L\,\sqrt{(k/F)}$

More firms if [1] larger market, [2] lower fixed cost, [3] larger disutility cost of non-ideal product

Equilibrium can be illustrated in figure on right
similar to P-R p. 438 Fig. 12.1 (b)
except that here MC is horizontal

For one firm, P = P*, Q = L/n is optimal
because its MR = MC there

Its maximized profit is zero
because AR = AC there

So fixed cost F must equal
profit rectangle (P*–MC) (L/n)