Oligopoly and Strategic Pricing

In this section we consider how firms compete when there are few sellers — an oligopolistic market (from the Greek).

Small numbers of firms may result in strategic interaction, in which what Firm 1 does in choosing price or quantity affects Firm 2's profits, and vice versa.

How to incorporate the reactions of your rivals into your profit-maximising?

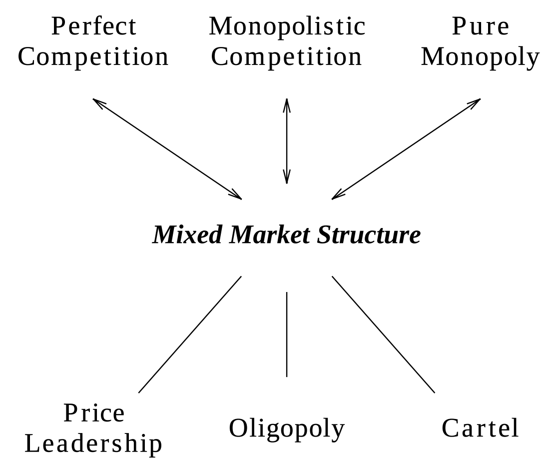
Look forwards and reason backwards.

Put yourself in their shoes, as they try to anticipate your actions.

Use *game theory*: assuming rationality.

After a brief look at *mixed market structures*, we consider:

1. **price leadership**, such as the OPEC cartel, and *limit entry pricing*,
2. **simultaneous quantity setting:** Cournot competition,
3. **quantity leadership**, with possible *first-mover advantage*,
4. **simultaneous price setting:** Bertrand competition,
5. **collusion** and *repeated interactions*,
6. predatory pricing, **"natural monopolies"**, skimming pricing, and tie-in pricing.



Cartel: a group of sellers acting together and facing a downwards-sloping demand curve, to fix price and quantity in concert. (H&H Ch. 8.5)

Oligopoly: A "few" sellers. (H&H Ch. 10)

Price Leadership: can occur in a market with one large seller (or cartel) and many small ones ("the competitor fringe" of price takers); the large firm can affect the price by varying its output.

Strategic Pricing — Oligopolistic Behaviour

No grand model. Many different behaviour patterns. A guide to possible patterns, and an indication of which factors important.

Duopoly — two firms, identical product.

Four variables of interest:

- each firm's price: p_1, p_2
- each firm's output: y_1, y_2

Sequential games:

1. A *price leader* sets its prices before the other firm, the *price follower*.
2. A *quantity leader* sets its quantities before the *quantity follower* does. (Stackelberg)

Simultaneous games:

3. Simultaneously choose *prices* (Bertrand), or
4. Simultaneously choose *quantities*. (Cournot)
5. *Collusion* on prices or quantities to maximise the sum of their profits — a cooperative game? (e.g. a cartel, such as OPEC) (See the Prisoner's Dilemma.)

Can use Game Theory to analyse all kinds: the discipline for analysing strategic interactions.

Benchmarking Equilibria I

Two firms produce homogeneous output. Industry demand $P = 10 - Q$, where $Q = y_1 + y_2$. Identical costs: $AC = MC = \$1$/unit.

The two benchmarks are comeptitive price-taking and monopoly.

We consider three oligopoly models below.

1. They behave as competitive *price takers*, each setting price equal to marginal cost.

   Price $P_{PC} = \$1$/unit, total quantity $Q = 9$, and each produces $y_1 = y_2 = 4.5$ units.

   Since $P_{PC} = AC$, their profits are zero: $\pi_1 = \pi_2 = 0$.

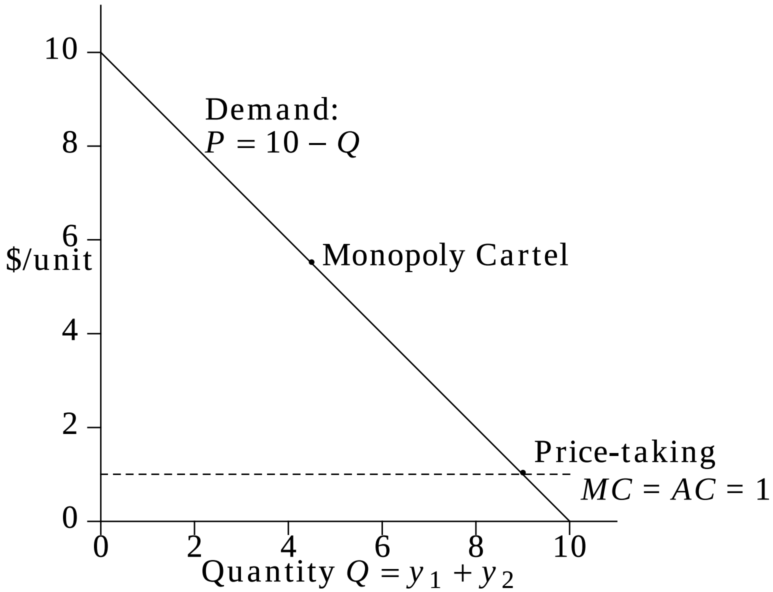
2. They collude and act as a monopolistic *cartel*. Each produces half of the monopolist's output and receive half the monopolist's profit.

   Total output Q_M is such that $MR(Q_M) = MC$ = \$1/unit.

   The MR curve is given by $MR = 10 - 2Q$, so $Q_M = 4.5$ units, $P_M = \$5.5$/unit, and $\pi_M = (5.5 - 1) \times 4.5 = \$20.25$.

   Each produces $y_1 = y_2 = 2.25$ units, and earns $\pi_1 = \pi_2 = \$10.125$ profit.

Graphically:



The other three models will fall along the demand curve between the Price-Taking combination of 9 units @ $1/unit and the Monopoly Cartel combination of 4½ units @ $5.50/unit.

1. Forchheimer's Dominant-Firm Price Leadership

See Reading __________.

One large firm and many small firms selling a homogeneous good.

- *one large firm* (or perhaps a *cartel*), the price leader—
  has some market power, but this is constrained by the—
- *many small firms*, the *"competitive fringe"*—
  who are price takers (they have *no* market power) and face a horizontal demand curve.

The large firm faces the *residual demand curve*
≡ the market demand curve
minus the supply curve of the *competitive fringe.*

What will the *strategy* of the price leader be?

(See the Package Reading ____.)

Limit Entry Pricing

Because of set-up costs & other irreversible investments, entry may *not* be costless, i.e., *barriers to entry*.

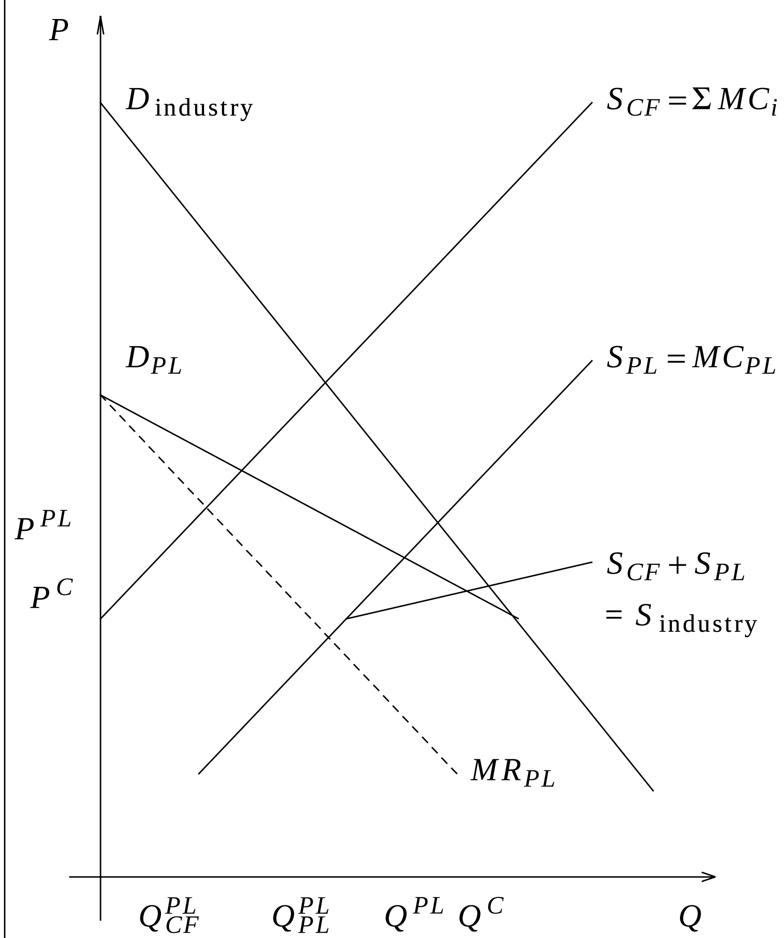
The price leader may forgo profits today for the sake of higher profits later by setting the price low enough to prevent entry by others (the "competitive fringe" CF).

If the industry is a falling-average-cost ($\Leftrightarrow$ IRTS) industry, then the firm can set an

limit entry price P_{LE}

so that: the competitive fringe (& other new entrants) will find it unprofitable to continue operating (or to enter).

Examples ?



Price Leadership

D_{PL} is the *residual demand curve*:

$D_{PL} \equiv D_{\text{industry}} - S_{\text{competitive fringe}}$

Comparison of Price Leadership (PL) & Competitive (C) Pricing without Limit Entry Pricing:

(i.e. long-run pricing)

	P^{PL}	$>$	P^{C}, competitive price
$\therefore$	Q^{PL}_{CF}	$>$	Q^{C}_{CF}, comp. fringe price (CF)
&	Q^{PL}	$<$	Q^{C}, industry output
$\therefore$	Q^{PL}_{PL}	$<$	Q^{C}_{PL}, price leadership output
but	π^{PL}_{PL}	$>$	π^{C}_{PL}, price leader profit

which explains it all! (See diagram above.)

P^{PL} is the price under price leadership

P^{C} is the competitive, price-taking price

Q^{PL} is the total quantity sold under price leadership

Q^{C} is the total quantity sold under price-taking

Q^{PL}_{PL}, π^{PL}_{PL} are the sales and profit of the Price Leader under price leadership

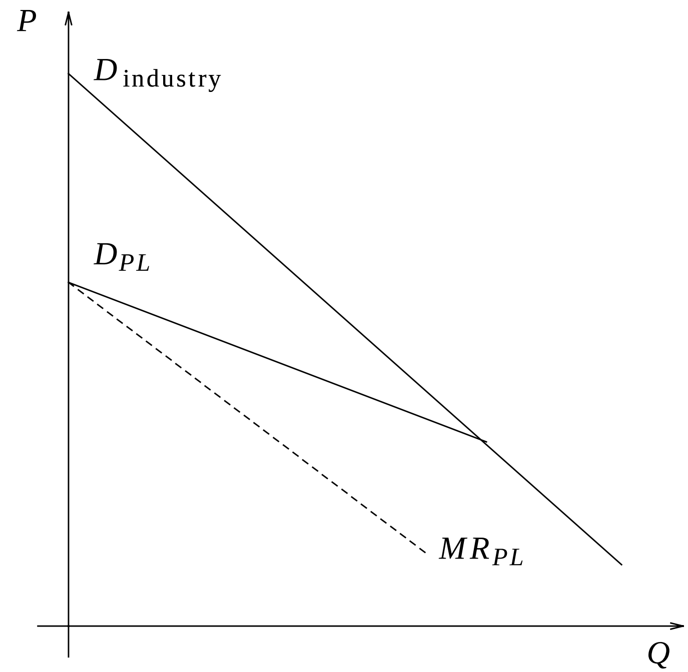
Q^{PL}_{CF}, π^{PL}_{CF} are the total sales and profits of the Competitive Fringe under price leadership

Q^{C}_{PL}, π^{C}_{PL} are the sales and profit of the Price Leader under competitive price taking

Q^{C}_{CF}, π^{C}_{CF} are the total sales and profits of the Competitive Fringe under competitive price taking

Question:

What is the Marginal Revenue when the Demand Curve is kinked?



Marginal Revenue with a Kinked Demand Curve

2. Simultaneous Quantity Setting

The Cournot model — set quantity, let market set price. (H&H Ch. 10.2)

- Symmetrical payoffs.
- One-period model: each firm forecasts the other's output choice and then chooses its own profit-maximising output level.
- Seek an equilibrium in forecasts, a *Nash equilibrium*[1], a situation where each firm finds its *beliefs about the other to be confirmed*, with no incentive to alter its behaviour.
- A *Nash–Cournot* equilibrium.
- Firm 1 expects that Firm 2 will produce y_2^e units of output.

— If Firm 1 chooses y_1 units, then the total out put will be

$$Y = y_1 + y_2^e,$$

— and the price will be:

$$p(Y) = p(y_1 + y_2^e).$$

— Firm 1's problem is to choose y_1 to max π_1:

$$\pi_1 = p(y_1 + y_2^e)\, y_1 - c(y_1)$$

— For any belief about Firm 2's output, y_2^e, exists an optimal output for Firm 1:

$$y_1^* = f_1(y_2^e)$$

— This is the *reaction function*: here one firm's optimal choice as a function of its *beliefs* of the other's action.

— Similarly, derive Firm 2's reaction function:

$$y_2^* = f_2(y_1^e)$$

— So the Firm 1's profits are a function of its output and the other firm's reaction function: $\pi_1 = \pi_1(y_1, y_2(y_1^e))$.

— In general each firm's assumption of the other's output will be wrong:

$$y_2^* \neq y_2^e, \text{ and}$$
$$y_1^* \neq y_1^e.$$

— Only when forecasts of the other's output are correct will the forecasts be mutually consistent:

$$y_1^* = f_1(y_2^*), \text{ and } y_2^* = f_2(y_1^*).$$
$$y_1^* = y_1^e \text{ and } y_2^* = y_2^e$$

- In a Nash–Cournot equilibrium, each firm is maximising its profits, given its beliefs about the other's output choice, and furthermore those beliefs are confirmed in equilibrium.
- Neither firm will find it profitable to change its output once it discovers the choice actually made by the other firm. No incentive to change: a Nash equilibrium.

1. John Nash jointly won the 1994 Nobel economics prize for his 1951 formulation of this.

- An example is given in the figure (Varian 25.2): the pair of outputs at which the two reaction curves cross: Cournot equilibrium where each firm is producing a profit-maximising level of output, given the output choice of the other.

2.1 Benchmarking Equilibria II

They behave as *Cournot oligopolists*, each choosing an amount of output to maximise its profit, on the assumption that the other is doing likewise: they are not colluding, but competing. They choose simultaneously.

Cournot equilibrium occurs where their *reaction curves* intersect and the expectations of each of what the other firm is doing are fulfilled. (Questions of stability are postponed until **Industrial Organisation /Economics** in Term 1 next year.)

Firm 1 determines Firm 2's reaction function: "If I were Firm 2, I'd choose my output y_2^* to maximise my Firm 2 profit conditional on the expectation that Firm 1 produced output of y_1^e."

$$\max_{y_2} \pi_2 = (10 - y_2 - y_1^e) \times y_2 - y_2$$

Thus $y_2 = ½(9 - y_1^e)$, which is Firm 2's reaction function.

Since the two firms are apparently identical, Cournot equilibrium occurs where the two reaction curves intersect, at $y_1^* = y_1^e = y_2^* = y_2^e = 3$ units.

So Q_{Co} = 6 units, price P_{Co} is then \$4/unit, and the profit of each firm is \$9.

3. Quantity Leadership

The Stackelberg model — describes a *dominant firm* or *natural leader* (once IBM, now Microsoft, or OPEC, etc.). *Cournot* or quantity competition. (H&H Ch. 10.2)

Model:

Leader Firm 1 produces quantity y_1
Follower Firm 2 responds with quantity y_2

- Equilibrium price P is a function of total output $Y = y_1 + y_2$:

$$P(y_1 + y_2)$$

- What should the Leader do?
  Depends on how the Leader thinks the Follower will react.

  Look forward and reason back.

- The Follower: choose y_2 to max profit π_2

$$= P(y_1 + y_2) y_2 - C_2(y_2)$$

  (from the Follower's viewpoint, the Leader's output is predetermined — a constant y_1).

- So Follower sets his $MR(y_1, y_2^*) = MC(y_2^*)$ to get y_2^*:

$$MR(y_1, y_2^*) \equiv P(y_1 + y_2^*) + \frac{\partial P}{\partial y_2} y_2^* = MC(y_2^*)$$

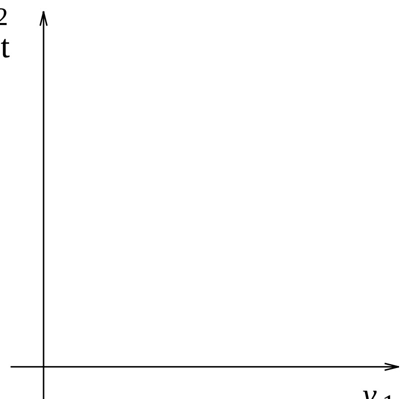
$$\rightarrow y_2^* = f_2(y_1)$$

  i.e. the profit-maximising output of the Follower y_2^* is a function of what the Leader's choice y_1 was already.

- This function is known as the Follower's *reaction function*, since it tells us how the Follower will react to the Leader's choice of output.
- e.g. Assume simple linear demand and zero costs.
  The (inverse) demand function is
  $$P(y_1 + y_2) = 10 - (y_1 + y_2)$$

— Firm 2's profit function:
$$\pi_2(y_1, y_2) = [10 - (y_1 + y_2)]\,y_2$$
$$= 10y_2 - y_1 y_2 - y_2^2$$

— Plot *isoprofit lines*: combinations of y_1 and y_2 that yield a constant level of Firm 2's profit π_2



(Varian 25.1)

— Since for any level of output y_2, π_2 increases as y_1 falls, the isoprofit lines to the left are on higher profit levels. The limit is when $y_1 = 0$ and so Firm 2 is a monopolist.

— For every y_1, Firm 2 wants to attain the highest profit: occurs at y_2 which is on the highest profit line: *tangency*.

— Firm 2's marginal revenue, from:
$$TR_2 = (10 - (y_1 + y_2))\,y_2$$
$$\therefore\ MR_2 = 10 - y_1 - 2y_2$$
$$= MC_2 = 0 \text{ (in this case)}$$
a straight line: Firm 2's *reaction function*,
$$y_2^* = \frac{10 - y_1}{2} = f_2(y_1)$$

- The Leader's problem:
  the Leader will recognise the influence its decision (y_1) has on the Follower, through Firm 2's reaction function, $y_2 = f_2(y_1)$
- So Firm 1 maximises profit π_1 by choosing y_1:
  $$\max_{y_1} P(y_1 + y_2)\,y_1 - C_1(y_1)$$
  $$\text{s.t. } y_2 = f_2(y_1)$$
  or
  $$\max_{y_1} P[y_1 + f_2(y_1)]\,y_1 - C_1(y_1)$$

— For the linear demand function above:
$$f_2(y_1) = y_2 = \frac{10 - y_1}{2}$$
(the Follower's reaction function)

— With zero costs (assumed), Leader's profit π_1:

$$\pi_1(y_1, y_2) = 10y_1 - y_1^2 - y_1 y_2$$

$$= 10y_1 - y_1^2 - y_1\left(\frac{10-y_1}{2}\right)$$

$$= \frac{10}{2}y_1 - \frac{1}{2}y_1^2 \text{ (choose } y_1 \text{ to max. } \pi_1\text{)}$$

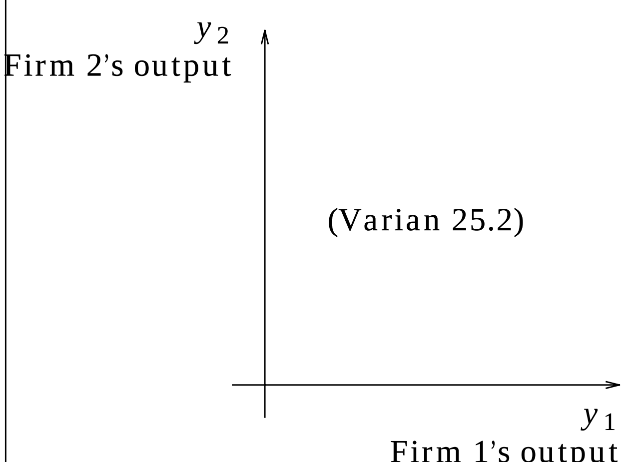
$$\text{Now } MR_1 = \frac{10}{2} - y_1 = MC_1 = 0$$

Hence the Nash equilibrium:

$$\Rightarrow y_1{}^* = 5, \;\; \pi_1{}^* = \frac{10^2}{8} = 12.5$$

$$\Rightarrow y_2{}^* = 2.5, \;\; \pi_2{}^* = \frac{10^2}{16} = 6.25$$

Note: *First-Mover Advantage* in this case.



— Firm 1 is on its reaction curve $f_2(y_1)$. Firm 2: choose y_1 on $f_2(y_1)$ on the highest isoprofit line, tangency at point A.

3.1 Benchmarking Equilibria III

Stackelberg Quantity Leadership: What if one firm, Firm 1, gets to choose its output level y_1 first? It realises that Firm 2 will know what Firm 1's output level is when Firm 2 chooses its level: this is given by Firm 2's reaction function from above, but with the actual, not the expected, level of Firm 1's output, y_1.

So Firm 1's problem is to choose y_1^* to maximise its profit:

$$\max_{y_1} \pi_1 = (10 - y_2 - y_1) \times y_1 - y_1,$$

where Firm 2's output y_2 is given by Firm 2's reaction function: $y_2 = ½(9 - y_1)$.

Substituting this into Firm 1's maximisation problem, we get: $y_1^* = 4.5$ units, and so $y_2^* = 2.25$ units, so that $Q_{St} = 6.75$ units and $P_{St} =$ \$3.25/unit.

The profits are π_1 = \$10.125 (the same as in the cartel case above) and π_2 = \$5.063 (half the cartel profit).

4. Simultaneous Price Setting

Instead of firms choosing quantity and letting the market demand determine price, think of firms *setting their prices* and letting the market determine the quantity sold — *Bertrand competition*. (H&H Ch. 10.2)

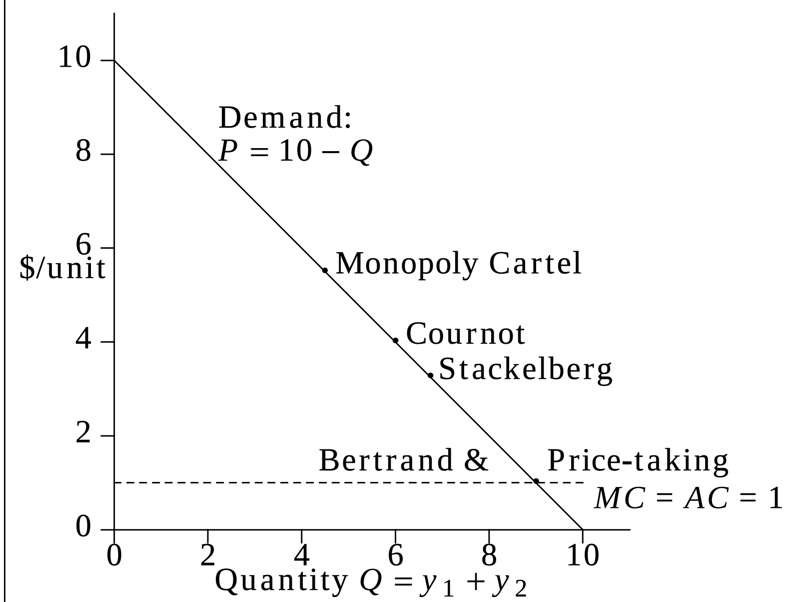
- When setting its price, each firm has to forecast the price set by the other firm in the industry.
- Just as in the Cournot case of simultaneous quantity setting, we want to find a pair of prices such that each price is a profit-maximising choice given the choice made by the other firm.
- With identical products (not differentiated), the *Bertrand equilibrium is identical with the competitive equilibrium* and 1, where $P = MC(y^*)$.
- As though the two firms are “bidding” for consumers’ business: any price above marginal cost will be undercut by the other.

4.1 Benchmarking Equilibria IV

Bertrand Simultaneous Price Setting. The only equilibrium (where there is no incentive to undercut the other firm) is where each is selling at $P_1 = P_2 = MC_1 = MC_2 = \$1$/unit. This is identical to the price-taking case above.

If MC_1 is greater than MC_2, then Firm 2 will capture the whole market at a price just below MC_1, and will make a positive profit; $y_1 = 0$.

Graphically:



5. Collusion — Cartel Behaviour

(H&H Ch. 10.4)

- Colluding over price may enable two or more firms to push price above the competitive level, by holding industry output below the competitive level.
- They must then agree how to share the monopolist's profits.
- This has elements of the *Prisoner's Dilemma* (See Reading __, Marks: "Competition and Common Property".)
- In a simple example: if both firms price High, each earns $100, while if both price Low, each earns only $70.
- But if one prices High while then other prices Low, the first earns –$10, while the second earns $140.

We plot a *payoff matrix*, which show the outcomes (each firm's profits) for all four combinations of pricing High and Low:

The Prisoner's Dilemma

		The other player	
		High	Low
You	High	$100, $100	–$10, $140
	Low	$140, –$10	**$70, $70**

TABLE 1. The payoff matrix (You, Other)
A *non-cooperative*, *positive-sum* game, with a *dominant strategy*.

- *Collusion* would see the firms agreeing to screw the customers and each charging High, the *joint-profit-maximising* combination of {$100, $100}.

- But the temptation is to screw the other firm too, by pricing Low when the other firm prices High.
  Nash Equ. of {Low, Low} → {$70, $70}.
  Efficient outcome is {High, High} and {$100, $100}. (ignoring whom?)
- Moreover, the risk is that you're left pricing High when the other firm prices Low.
- The *dominant strategy* is to price Low.
- So both do, resulting in an *inefficient Nash equilibrium* of {Low, Low}, of {$70, $70}.
- Collusion {High, High} can only occur (laws prohibiting collusive behaviour apart) when each firm overcomes the temptation to cheat the other firm and the fear of being cheated. We need a credible commitment.
- If two or more producers collude to push prices up while squeezing output, then they are acting as a *cartel*.

Other games?

(See Dixit and Nalebuff's book *Thinking Strategically*.)

e.g. Chicken! — competition
e.g. Battle of the Sexes — coordination

6. Predatory Pricing:

is cutting prices below the break-even point of competing firms, to cause them to leave the industry. (H&H Example 10.2)

But it may be cheaper to buy out rivals than to force them out by predatory pricing.

Firm 1 (with market power) prices at P:
$AC_1 < P < AC_2$, means that Firm 2 (with higher costs) cannot make a positive profit.

Unless the production process exhibits *decreasing costs* (Increasing Returns to Scale, IRTS) over a long range of output (perhaps because of high fixed costs), in which case a *firm with larger market share will have lower average cost* than do smaller firms, and the large firm may be able to continue making profits while forcing out the smaller firms.

→ a race for market share, e.g. ?

(See *Fortune* article in Package.)

↓

A "Natural Monopoly" (with falling average cost)

>> Include H&H Fig 8.6 <<

7. Dilemma of "Natural Monopolies":

(H&H Ch. 8.3)

A. Profit maximizing $\rightarrow P_m, Q_m$ the *monopoly output* where $MR = MC$.

B. The competitive solution (P_c, Q_c) where $P = MC$ & $S = D$: the firm will fail because $P < AC$, and yet this is the *ideally efficient outcome.*

C. The *breakeven solution* (P_r, Q_r) where $P = AC$, but at a dead-weight loss (DWL) of consumers' and producers' surplus.

This diagram shows why "natural monopolies" are often

(a) closely regulated (e.g. ?) or

(b) government-owned.

Skimming Pricing

- Set relatively high prices at the outset then lower them progressively as the market expands later.

  (One way of segmenting the market into segments of increasing price elasticity of demand.)

  Example?

Tie-In Sales

- Require retailers to buy a “bundle” or “block” of less preferred as well as more preferred.

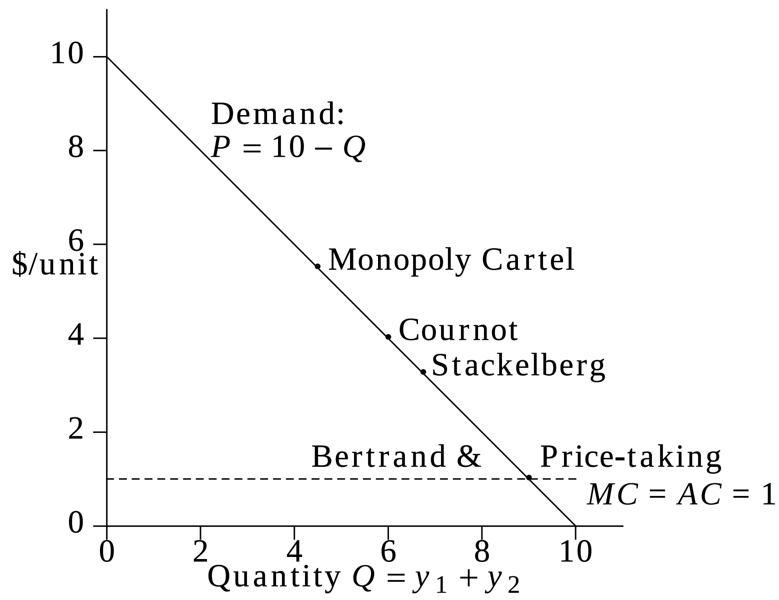
  (A way of capturing more of the retailer’s *consumer’s surplus* or *net willingness to pay*.)

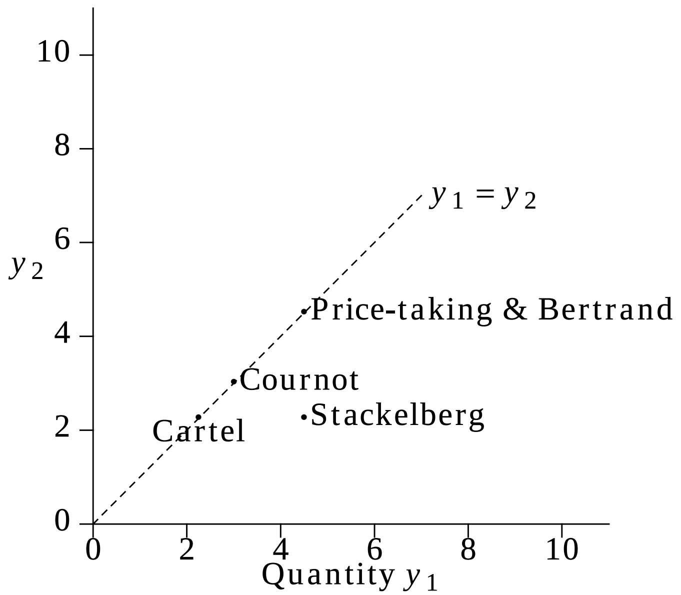
  or *Leasing* may prevent resale among price-discriminated customers.

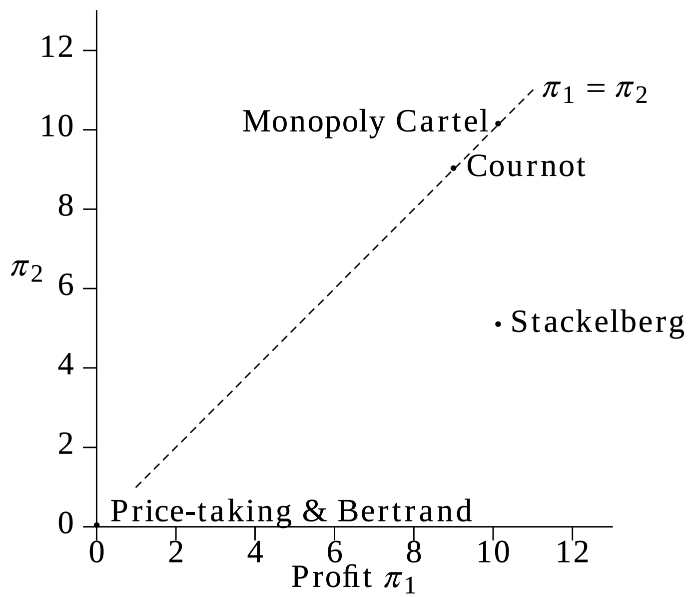
To summarise the equilibria considered in these Lectures:

	y_1	π_1	y_2	π_2	P	Q
Price-taking	4.5	0	4.5	0	1	9
Cartel	2.25	10.125	2.25	10.125	5.5	4.5
Cournot	3	9	3	9	4	6
Stackelberg	4.5	10.125	2.25	5.063	3.25	6.75
Bertrand	4.5	0	4.5	0	1	9

Graphically:




10
8
6
4
2
0
y_2
$y_1 = y_2$
Price-taking & Bertrand
Cournot
Stackelberg
Cartel
0 2 4 6 8 10
Quantity y_1


12
10
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π_2
$\pi_1 = \pi_2$
Monopoly Cartel
Cournot
Stackelberg
Price-taking & Bertrand
0 2 4 6 8 10 12
Profit π_1