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,

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**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 competitive 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:

\[ Q = y_1 + y_2 \]

Demand:
\[ P = 10 - Q \]

MC = AC = 1

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
\[ \equiv \text{the market demand curve} \]
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 (⇌ 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 ?
Comparison of Price Leadership (PL) & Competitive (C) Pricing without Limit Entry Pricing:

(i.e. long-run pricing)

\[ P_{PL} > P_C, \text{ competitive price} \]
\[ \therefore Q_{PL} > Q_{CF}, \text{ comp. fringe price (CF)} \]
\[ & Q_{PL} < Q_C, \text{ industry output} \]
\[ \therefore Q_{PL} < Q_{PL}, \text{ price leadership output} \]
\[ \text{but } \pi_{PL} > \pi_{PL}, \text{ price leader profit} \]

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
\[ Q_{PL}, \pi_{PL} \] are the sales and profit of the Price Leader under price leadership
\[ Q_{CF}, \pi_{CF} \] are the total sales and profits of the Competitive Fringe under price leadership
\[ Q_{PL}, \pi_{PL} \] are the sales and profit of the Price Leader under competitive price taking
\[ Q_{CF}, \pi_{CF} \] 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 output 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 \(\pi_1\):
    \[ \pi_1 = p(y_1 + y_2^e)y_1 - c(y_1) \]
  - 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.

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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 $y_1^e$.”

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

Thus $y_2 = \frac{1}{2} (9 - y_1^e)$, 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 $\pi_2$

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

(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 $y_2^*$:

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

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

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:
    \[ \pi_2(y_1, y_2) = [10 - (y_1 + y_2)]y_2 = 10y_2 - y_1y_2 - y_2^2 \]

  - Plot isoprofit lines: combinations of \( y_1 \) and \( y_2 \) that yield a constant level of Firm 2’s profit \( \pi_2 \)

— Since for any level of output \( y_2 \), \( \pi_2 \) 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, \( y_2 = f_2(y_1) \)

— Firm 1 maximises profit \( \pi_1 \) by choosing \( y_1 \):
\[ \max_{y_1} P(y_1 + y_2)y_1 - C_1(y_1) \] 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 $\pi_1$:

$\pi_1(y_1, y_2) = 10y_1 - y_1^2 - y_1y_2$

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

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

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 1 solves for $y_1$ on its reaction curve to maximise profit,
which gives $y_1^* = 4.5$ units, and $y_2^* = 2.25$ units, so that $Q_{St} = 6.75$ units and $P_{St} = \frac{10}{3.25} = \$3.25/unit.$

The profits are $\pi_1 = 10.125$ (the same as in the cartel case above) and $\pi_2 = 5.063$ (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 \( P_1 = P_2 = MC_1 = MC_2 = $1/\text{unit} \). 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**

<table>
<thead>
<tr>
<th>The other player</th>
<th>High</th>
<th>Low</th>
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</thead>
<tbody>
<tr>
<td>High</td>
<td>$100, $100</td>
<td>−$10, $140</td>
</tr>
<tr>
<td>Low</td>
<td>$140, −$10</td>
<td>$70, $70</td>
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</tbody>
</table>

**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 {High, High}. 
• But the temptation is to screw the other firm too, by pricing Low when the other firm prices High.
  Nash Equ. of \{Low, Low\} \rightarrow \{$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)
7. Dilemma of “Natural Monopolies”:
(H&H Ch. 8.3)

A. Profit maximizing → \( P_m, Q_m \) 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.

<table>
<thead>
<tr>
<th>To summarise the equilibria considered in these Lectures:</th>
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<tbody>
<tr>
<td>Y₁</td>
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<tr>
<td>Price-taking</td>
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<tr>
<td>Cartel</td>
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<tr>
<td>Cournot</td>
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<tr>
<td>Stackelberg</td>
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<tr>
<td>Bertrand</td>
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Graphically:

Demand: $P = 10 - Q$

MC = AC = 1
Price-taking & Bertrand
Cartel
Cournot
Stackelberg

\[ y_1 = y_2 \]

\[ \pi_1 = \pi_2 \]

Price-taking & Bertrand
Cartel
Cournot
Stackelberg