

# Lecture 1 - Oligopoly

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## Market Structures

# Industrial Organisation: Overview

Economic models rest on key assumptions about market structure and firm behaviour.

## **Under perfect competition:**

- ▶ Markets are efficient
- ▶ Price equals marginal cost

## **Under imperfect competition:**

- ▶ Markets generate welfare losses
- ▶ Strategic firm behaviour matters

# Beyond Static Models

In reality, many markets feature:

- ▶ **Dynamic entry/exit:** Number of firms changes over time
- ▶ **Product differentiation:** Firms compete on product variety
- ▶ **Technological change:** Innovation and R&D investment
- ▶ **Demand shifts:** Advertising and marketing effects

→ Static models provide a foundation, but IO studies these dynamic elements.

## Market Structures

## Case: Alcoa as a Natural Monopoly

### **i** Note

Sources of market power in early aluminium production (c. 1886–1914).

- ▶ **Patent advantage (1886):** Smelting process patented; only a small number of firms can produce at scale initially.
- ▶ **Economies of scale:** Alcoa expands output and develops downstream markets (intermediate and final aluminium products).
- ▶ **Input foreclosure (energy):** In 1893, Alcoa contracts in advance for hydroelectric power from Niagara Falls.
- ▶ **Input foreclosure (bauxite):** Alcoa secures major North American bauxite sources.
- ▶ **Dynamic efficiency and entry deterrence:** Cost reductions make entry difficult even after patent expiration.

# Market Structure Typology

Three key competitive regimes:

Structure	# Firms	Price Setting	Output
<b>Perfect Competition</b>	Many	Price-taker	Competitive
<b>Monopoly</b>	1	Monopolist	Restricted
<b>Cournot Oligopoly</b>	Few	Strategic	Intermediate

# Cournot Quantity Competition

**Firm  $i$ 's maximisation problem:**

$$\max_{q_i} q_i (P(q_i + q_{-i}) - c(q_i))$$

**Cournot Pricing Formula:**

$$\frac{P - c'(q_i)}{P} = \frac{\alpha_i}{\eta}$$

Where:

- ▶  $\alpha_i = \frac{q_i}{Q}$  is firm  $i$ 's market share
- ▶  $\eta = -\frac{dQ/Q}{dP/P}$  is the price elasticity of demand
- ▶ LHS is the Lerner index (mark-up rate)

# Cournot Pricing Formula: Interpretation

## Key Insight

The mark-up is directly proportional to market share and inversely related to demand elasticity.

- ▶ Larger market share  $\rightarrow$  higher mark-up
- ▶ More elastic demand  $\rightarrow$  lower mark-up

This formula shows how market power arises from market concentration.

## Welfare Analysis

# Welfare Measures in Equilibrium

Three welfare concepts:

- ▶ **Consumer Surplus (CS):** Benefit to buyers
- ▶ **Producer Surplus (PS):** Profit to firms
- ▶ **Welfare Loss (WL):** Deadweight loss from inefficiency

## Equilibrium Welfare Comparison

Market Structure	Consumer Surplus	Producer Surplus	Welfare Loss
<b>Perfect Competition</b>	Max	0	0
<b>Monopoly</b>	Low	High	High
<b>Cournot Oligopoly</b>	Medium	Medium	Medium

### ! Key Finding

Cournot oligopoly equilibrium is constrained efficient: it maximises neither consumer surplus nor aggregate surplus—the outcome reflects strategic interdependence without coordination.

## Example: Three-Firm Market

### Setup:

- ▶ Demand:  $P = 20 - Q$
- ▶ Marginal costs:  $c_1 = 0$ ,  $c_2 = 5$ ,  $c_3 = 7$

**Perfect Competition** (firm 1 at  $p = MC = 0$ ):

- ▶  $CS = 200$ ,  $PS = 0$ ,  $WL = 0$

**Monopoly** (firm 1 alone):

- ▶  $CS = 50$ ,  $PS = 100$ ,  $WL = 50$

# Derivation of Cournot Triopoly

## **Cournot Triopoly:**

►  $CS = 72, \quad PS < 96, \quad WL > 32$

→ Oligopoly equilibrium output lies strictly between monopoly and perfect competition; price and profits are correspondingly intermediate.

# Cournot Welfare Maximand

**Equilibrium maximises a weighted combination:**

$$\max_Q \{ (n-1)[u(Q) - P(Q)Q] + n[P(Q)Q - nc(Q/n)] \}$$

With  $u'(Q) = P(Q)$  and  $n$  identical firms.

**Interpretation:**

- ▶ Weight on PS is too high vs. social optimum (full competition)
- ▶ Weight on PS is too low vs. monopoly outcome (full collusion)

## **i** Note

Oligopoly equilibrium reflects the tension between individual profit maximisation and the aggregate effect of firms' choices on market price and quantity.

# Welfare Weights Across Market Structures

**Recall the Cournot welfare maximand:**

$$\max_Q \{ (n-1)[u(Q) - P(Q)Q] + n[P(Q)Q - nc(Q/n)] \}$$

**Interpreting the weights  $(n-1)$  and  $n$  at extreme cases:**

Perfect Competition:  $n \rightarrow \infty$

$$\text{Weight on CS} = (n-1) \rightarrow \infty$$

$$\text{Weight on PS} = n \rightarrow \infty \quad (\text{but each firm gets } \pi_i = \frac{n \cdot \pi}{n} \approx 0)$$

**Result:** The welfare function places infinite weight on consumer surplus relative to individual firm profits. The equilibrium maximises CS subject to firms earning zero economic profit.

# Welfare Weights Across Market Structures

Monopoly:  $n = 1$

$$\text{Weight on CS} = (n - 1) = 0$$

$$\text{Weight on PS} = n = 1$$

**Result:** The monopolist ignores consumer surplus entirely and maximises its own profit alone. The equilibrium is the unconstrained monopoly outcome.

# Welfare Weights Across Market Structures

Cournot Oligopoly:  $1 < n < \infty$

Weight on CS =  $(n - 1) \in (0, \infty)$

Weight on PS =  $n \in (1, \infty)$

**Result:** Oligopoly equilibrium balances consumer and producer surplus with intermediate weights. The outcome reflects the tension between:

- ▶ Individual firm profit incentives (weight  $n$ )
- ▶ Aggregate demand response to total output (weight  $n - 1$ )

## **i** Interpretation

As  $n$  increases from 1 to  $\infty$ , the weight on consumer surplus grows relative to producer surplus, driving equilibrium output toward the competitive level and price toward marginal cost.

## Differentiated Products

## Cournot vs. Bertrand: Strategic Variables Matter

**Core question:** Do firms compete on quantity or price?

Model	Strategic Variable	Best Response	Competitiveness
Cournot	Quantity	Downward-sloping	Less competitive
Bertrand	Price	Upward-sloping	More competitive

**Key insight:** The choice of strategic variable fundamentally affects market outcomes.

# Cournot with Differentiated Products

**Inverse demand functions:**

$$P_1 = a - bq_1 - dq_2$$

$$P_2 = a - dq_1 - bq_2$$

**Parameters:**

- ▶  $b > |d|$  (own effect  $>$  cross effect)
- ▶  $d \in (-b, b)$  measures product differentiation

**Interpretation of  $d$ :**

- ▶  $d < 0$ : Goods are complements
- ▶  $d = 0$ : Goods are independent
- ▶  $d > 0$ : Goods are substitutes

## Cournot with Substitutes: Best Response

For substitute goods ( $d > 0$ ):

$$BR_i(q_j) = \frac{a - dq_j - c_i}{2b}$$

**Key feature:** Downward-sloping best response

→ Quantities are strategic substitutes

- ▶ If competitor increases output, my optimal response is to decrease output
- ▶ This dampening of quantities is characteristic of strategic substitutes

# Bertrand with Differentiated Products

**Demand functions:**

$$Q_1 = \tilde{a} - \tilde{b}p_1 + \tilde{d}p_2$$

$$Q_2 = \tilde{a} + \tilde{d}p_1 - \tilde{b}p_2$$

Parameters transform the problem:

►  $\tilde{a} = \frac{a}{b+d}$

►  $\tilde{b} = \frac{b}{b^2-d^2}$

►  $\tilde{d} = \frac{d}{b^2-d^2}$

## Bertrand with Substitutes: Best Response

For substitute goods ( $d > 0$ ):

$$BR_i(p_j) = \frac{\tilde{a} + \tilde{d}p_j + \tilde{b}c_i}{2\tilde{b}}$$

**Key feature:** Upward-sloping best response

→ Prices are strategic complements

- ▶ If competitor raises price, my optimal response is to raise price
- ▶ This price complementarity reflects firms' incentive to maintain price alignment

# Cournot vs. Bertrand: Equilibrium Prices

**Cournot equilibrium** ( $c_i = 0$ ):

$$p_i^C = \frac{ab}{2b + d}$$

**Bertrand equilibrium** ( $c_i = 0$ ):

$$p_i^B = \frac{a(b - d)}{2b - d}$$

**Price comparison:**

$$p_i^C - p_i^B = \frac{ad^2}{4b^2 - d^2} > 0$$

## **i** Competition Intensity

Price competition (Bertrand) leads to lower prices and larger quantities than quantity competition (Cournot)

## Oligopoly Coordination

# The Coordination Challenge

**Can competing firms coordinate pricing without explicit contracts?**

**Obstacles:**

- ▶ Individual profit motives conflict with group interest (monopoly profit)
- ▶ No legal mechanism to enforce agreements
- ▶ Constant temptation to cheat on “deals”

**Result:** The non-cooperative (Nash) equilibrium is Pareto-dominated by coordinated outcomes.

# Facilitating Devices

Firms use **facilitating devices** to overcome coordination problems:

- ▶ **Increase incentives to cooperate** — benefit from higher prices
- ▶ **Decrease incentives to cheat** — punishment for deviation

**Legal examples:**

- ▶ Most-Favoured-Nation (MFN) clauses
- ▶ Most-Favoured-Customer (MFC) clauses



## Policy Scrutiny

These devices alter payoff structures in ways that enable tacit collusion; competition authorities scrutinise them accordingly.

# The Prisoner's Dilemma: Setup

**Two firms, one period. Payoff matrix:**

	High Price	Low Price
High Price	100, 100	-10, 140
Low Price	140, -10	70, 70

**Nash equilibrium:**  $(p_L, p_L)$  with payoffs 70, 70

**Cooperative outcome:**  $(p_H, p_H)$  with payoffs 100, 100

**Problem:** Cooperation is not a Nash equilibrium without commitment or repeated-game structure.

# Why Coordination Fails: Incentive Incompatibility

Starting from  $(p_L, p_L)$ , why cannot both firms coordinate on  $(p_H, p_H)$ ?

## Sequential move problem:

1. **First-mover disadvantage:** Leader gets payoff  $-10$  while follower earns  $140$
2. **Incentive to delay:** Follower waits to capture the  $140$
3. **Leader's temptation to revert:** Seeing no response, leader drops back to  $p_L$

### ! Coordination Failure

Unilateral deviation is profitable from any proposed high-price agreement; hence the prisoner's dilemma equilibrium is the unique Nash equilibrium of the simultaneous-move game.

# Solving Coordination: The Adjusted Payoff Matrix

**Reduce follower's transitional gain:**

	High Price	Low Price
High Price	100, 100	-10, 90
Low Price	90, -10	70, 70

**Then  $(p_H, p_H)$  is a Nash equilibrium in the single-period game.**

**Equilibrium characterisation:**

- ▶ If firm moves to  $p_H$ , it earns  $-10$  in the transition
- ▶ Given the opponent is at  $p_H$ , best response is also  $p_H$ , earning 100
- ▶ Both firms converge to  $(p_H, p_H)$  with payoffs 100, 100 (symmetric equilibrium)

# Most-Favoured-Nation (MFN) Clause Explained

## What is an MFN clause?

A seller commits to:

- ▶ Charge a specified minimum price
- ▶ Refund buyers if a lower price is offered later
- ▶ Pay penalties equivalent to price differences

## Effect:

Action	Without MFN	With MFN
Price cut	Capture all new buyers	Lose many to refunds
benefit		
Price cut cost	Minimal	Refund obligations + penalties

→ MFN raises the cost of deviation from high price.

## MFN as Self-Enforcement

**For MFN to work, it must be self-enforcing:**

Gross profit from deviation — Refunds  $<$  Profit under MFN

### **Example:**

- ▶ Gross profit gain from cutting price: 0.897
- ▶ Refunds owed to existing customers: 0.056
- ▶ Net gain: 0.841 (which is less than staying at MFN price)

→ Deviation becomes unprofitable.

### **i** Free Rider Effect in Reverse (Salop 1985)

Individual buyers value MFN protection, but collectively it harms them by preventing sellers from offering discounts to future customers.

## Numerical Example: Setup

**Bertrand duopoly with differentiated products:**

Demand:

$$Q_1 = 3 - 2p_1 + p_2$$

$$Q_2 = 3 + p_1 - 2p_2$$

Costs:  $c_1 = c_2 = 1$

# Baseline Bertrand Equilibrium

**Best response functions:**

$$BR_i(p_j) = \frac{5 + p_j}{4}$$

**Equilibrium:**

- ▶  $p_1^B = p_2^B = \frac{5}{3} \approx 1.667$
- ▶  $\pi_i^B = \frac{8}{9} \approx 0.889$

**Question:** Can Firm 1 increase profits by adopting an MFN clause?

## Firm 1 Adopts MFN Clause

**Firm 1 commits to price**  $p_1^* = \frac{12}{7} \approx 1.714$

**Firm 2's best response:**

$$p_2^* = BR_2(p_1^*) = \frac{47}{28} \approx 1.678$$

**Outcomes:**

- ▶  $Q_1^* = \frac{5}{4}$
- ▶  $\pi_1^* = \frac{25}{28} \approx 0.893 > 0.889$

**i** Note

Firm 1's profits rise to  $\approx 0.893$  from the Bertrand equilibrium level of 0.889 by committing to a higher price via the MFN clause.

## Can Firm 1 Deviate from MFN?

**Firm 1 considers deviating to  $\tilde{p}_1 = BR_1(p_2^*) = \frac{187}{112} \approx 1.669$**

**Gross profit from deviation:**

- ▶  $\tilde{Q}_1 = \frac{75}{56}$
- ▶  $\tilde{\pi}_1 = \frac{5625}{6272} \approx 0.897$

**But MFN requires refunds:**

$$\text{Refunds} = Q_1^*(p_1^* - \tilde{p}_1) = \frac{25}{448} \approx 0.056$$

**Net profit after refunds:**

$$\tilde{\pi}_1 - \text{Refunds} = \frac{5275}{6272} \approx 0.841$$

**!** Important

Net profit from deviation (0.841) is strictly less than profit

## MFN Exercise

**What if Firm 1 commits to an even higher MFN price of  $p_1^* = 2$ ?**

Calculate:

- ▶ Firm 2's best response:  $p_2^* = BR_2(2) = ?$
- ▶ Firm 1's quantity:  $Q_1^* = ?$
- ▶ Firm 1's profit:  $\pi_1^* = ?$

**Discussion:**

- ▶ Does the higher MFN price further increase Firm 1's profits?
- ▶ At what price do incentives to deviate become compelling?
- ▶ Can the MFN clause be too restrictive?

# Summary and next week

## Summary

1. **Coordination problem:** Joint profit maximisation yields higher payoffs than Nash equilibrium, but the cooperative outcome is not self-enforcing in simultaneous-move games
2. **Single-period dilemma:** The Nash equilibrium is Pareto-inefficient
3. **Facilitating devices:** MFN clauses alter the payoff structure to align individual and collective incentives
4. **Self-enforcement:** Properly structured MFN clauses render deviation less profitable than compliance, inducing equilibrium behaviour

## Next week: Product Differentiation

Not all products are the same. Firms strategically differentiate their offerings to:

- ▶ Reduce direct price competition
- ▶ Create brand loyalty

## References

(Belleflamme and Peitz 2015)

- ▶ Belleflamme, P., & Peitz, M. (2015). *Industrial Organization: Markets and Strategies* (2nd ed.). Cambridge University Press. Chapters 2.1–2.3, 3.2–3.3.
- ▶ Cooper, T. E. (1986). Most-Favored-Customer Pricing and Tacit Collusion. *The RAND Journal of Economics*, 17(3), 377–388.
- ▶ Salop, S. C. (1986). Practices that (Credibly) Facilitate Oligopoly Co-ordination. In: Stiglitz, J. E., Mathewson, G. F. (eds) *New Developments in the Analysis of Market Structure*. International Economic Association Series, vol 77. Palgrave Macmillan.
- ▶ Shy, O. (1996). *Industrial Organization: Theory and Applications*. MIT Press. Chapters 3.2, 6.1

Belleflamme, Paul, and Martin Peitz. 2015. *Industrial Organization: Markets and Strategies*. Cambridge University Press.