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# EC5230 - Industrial Organisation

## Lecture 1 - Oligopoly

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# Market Structures

# Industrial Organisation: Overview



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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.

# Case: Alcoa as a Natural Monopoly



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- ▶ Dynamic efficiency and entry deterrence: Cost reductions make entry difficult even after patent expiration.
- ▶ Institutional environment: Public policy, tariff protection, and limited antitrust enforcement before 1914.

# Market Structure Typology

Three key competitive regimes:

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



# Cournot Quantity Competition



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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



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## **i** Key Insight

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

- ▶ Larger market share → higher mark-up
- ▶ More elastic demand → 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
Perfect Competition	Max	0	0
Monopoly	Low	High	High
Cournot Oligopoly	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  $p = MC = 0$ ):

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

Monopoly (firm 1 alone):

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

# 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



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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:  $n \rightarrow \infty$

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

Weight on PS =  $n \rightarrow \infty$  (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



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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: $1 < n < \infty$

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

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

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  $n - 1$ )

# Welfare Weights Across Market Structures

## **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.



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# Differentiated Products

# Cournot vs. Bertrand: Strategic Variables Matter



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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



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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



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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



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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:

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

# Cournot vs. Bertrand: Equilibrium Prices



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## **i** Competition Intensity

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

The strategic variable selection determines equilibrium price, output, and total welfare.



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# 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



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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



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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 benefit	Capture all new buyers	Lose many to refunds
Price cut cost	Minimal	Refund obligations + penalties

# Most-Favoured-Nation (MFN) Clause Explained

→ MFN raises the cost of deviation from high price.

# MFN as Self-Enforcement

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

$$\text{Gross profit from deviation} - \text{Refunds} < \text{Profit under MFN}$$

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



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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



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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:

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

# Can Firm 1 Deviate from MFN?



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## ! Important

Net profit from deviation (0.841) is strictly less than profit under MFN commitment (0.893). The MFN clause is thus self-enforcing: no firm has incentive to deviate unilaterally.

# 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

# Summary and next week

- ▶ Create brand loyalty
- ▶ Capture different market segments

Next lecture: How does differentiation affect competition and welfare?

# References

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