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

$\rightarrow$ Static models provide a foundation, but IO studies these dynamic elements.

Market Structures

Case: Alcoa as a Natural Monopoly

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
Perfect Competition	Many	Price-taker	Competitive
Monopoly	1	Monopolist	Restricted
Cournot Oligopoly	Few	Strategic	Intermediate

Cournot Quantity Competition

Firm i's maximisation problem:

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

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
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

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

Cournot Welfare Maximand

Equilibrium maximises a weighted combination:

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

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)

> **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:

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

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

Perfect Competition: $n \to \infty$

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

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

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: $1 < n < \infty$

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

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

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 $n-1$)

Interpretation

As n increases from 1 to ∞, 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

$\rightarrow$ 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

$\rightarrow$ 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:

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

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

$\rightarrow$ 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)

$\rightarrow$ Deviation becomes unprofitable.

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:

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

Note

Firm 1's profits rise to ≈ 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

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