Industrial Organisation

Auxiliary teaching material

accompanying the textbook

Jeffrey Church – Roger Ware:

Industrial Organisation: A Strategic Approach

Irwin – McGraw Hill, Boston et al. 2000

compiled by

Anita Pelle – János Zoltán Varga

Methodological expert: Edit Gyáfrás

University of Szeged, 2020

This teaching material has been made at the University of Szeged, and supported by the European Union. Project identity number: EFOP-3.4.3-16-2016-00014

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Contents

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Knowledge, Skills, Attitude and Autonomy

In completing the **Industrial Organization** course, students gain the following competences in terms of knowledge, skills, attitude and autonomy.

a) Regarding **knowledge**, the student

- understands the structure, operating process and relationships of economic organizations along with their motivations and information related factors;
- has a firm grasp on the concepts, theories, processes and characteristics of perfect and imperfect markets; the student is up to date with the defining economic facts;
- is familiar with the characteristics of monopoly market: market power, price discrimination, product quality;
- is familiar with the concepts, theoretical and empirical methods related to oligopoly pricing: static and dynamic game theory, product differentiation, identification and measurement of market power;
- -is familiar with the concepts and models of strategic behaviour: aspects of entry deterrence; the role of investment, research and development, and advertisement in strategic behaviour;
- is familiar with the rationale for regulation.

b) Regarding **skills**, the student

- can make independent and new deductions, formulate original thoughts and solution methods, utilise sophisticated analytical and modelling methods. The student is capable of formulating solution strategies for complex problems and decisions within the organizational culture both in a domestic and an international setting;
- regardless of the product, is able to analyse any market: structure, competitors, strategic situations, impacts of regulations;
- can contribute to and support the organization's decision making process in relation to pricing, investment, research and development, advertisement;
- is able to read, understand and utilise the relevant scientific papers.

c) Regarding **attitude**, the student

- is open to team work, knows that the efficacy of the organization depends on cooperation among co-workers;
- takes a critical attitude towards the work and behaviour of his/her employees and also of himself/herself. Furthermore, the student exhibits an innovative and proactive attitude to solving economic problems;
- is open to new results and achievements of economic research and practical experiments;
- behaves in a cultured, ethical way worthy of an intellectual when treating other people and when dealing with social problems;
- becomes initiative in solving problems, creating strategies and in supporting the cooperation of co-workers both within the

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organisation and between different institutions;

d) Regarding **autonomy and responsibility**, the student

- selects and utilises the relevant problem-solving methods independently even in connection with fields connected to organizational policies and leadership, performs tasks related to economic analysis, decision planning and advisory responsibilities on his/her own;
- takes responsibility for his/her own work, the organization or company he/she is leading and the workers he/she is employing. The student identifies, plans and organises his/her own and his/her employees' professional development and takes personal responsibility for them;
- employs a wide range of methods and techniques independently in practice in connection with contexts of different complexity and predictability.

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Part I: Foundations

Chapter 1: Introduction

Market transaction: "an exchange that is voluntary: each party can veto it, and (subject to the rules of the marketplace) each freely agrees to the terms." (McMillan 2002, Reinventing the Bazaar p. 6.) Market is a forum for carrying out such exchanges.

Perfectly competitive markets are rarely observed, instead, most real-world markets are imperfectly competitive. This means that (one or more of) the conditions of perfect competition are violated. In order to obtain valid insights of such markets, the analysis requires more sophisticated tools and approaches. Behaviour of firms in such markets differ from perfect competition, hence the focus is on the structure of the market (the factors that affects the competitiveness of markets) and the behaviour of the firms. In other words, Industrial organization (I/O henceforward) is the supply side analysis of real-world markets.

I/O mainly concentrates on the following questions:

1. What are the main factors that lead to different market structures and configurations?

Four features of markets are intensively researched:

1. **Firm boundaries**: the vertical extent of the firm in the chain of production.
2. **Seller concentration:** the number and size distribution of firms in a market. Real world markets are highly diverse in that regard, and I/O tries to unfold the reasons.
3. **Product differentiation**. Product differentiation exists when products produced by different firms are not viewed as perfect substitutes by consumers. That is, products are not homogeneous. Important to emphasize that the consumers' *perception* of the product must be different, regardless of the actual product.
4. **Conditions of Entry**. The conditions of entry refer to the ease with which new firms can enter a market. They can be grasped through the time expense and cost that the firm must incur in order to enter the market (they are called barriers). I/O investigates the causes of certain barriers. Are they the results of the cost structure of the market, or created by firms already operating in the market? Or maybe they are erected by the government to reach a certain goal.

2. How is the behaviour of firms affected, influenced by the market structure?

3. How is the market structure influenced by the conduct of firms?

Market structure usually cannot determine perfectly the behaviour of firms, the latter make deliberate actions to alter the structure of the market in a favourable way. Product differentiation clearly plays an important role in that, hence research and development and the various marketing techniques are important aspects of real markets.

The last two questions show that there is a constant interaction, feedback between market structure and firm behaviour.

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Questions for self-study

1. What is Industrial Organization (I/O)?
2. Which are the four aspects of market structure that I/O focuses on? Explain each briefly.
3. Outside price, what other factors play a role in competition?
4. How does the behaviour (conduct) of firms influence market structure? Which are the exogenous and endogenous factors in respect of market structure?

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Chapter 2: The Welfare Economics of Market Power

2.1 Profit maximisation

Firm: an organization that transforms inputs (resources it purchases) into outputs (valued products that it sells).
A firm's goal is to maximise profit:

$$\text{Profit} = \text{Revenues} - \text{Costs}$$
$$\pi(q) = R(q) - C(q)$$

where q is the level of output.
Profit-maximising condition: $MR(q) = MC(q)$

2.2 Perfect competition

Perfect competition occurs only if (at least) **4 assumptions** hold. Otherwise imperfectly competitive markets can be observed. Assumptions:

1. **Economies of scale are small** relative to the size of the market. This means that average costs will rise rapidly if a firm increases output beyond a relatively small amount. Consequently, in a perfectly competitive industry there will be a large number of sellers. We also assume that there are many buyers, each of whom demands only a small percentage of total demand.
2. **Products are homogeneous**. That is, consumers cannot distinguish between products produced by different firms.
3. **Information is perfect**. All firms are fully informed about their production possibilities and consumers are fully aware of their alternatives.
4. **There are no entry or exit barriers**. This means that the number of firms in the industry adjusts over time so that all firms earn zero economic profits or a competitive rate of return.

Assumptions 1–3 imply **price-taking behaviour**. Price takers believe or act as if they can sell or buy as much or as little as they want without affecting the price. In effect they act as if prices are independent of their behaviour.
So a single price taking firm's revenue functions is the following:

$$R(q)=p*q$$
$$MR(q)=dR(q)/dq=p$$

That is, the **marginal revenue** of the firms, which is the first derivative of the revenue function with respect to quantity, equals the market price. Thus, the profit-maximising condition for a price taking firm is where the price equals the marginal cost.

$$p=MC(q)$$

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This tells that cost of the last product that the company sells should equal the market price. A firm can create value if market price is higher than its average cost. That means that on average the firm is able to sell the products at a higher price than the production cost of the items.

The difference between the market price and the average cost is called the firm's **quasi-rent**. Quasi here refers to that the rent is expected to be only temporary in a competitive market, so the difference would tend to decrease to zero. Non-zero quasi-rents invites new firms to enter the market, increasing the supply and the gap between price and average avoidable cost will be zero. The firm's supply is zero if average avoidable cost are higher than the market price, the company is better off by not producing at all. This is illustrated on Fig. 2.1 a.

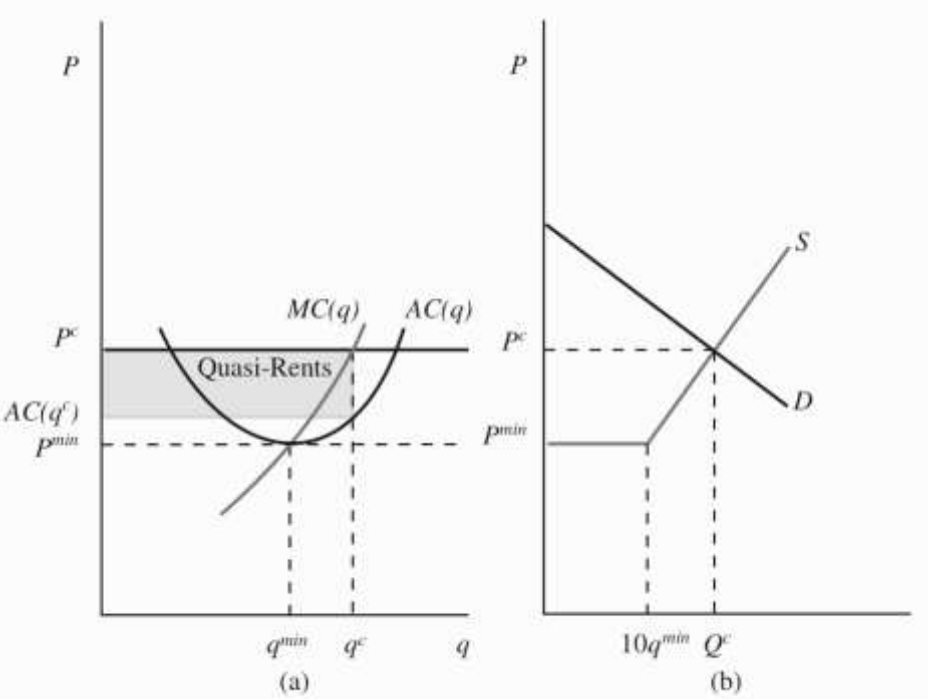

Figure 2.1 Competitive Equilibrium: (a) Firm; (b) Market

In a competitive market the market supply (denoted by $Q^s(p)$)is simply the aggregate supply of individual firms. The market demand function, $Q^d(p)$, is the relationship between price and total quantity demanded. It shows for every possible price the total amount that consumers are willing to purchase. We find it by summing up the individual demand curves of all consumers in the market. Individual demand curves are the results of the consumers' utility maximisation. The market is said to be in equilibrium if $Q^s(p) = Q^d(p)$. This is illustrated in Fig. 2.1.b.

2.3 Efficiency

Willingness to pay: the highest price that the consumer is willing to pay for the product, in other words, a price, where the consumer is indifferent between consuming and abstaining. Individual Consumer Surplus is the difference between the consumer's willingness to

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pay and the price actually paid. (Fig 2.2. a)
(Total) Consumer surplus: the sum of all the individual consumer surplus. Producer surplus (quasi-rents) is the difference between revenues and total avoidable costs. This is illustrated in Fig 2.2 (b).
Total Surplus is the sum of (total) consumer surplus and producer surplus.

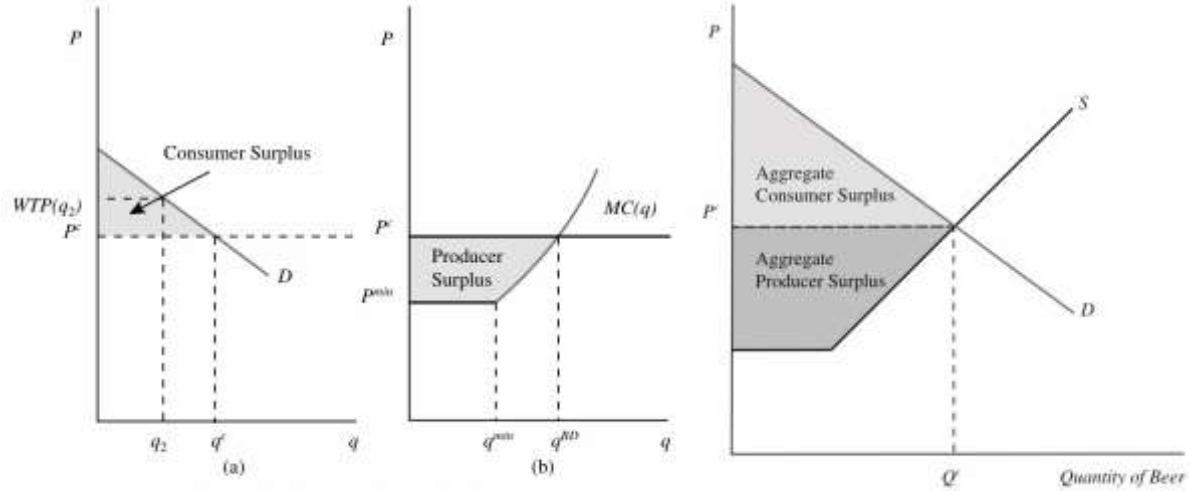

Figure 2.2 Consumer and Producer Surplus

Figure 2.3 Gains from Trade in Competitive Equilibrium

The quantity of output that maximises total surplus is where *WTP* = *MC*: at this level of output the amount of other goods consumers are willing to give up for one more unit exactly equals the amount of other goods they have to give up. Competitive markets maximise the total surplus. (Fig 2.3)
An allocation is **Pareto optimal** if no one's position can be improved without making someone's position worse. **Pareto improvement (PI)** is a change from allocation *A* to *B* that makes someone better off without making someone else worse off. A change in allocation is **potential Pareto improvement (PPI)** if the winners could compensate the losers and still be better off, but they don't.
The theory of the second best is that maximisation of total surplus in one market, say, bananas, may not be efficient if surplus in other markets is not also maximised.

2.4 Market Power

A firm has market power if it finds it profitable to raise price above marginal cost. The ability of a firm to profitably raise price above marginal cost depends on the extent to which consumers can substitute to other suppliers. It is possible to distinguish between supply and demand substitution.
Supply side substitution is relevant when products are homogeneous. The potential for supply substitution depends on the extent to which consumers can switch to other suppliers of the *same* product.
Demand side substitution is applicable when products are differentiated. The potential for demand substitution depends on the extent to which other products are acceptable substitutes.
Firm with market power is called a **price maker.** A price maker realises that its output decision will affect the price it receives. If it sells more, the price it sets

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has to be lower, and conversely if it sells less, it is possible to raise the price. The demand curve a price maker firm is facing is *downward sloping.*

Firm is a **monopolist** if there are no close substitutes for its product. Substitution can be understood through cross-price elasticity, which is the percentage change in the demand of a certain product for 1% change in the price of another product. If the cross-price elasticities between the monopolist and other firms are small, then changes in the price charged by the monopolist will have very little effect on the demand for the products supplied by other firms.

Profit of a monopolist:

$$\pi(q) = R(Q) - C(Q) = P(Q)*Q - C(Q)$$

$$MR = \frac{dR}{dQ} = \frac{dP(\mathrm{Q})\mathrm{Q}}{dQ} = P(Q) + \frac{dP(\mathrm{Q})}{dQ}Q = MC\left(Q\right)$$

The second term in the marginal revenue function is less than zero, so the marginal revenue of a monopolist firm lies under the demand curve. This implies that the monopolist's profit maximising point (Q^m) is lower than Q^s where the *MC* would be equal to the price => there are consumers who would be willing to pay a price which is still higher than the firm's marginal price, but that price is lower than the price set by the monopolist => loss of efficiency.

Deadweight loss (DWL) is the difference between the total surplus under monopoly and maximum total surplus.

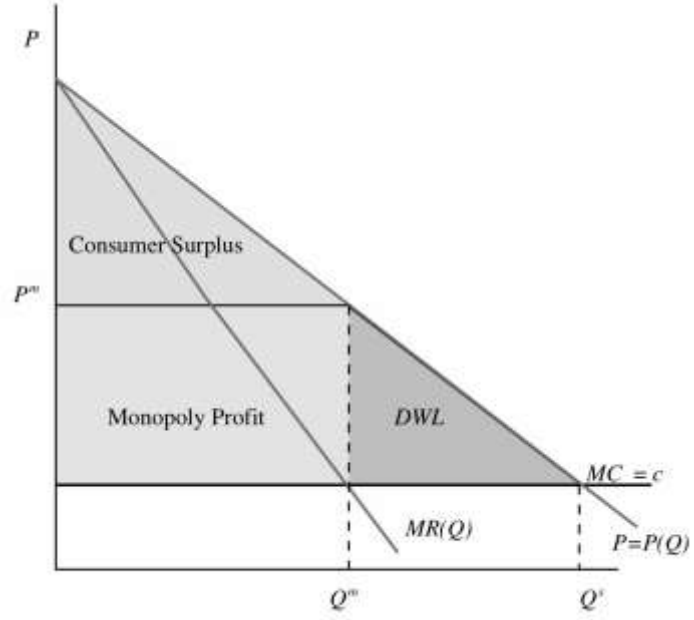

Figure 2.5 Profit-Maximizing Monopolist

Lerner index (L) is defined as the ratio of the firm's profit margin *Pm− MC(Qm)* and its price. It is a measure of market power since it is increasing in the price distortion between price and marginal cost. The key determinant of a firm's market power therefore is the elasticity of its demand.

The size of DWL:

$$DWL \approx \frac{1}{2}\Delta Q \Delta P$$

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It can be shown that

$$DWL = \frac{1}{2}\varepsilon P^m Q^m L^2$$

This suggests that the inefficiency associated with monopoly pricing is greater, the larger the elasticity of demand (ε), the larger the Lerner index, and the larger the industry (as measured by the firm's revenues).

Questions for self-study

1. What is the basic assumption of I/O in respect of firms' objective?
2. Which are the four standard assumptions of perfectly competitive markets? What do assumptions nos. 1-3 imply regarding price?
3. What is the marginal revenue (MR) function of a price-taking firm?
4. When is it worth staying in business?
5. What are the quasi-rents of a firm?
6. What is the market demand function (Qd(p))? What does the demand curve of price-taking firms look like?
7. What are consumers maximising?
8. Please interpret Figure 2.1. (a) and (b).
9. What do we know about the long-run competitive equilibrium price?
10. What does the term willingness to pay (WTP) cover? How is it related to optimal consumption level?
11. Please interpret Figures 2.2. (a) and (b) and Figure 2.3. What is consumer surplus, producer surplus, and total surplus?
12. In what case is an outcome Pareto optimal? What is Pareto improvement? What is potential Pareto improvement?
13. What does the theory of the second best say about surplus maximisation?
14. When does a firm have market power?
15. Please explain supply side substitution and demand side substitution, highlighting the difference between them.
16. Why do we call a firm with market power a price maker? What does that imply regarding such firm's expected behaviour?
17. What does cross-price elasticity mean?
18. Please interpret Figure 2.5. Why do we say that monopoly pricing is inefficient? What is the deadweight loss (DWL) and what does it tell about monopoly?

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19. What is the key determinant of a firm's market power?
20. How is market power related to time?
21. What are the determinants of DWL?
22. In what way does market power justify policy intervention in markets?

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Chapter 3: Theory of the Firm

3.1 Neoclassical Theory of the Firm

Firm: an organization that transforms inputs (resources it purchases) into outputs (valued products that it sells). The production function describes the feasible transformations. A firm's goal is to maximise profit which involves cost minimisation.
The cost function summarises the economically relevant production possibilities of the firm. The cost function C(q) gives the minimum cost of producing q units of output. It incorporates both technological efficiency and the opportunity cost of inputs.

- **Opportunity cost:** the best value of the alternative use of the resource.
- **Avoidable cost:** costs that are not incurred if production stops.
- **Variable cost**: costs that change with the production (level of output). This is in contrast with Fix cost, which is independent of production.
- **Sunk cost:** portion of the fixed cost that is not recoverable. It arises because productive activities often require specialized assets.

Durable inputs are used in production for more than one period. The opportunity cost of using a durable input consists of two parts. The first is economic depreciation. This is the reduction in the resale value of the input from using it for the period. Notice that economic depreciation incorporates physical depreciation – the loss in productive capabilities from the wear and tear of using the asset. The second component is the rate of return on the capital that could have been earned if the durable input had been sold at the beginning of the period.
Economists usually distinguish **short run** and **long run**. It is assumed that on short run some inputs in production cannot be changed *costlessly*. The long run is sufficiently long period that every factor can be varied without incurring costs.
Economies of scale is the situation when average cost is decreasing as the output increases. Minimum efficient scale is the level of output where the firm has exhausted the economies of scale, that is, where the average cost is the lowest.

> Economies of scale arise because of indivisibilities. Indivisibilities arise when it is not possible to scale some inputs down proportionately with output. Indivisibilities mean that it is possible to do things on a large scale that cannot be done on a small scale. Economies of scale arise because of indivisibilities.

Economies of scope refers to the situation when it is cheaper to produce two output levels together in one plant than to produce similar amounts of each good in single-product plants. Just like economies of scale, economies of scope arise due to indivisbilities. For example, a company possess certain know-how or expertise in producing a certain product, and that expertise can be used in producing a different product (e.g. a bank, besides offering various loan contracts, may find it much easier to enter the lease market, than for example a firm operating in agriculture would).

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3.2 Why Do Firms Exist?

Firm boundaries: the vertical extent of the firm in the chain of production. The process of converting raw materials into a final product can be divided into 5 stages: (i) raw materials; (ii) parts; (iii) systems (parts are assembled into systems); (iv) assembly (systems are assembled into final goods); and (v) distribution to customers. This is illustrated in Fig 3.3.

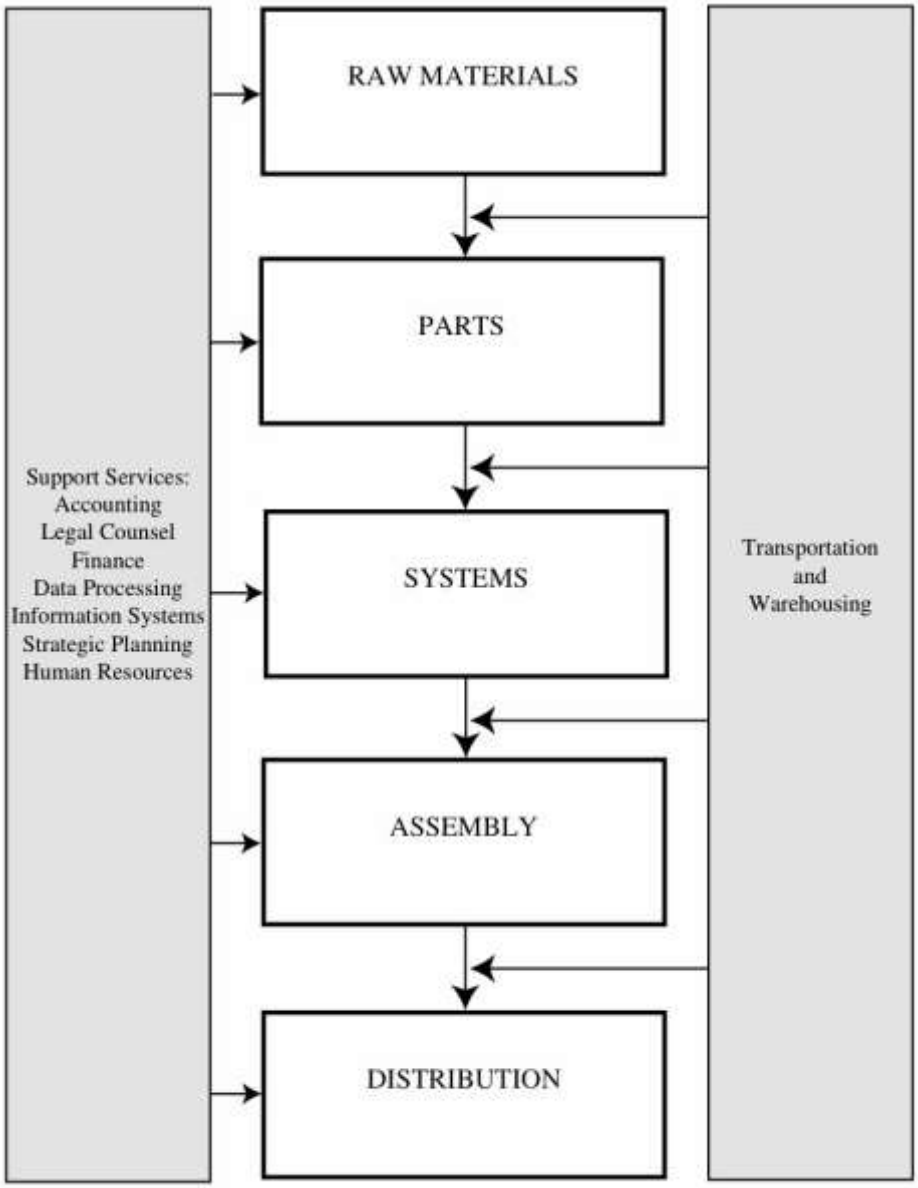

Figure 3.3 The Vertical Chain of Production: From Raw Materials to Final Goods

Within firms, the transactions are not market transactions, production is organized by command. So the quantities produced are not determined by market mechanisms but by the management (although the management decisions are influenced by market forces). According to Ronald Coase this is one of the hallmark features of firms.

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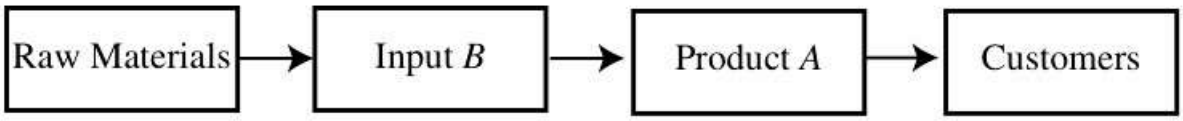

Figure 3.4 Simplified Make or Buy

In Fig. 3.4 a simplified production process can be seen. There are only two stages of production: the raw material first transformed into Input B and in turn it is converted into the final product (product A). Producer of B and A are called upstream firm and downstream firm, respectively.
Using this simplified process as an example, the three basic types of economic organization can be described as the following:

1. Spot Markets

The total amount of input B produced, and its price are determined in a competitive market based on the interaction of supply and demand. Producers of A source their requirements for input B in the market. Moreover, the terms of trade, most importantly the price, are determined on a transaction by transaction basis.
The party who receives the remaining income after all the expenses are deducted (that is, the net income from a project) is called **residual claimant**. For example, producer of input B can claim the amount that is left from the total revenue generated by selling product A to the customers. This means that the gains from investments in cost reduction and/or efforts to reduce costs are internalized, therefore producer of B is incentivized to do so.

Relationship-specific investment refers to any investment that is undertaken for the sake of a certain buyer (supplier). Part of this investment cannot be recovered if the partner is switched, so it is considered as sunk cost. This means that certain assets have a higher usability in relation to a specific buyer (supplier) (**asset specificity**).

2. Long-Term Contracts

Producers of A enter into contracts with suppliers of B. The terms of the contract determine the price a producer of A will pay and how much she will purchase. The terms of trade are specified in the contract and govern present and future transactions between the two firms. The contract may specify how the terms of trade will change over time as conditions change.
However, in a supplier-buyer relationship where actors are locked in through a long-term contract, each party can abuse its power and not supply/buy in order to force the other party into some arrangement (e.g. increase/decrease price). This situation is called the **holdup problem.** This implies that in case of asset specific investment, parties may be reluctant to supply or buy the products on spot markets.
A contract is an agreement that defines the terms and conditions of exchange. If contracts can be enforced in court, the parties involved are incentivized to

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commit to the agreement. A **complete contract** specifies every possible outcome and every possible situation. Although, due to transaction costs and future uncertainties, contracts are rarely complete, but **incomplete**. In a world of incomplete contracts, the incentives are not fully aligned and there might be a possibility to hold up. Therefore, contracts can mitigate the holdup problem at a cost of loss of efficiency and higher contracts expenses. If these are relatively high, the firm might try to internalize the transaction.

3. Vertical Integration

Producers of A integrate into the production of B. Instead of buying from a supplier of B they produce B by themselves. The transaction is organized and governed internally.
In vertical integration, owners want to control the transaction, as compared to market transaction or contractual relationship. Complete contracts would guarantee that the asset is always used according to an agreement. With incomplete contracts and possible hold up, the owner of the asset decides when and how to use the asset in case of contract uncertainties and gaps (**residual control rights**).
Vertical integration might reduce transaction costs and eliminate hold up problems, but it generates incentive problems which in turn can lead to cost disadvantages. Producing input B instead of buying on spot market or through contract agreements, results in a loss of incentives for the input supplier. Previously, the supplier was a residual claimant when it was independent, therefore it had appropriate incentives to invest in cost minimisation. With integration, the supplier is no longer a residual claimant. The independent supplier has a greater incentive to exert effort on cost minimisation.
Incentive problems arise because of information asymmetries within the firm. It can take two forms: the managers and owners have different information sets – usually the managers know more about the demand and costs (**hidden information**); the actions of managers may not be fully observable (**hidden action**). If the goals of the managers and owners are not completely aligned, information asymmetries allow the managers, to some extent, to take action which do not maximise profit but maximise the managers' utility (this is referred to as managerial slack). Agency costs are the costs associated with providing incentives, monitoring managers and managerial slack. However, there are constraint on **managerial opportunism**:

- *Managerial Labour Markets*: performance of firms with shares publicly traded can be judged easily, and managers who are considered not to maximise the value of equity (and enterprise) will face long term reputation and thus career risks.
- *The Market for Corporate Control*: Takeovers: underperforming companies can be the target for buying up by other firms, which may result in the change of management.
- *Bankruptcy Constraints*: bankruptcy occurs when the firm is unable to fulfil its financial obligations.
- *Product Market Competition*: managerial slack can lead to inefficiencies, a competitive market for products can punish (decreasing revenue) and eventually drive out products and companies.

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Questions for self-study

1. How do we define the firm?
2. Please explain the various types of costs: opportunity cost, economic cost of durable inputs, avoidable costs and sunk expenditures, variable & fixed costs, and the time horizon in relation to costs.
3. What is economies of scale? What is minimum efficient scale (MES)?
4. What are indivisibilities? How are they related to economies of scale?
5. What is economies of scope?
6. What are the vertical boundaries to the firm?
7. What makes a firm according to Coase?
8. Please explain Figures 3.3. and 3.4.
9. Please introduce the three basic types of economic organisation.
10. Who is the residual claimant?
11. Please explain relationship-specific investment and asset specificity.
12. What does the holdup problem consist of?
13. How are contracts related to economic organisation?
14. What is vertical integration?
15. How is ownership related to residual control rights?
16. What is Coase's definition of a firm?
17. What are the limits to firm size?
18. Please introduce managerial slack and agency costs. How are these related to each other?
19. What other factors play a role in a firm's operation outside profit maximisation? What is the role of managers in this respect?
20. What are the external limits to managerial opportunism? Explain these.

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Part II: Monopoly

Chapter 4: Market Power and Dominant Firms

4.1. Sources of market power

Market power can only be sustained in the longer run if there are **barriers to entry** as higher-than-competitive price (i.e. the very consequence of market power) makes the market attractive. Therefore market power is a dynamic category; not stable over time – it can be eroded or eventually eliminated by entry. With time, only barriers to entry can limit the extent of competition.

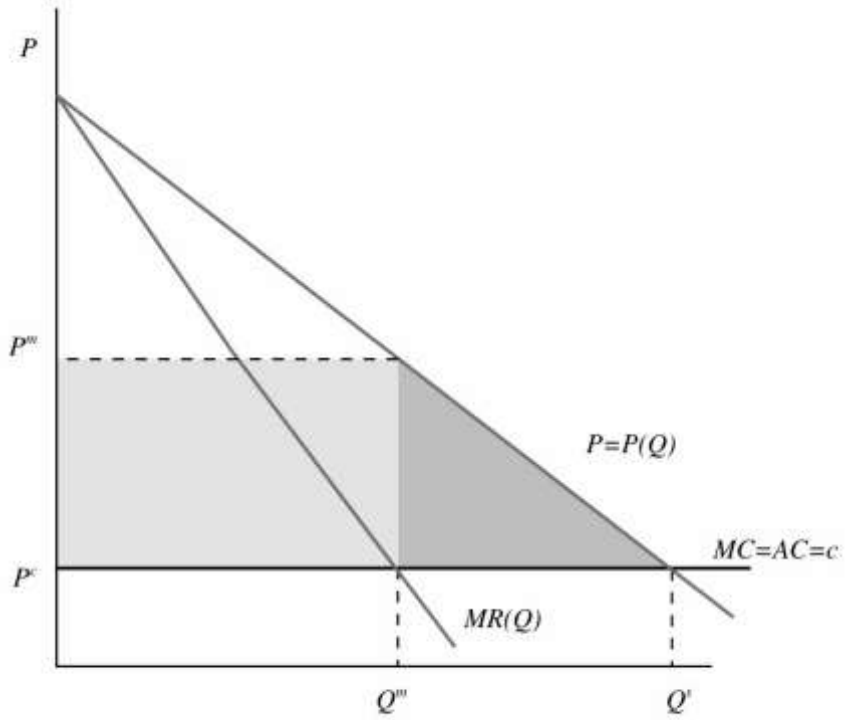

Figure 4.1 Monopoly Pricing

In this context, the incumbent's prior strategic objective is **profitable entry deterrence**. Profitable entry deterrence occurs when incumbent firms are able to earn monopoly profits without attracting entry.

From a **public policy perspective**, if entry is timely, likely and sufficient, firms' attempts to exercise or create market power will eventually be unsuccessful. Accordingly, no or low barriers to entry imply no concerns of anti-competitive behaviour for competition (US: antitrust) policy.

We distinguish between two basic types of entry barriers according to their source: (1) by government; (2) structural.

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(1) Main reasons for government-created barriers to entry: natural monopoly; it is a source of revenue; to redistribute rents; intellectual property rights (IPRs).
(2) Structural barriers to entry: economies of scale; sunk expenditure of the entrant; absolute cost advantages; sunk expenditure by consumers & product differentiation.

Ricardian rents: rents (profits) attributable to a feature/circumstance that is given for the producer (e.g. sunshine for wine in Portugal).
Monopoly rents: rents (profits) deriving from market power.
The **pre-entry behaviour of the incumbent** may influence the height of entry barriers or entry deterrence by reducing the profitability of entry.

- **aggressive post-entry behaviour**: reducing economic costs post-entry by making sunk investments prior to entry
- **raising rivals' costs**: making it more costly to rival firms to enter/be in the market
- **reducing rivals' revenues**: reducing/restricting rival firms ability to realise revenues/profits in the market

4.2. A dominant firm with a competitive fringe

Two factors can contribute to the emergence of a **dominant firm**:

(1) Dominant firm is more efficient and thus enjoys considerable cost advantage (e.g. Intel microprocessor).
(2) The dominant firm has a superior product (e.g. Apple with the first iPhone in 2007).

Characteristics of the market structure with a **dominant firm and a competitive fringe**:

Dominant firm: market power, price maker – but ability to set price is restricted/limited.
Competitive fringe: many small firms, price takers – at a given price they produce a given quantity, the rest of the market is the residual demand to be served by the dominant firm.

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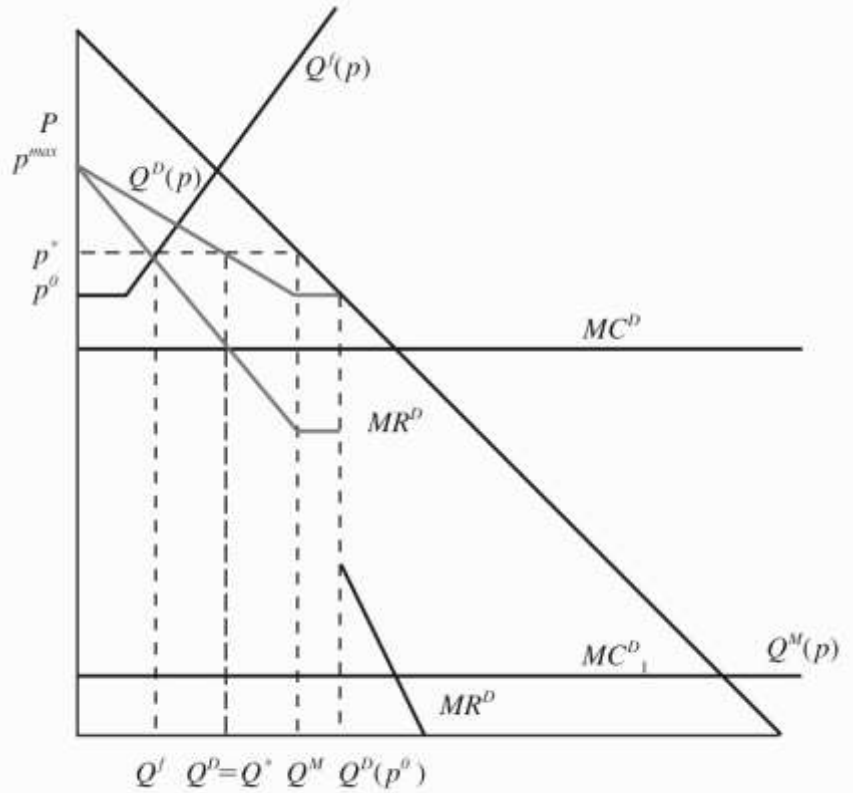

Figure 4.2 Dominant Firm with Competitive Fringe

- p_0: minimum price under which there is no production
- p_{max}: maximum price at which fringe is meeting full market demand
- *Q(p)*: all quantities (supply) are (is) function(s) of (dependant on) price
- $Q^D+Q^f=Q^m$
- Q^*, p^*: quantity and price is formed where $MC^D=MR^D$

The **essential trade-off for the dominant firm** is between current and future profits: whether to "make hay while the sun shines" or "husband the surplus" and price more modestly. **Dynamic limit pricing**: the dominant firm with a competitive fringe is from time to time (dynamically) setting the market price in order to limit entry.
The factors affecting the **optimal price trajectory**:

- the rate of interest
- the relative cost position of the dominant firm and the entrant(s)
- the response of the fringe entry to higher prices charged by the dominant firm

4.3. Durable goods monopoly

Durable goods do not lose quality over time. This way used products are substitutes (i.e. competitors) to new products.

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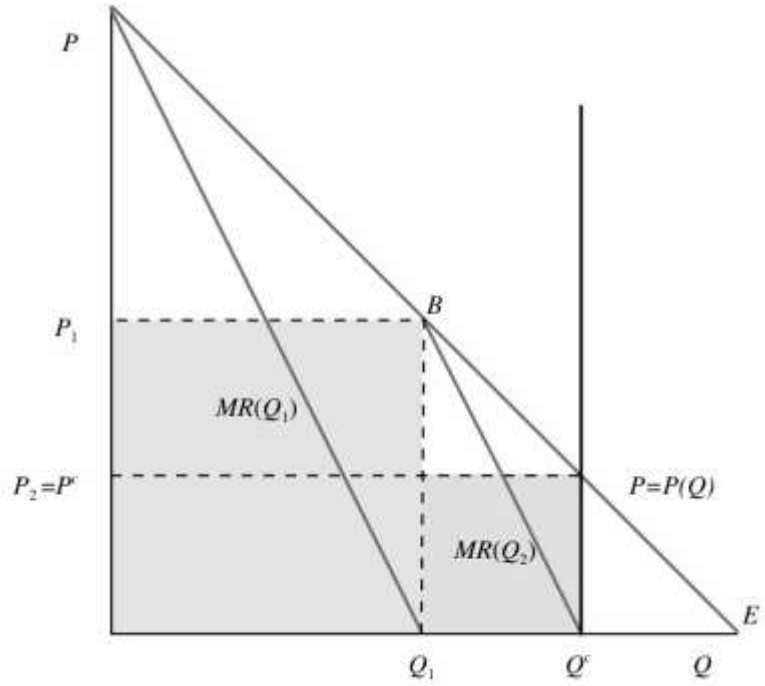

Figure 4.4 Durable Goods Monopoly

Coase conjecture: with sufficiently patient consumers, the durable goods monopolist cannot exercise its market power.

- **intertemporal price discrimination**: setting different prices for the same product in different time periods (over time)
- **inframarginal consumers** have an incentive to wait and "pay the cost" of not owning the good in the first (/earlier) period(s)

Strategies to mitigate the Coase conjecture:

- leasing
- reputation: the monopolist can invest in reputation by not succumbing to the temptation to increase supply (e.g. numbered, limited series products such as certain Swiss watches)
- contractual commitments
- limit capacity
- production takes time
- new customers
- **planned obsolescence**: to deliberately derogate the durability of the good

Pacman strategy: by selling the product at the WTP level of each (unit of) consumer, the durable goods monopolist can maximise its gains from market power (→ producer surplus).

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4.4. Market power: a second look

X-inefficiency: a firm with market power may witness increase in costs because employees perceive that they do not need to maximise effort.
Quiet life hypothesis: X-inefficiency is positively correlated with market power (the larger the market power, the larger the X-inefficiency).

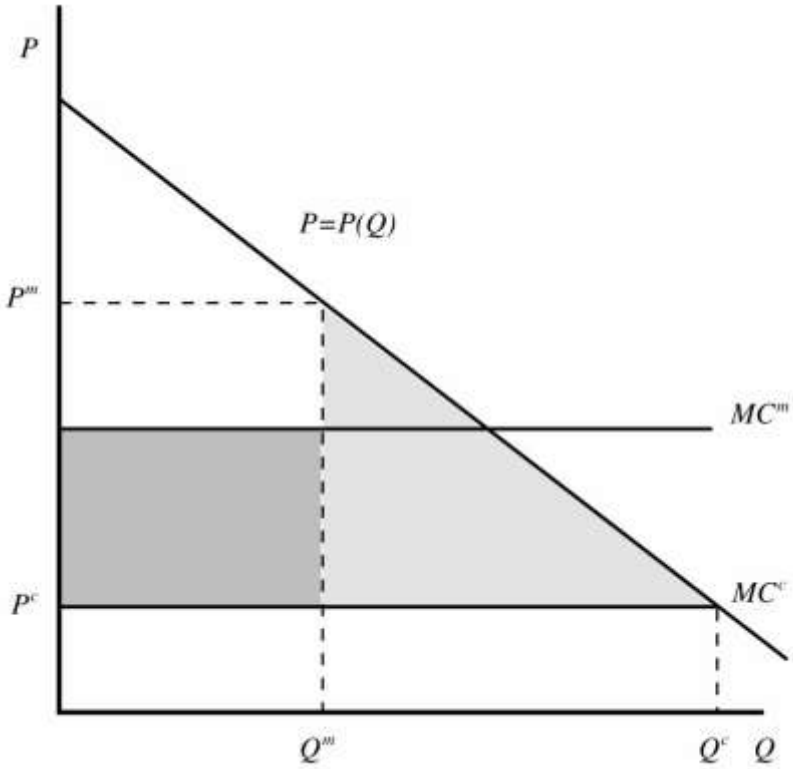

Figure 4.5 Welfare Implications of the Quiet Life Hypothesis

- marginal cost of monopolist exceeds marginal cost in the competitive market ($MC^m > MC^c$)
- the dark grey area of the monopolist is wasted due to the failure of the monopolist to minimise costs

Rent-seeking: monopoly profits are viewed as a "prize to be won" in a contest and rent-seeking refers to the efforts of firms to win this contest. Two components of the **rent-seeking hypothesis**:

(1) Rent-seeking expenditures are wasteful.
(2) Complete rent dissipation.

4.5. Benefits of monopoly

Benefits of monopoly: possibility to realise / exploit economies of scale; profit serves as an incentive to invest in R&D.

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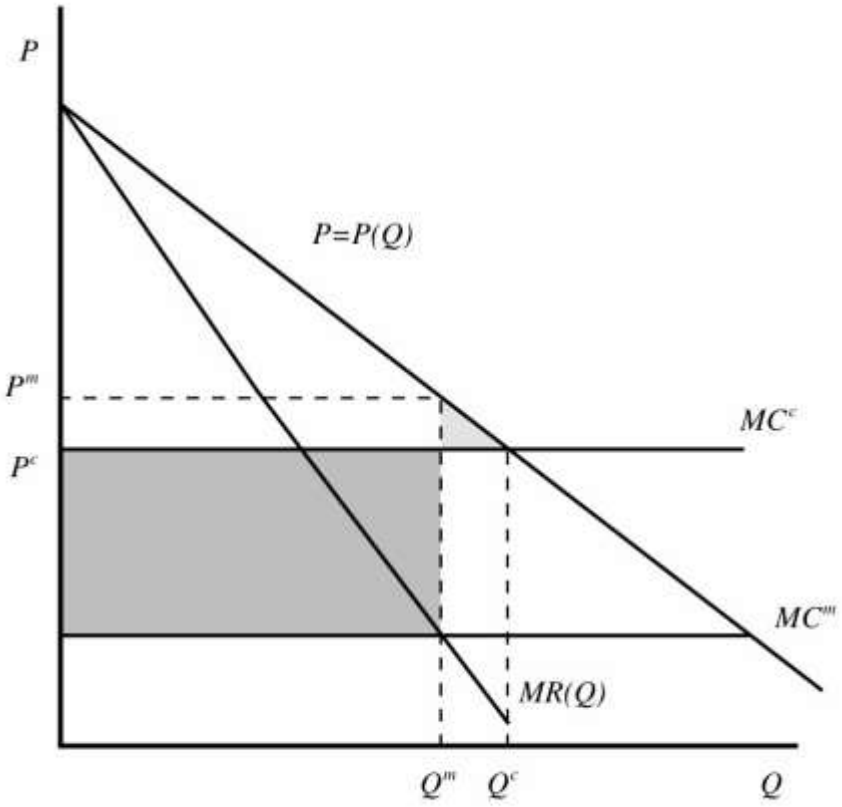

Figure 4.6 Cost Advantages of a Monopolist

– The light grey triangle is the lost consumer surplus due to monopoly pricing ($p^m > p^c$). The dark grey area is the cost savings associated with the lower costs of the monopolist ($MC^m < MC^c$).

Schumpeter made an important observation regarding the optimal market structure for research and development: he argued that market power was a necessary incentive for research and development as, without the monopoly profits, firms would not have sufficient incentives to undertake R&D.

Questions for self-study

1. How are market power and barriers to entry related?
2. When does profitable entry deterrence occur?
3. How are entry barriers linked to public (antitrust) policy?
4. Which are the two basic types of entry barriers according to their source? Please list the main reasons for government-created barriers to entry. Which are the four main structural characteristics considered as entry barriers?

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5. What is the distinction between Ricardian rents and monopoly rents?
6. Please explain how incumbents' behaviour pre-entry is affecting the profitability of entry.
7. When do we call a firm dominant? In what ways (2) can a dominant firm evolve?
8. What are the characteristics of the market structure with a dominant firm and a competitive fringe? Please interpret Figure 4.2.
9. What is the essential trade-off for the dominant firm?
10. In the dynamic context, what are the factors affecting the optimal price trajectory in the dominant-firm model?
11. What are the characteristics of durable goods? How do these goods affect basic market features? Please recall the Coase conjecture in relation to durable goods.
12. How is monopolist's incentive to supply the durable good related to consumers' willingness to pay? And how is consumer strategy related to monopoly power in the case of durable goods?
13. What is intertemporal price discrimination?
14. What are the strategies to mitigate the Coase conjecture? What is planned obsolescence?
15. What constitutes the Pacman strategy? Please contradict the Coase and Pacman cases.
16. Please explain X-inefficiency and the quiet life hypothesis. Please interpret Figure 4.5.
17. What is rent-seeking? What are the two components of the rent-seeking hypothesis?
18. Please explain the benefits of monopoly. Please interpret Figure 4.6.
19. Schumpeter made an important observation regarding the optimal market structure for research and development. What was it?

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Chapter 5: Non-linear pricing and price discrimination

5.1. Examples of price discrimination

The main aim of firms in relation to **price discrimination** and **non-linear pricing** is to extract more surplus.

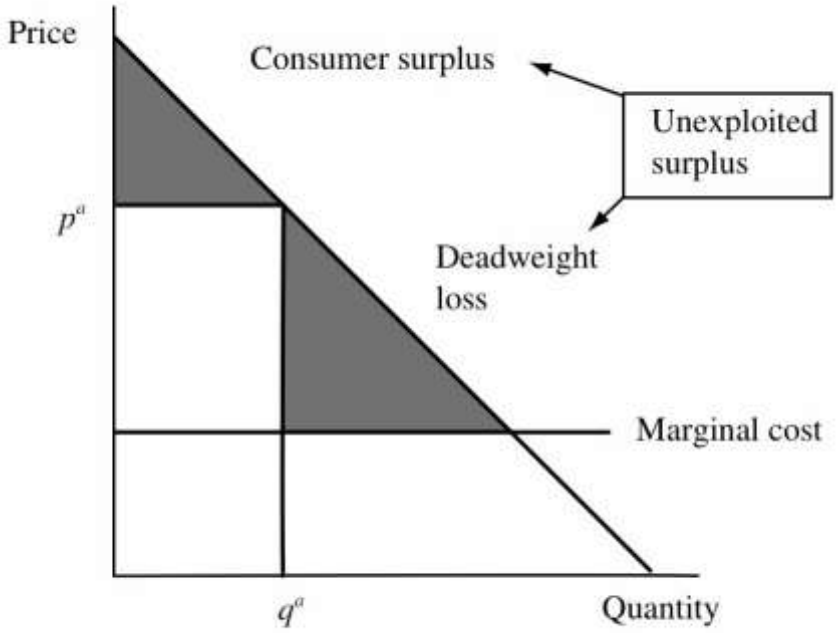

Figure 5.1 The Motive for Price Discrimination: Unexploited Surplus

Price discrimination is **related to Pareto efficiency**: if part of the deadweight loss is in fact realised through price discrimination, there is Pareto improvement. Fully exploited first-degree (perfect) price discrimination is Pareto efficient (optimal).
Price discrimination can target **consumer surplus** (yet unexploited *by the firm*), or the **deadweight loss** (which is a loss to society without such price discrimination). First case is not Pareto improvement, second case is.

5.2. Mechanisms for capturing surplus

Mechanisms for capturing surplus are the following:

(1) market segmentation (geographic, along consumer characteristics etc.)
(2) two-part pricing (a fixed fee + a variable charge)
(3) non-linear pricing: prices vary by blocks or units
(4) tying (the purchase of a product is linked (tied) to the purchase of another one) and bundling (selling goods in "bundles" or packages)
(5) quality discrimination

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5.3. Necessary conditions for price discrimination

The (two) necessary conditions for price discrimination are:

(1) the firm possesses market power
(2) arbitrage among (groups of) consumers can be prevented

5.4. Types of price discrimination

There are three main types of price discrimination:

(1) first-degree: all surplus is extracted from a heterogeneous set of consumers
(2) second-degree: consumers "self-select" from a menu
(3) third-degree: market segmentation along with certain identifiable characteristics

Questions for self-study

1. What is the main aim of firms in relation to price discrimination and non-linear pricing? Please interpret Figure 5.1.
2. How is price discrimination related to Pareto efficiency?
3. Which are the most typical mechanisms for capturing surplus? Please explain each of these briefly.
4. What are the necessary conditions for price discrimination?
5. Please introduce first-degree, second-degree and third-degree price discrimination. Which one of these is Pareto optimal?
6. What do we call tying? And bundling? In what case is bundling a good strategy for the firm?

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Chapter 6: Market power and product quality

This chapter discusses whether firms with market power have the right incentives to produce quality.

Quality in I/O: the vertical attributes of a product (e.g. power performance, risk of breaking down). Based on consumers' ability to identify quality, we distinguish between search goods and experience goods.

6.1. Search goods

In case of **search goods**, consumers can collect sufficient information on quality prior to purchase.

Quality discrimination occurs when firms set different prices for different quality versions of the (more-or-less) same product or service. The mechanism by which this is achieved is formally identical to non-linear price discrimination.

6.2. Experience goods and quality

In case of **experience goods** however, quality is only assessable post-consumption. This way there is asymmetric information on quality (producer knows more than consumer), which may give rise to **moral hazard** on behalf of producers but also gives **incentives for signalling quality** (e.g. through advertising).

> **Moral hazard**: with experience goods, there is an incentive to lower the quality if consumers cannot detect it quickly.
>
> **Adverse selection**: since in markets with informational asymmetry (i.e. where the buyer knows much less about the product than the seller) there is an incentive on behalf of the seller to lower quality and everybody knows that, eventually good-quality products are sorted out from the market (and a market for "lemons" is created).

The lemons problem (Akerlof's "market for lemons")

"The Market for Lemons: Quality Uncertainty and the Market Mechanism" is a well-known 1970 paper by economist George Akerlof which examines how the quality of goods traded in a market can degrade in the presence of information asymmetry between buyers and sellers, leaving only "lemons" behind. In American slang, a lemon is a car that is found to be defective after it has been bought.

Suppose buyers cannot distinguish between a high-quality car (a "peach") and a "lemon". Then they are only willing to pay a fixed price for a car that averages the value of a "peach" and "lemon" together (p_{avg}). But sellers know whether they hold a peach or a lemon. Given the fixed price at which buyers will buy, sellers will sell only when they hold "lemons" (since $p_{lemon} < p_{avg}$) and they will leave the market when they hold "peaches" (since $p_{peach} > p_{avg}$). Eventually, as enough sellers of "peaches" leave the market, the average willingness-to-pay of buyers will decrease (since the average quality of cars on the market decreased), leading to even more sellers of high-quality cars to leave the market through a positive feedback loop.

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Thus the uninformed buyer's price creates an adverse selection problem that drives the high-quality cars from the market. Adverse selection is a market mechanism that can lead to a market collapse.
Akerlof's paper shows how prices can determine the quality of goods traded on the market. Low prices drive away sellers of high-quality goods, leaving only lemons behind. In 2001, Akerlof, along with Michael Spence, and Joseph Stiglitz, jointly received the Nobel Memorial Prize in Economic Sciences, for their research on issues related to asymmetric information.

Source: https://en.wikipedia.org/wiki/The_Market_for_Lemons

6.3. Signalling high quality

There are fundamentally two ways for firms to convince consumers that an experience good is of high quality: (1) through reputation, (2) by commitment. So, a firm can signal (high) quality by reputation or commitment. High-quality products must earn a rent in all subsequent period, which is the return on the investment in reputation that the firm must make in the first period.

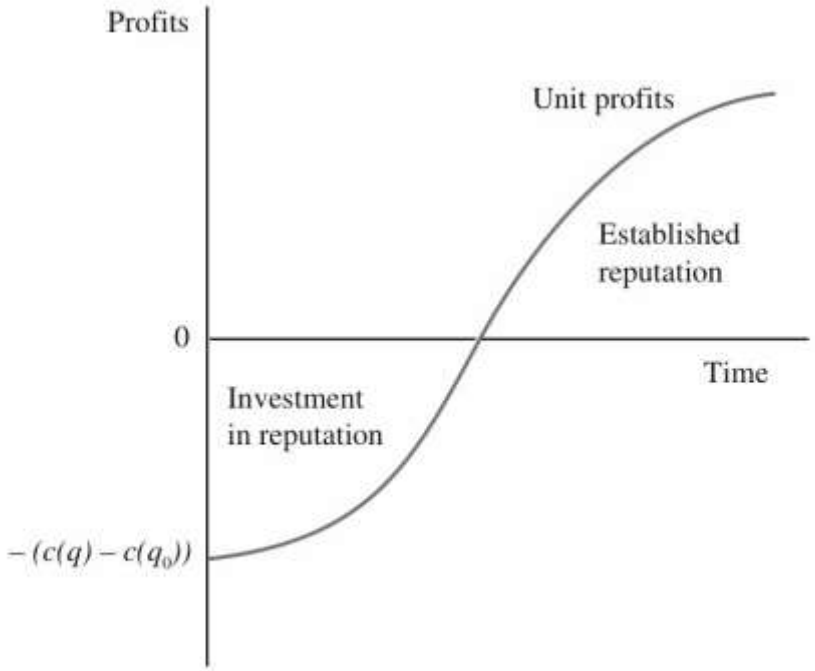

Figure 6.6 Unit Profits in a General Model Where Reputation Is Built over Several Periods

Figure 6.6: at the stage of investing in reputation (e.g. when appearing in a new market), price is lower in order to "finance" the consumer/customer experience of good quality. Once reputation is established, price can be increased, and profits are realisable (preferably investment in reputation is recovered + more profit is made).

Advertising: the fact that the company invests in / commits

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itself to advertising is already a signal of quality: it can afford it.
Warranties: an instrument available to a seller for signalling high quality. Should the product break down, repairmen / replacement is provided free of charge.

Questions for self-study

1. How is quality interpreted by I/O?
2. What is the main difference between search goods and experience goods? How is asymmetric information related to quality?
3. What do we call quality discrimination?
4. Please explore the relation between quality, experience goods, advertising as a signal of quality, and moral hazard.
5. Please introduce Akerlof's lemons problem of 1970.
6. In what ways can a firm signal (high) quality? Please interpret Figure 6.6.
7. How are warranties related to signalling quality?

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Part III: Oligopoly pricing

Chapter 7: Game theory I

This chapter is a nontechnical user-friendly guide to non-cooperative game theory; it is a conceptual introduction to the applicable techniques.

7.1. Why game theory?

The defining concept of a game-theoretic situation is: **payoff-interdependency**. It exists when the optimal choice by an agent depends on the actions (decisions) of others.
In game theory we deal with **decision-theoretic problems**. A market situation is game-theoretic if there is payoff interdependence of actions. As a result, firms are forced to reason strategically: form expectations about how their competitors will behave when deciding on their course of action. Recognised payoff interdependency gives rise to independent decision-making.

> **Interdependent decision-making**: the optimal choice of an agent depends on the actions of others / own decision is influenced by the actions/behaviour of others.

7.2. Foundations and principles

The **basic elements** of a game:

1. Players
2. **Rules** that specify (a) timing of all players' moves; (b) the actions available to a player at each of his moves; (c) the information that a player has at each move.
3. **Outcomes** (the set of outcomes is determined by all of the possible combinations of actions taken by players)
4. Payoffs

Types of games:

	complete information	**incomplete information**
static		
dynamic		

- **Static game**: each player moves once.
- **Dynamic game**: players move sequentially and have some information on the "history" of the game.
- **Game of perfect information**: all players know the entire history of the game when it is their turn.
- **Game of imperfect information**: players know their own payoffs but there are some players who do not know the payoffs of some of the other players.

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The equilibrium concept: solving for an equilibrium is similar to making a prediction about how the game will be played.
Fundamental assumptions:

- **Rationality**: players are interested in maximising their payoffs. (Payoffs for firms: their profits.)
- **Common knowledge**: all players know the structure of the game and that all players are rational.

7.3. Static games of complete information

The **normal form** representation of a static game of complete information is given by

- a set of players: *(1, 2, …, I)*, *I*: number of players
- a set of actions or strategies for each player *i*: S_i
- a payoff function for each player i: $\pi_i(s)$, $s=(s_1, s_2, \ldots, s_i)$, $s_i \in S_i$

A strategy is **strictly dominant** for a player if it maximises his payoff regardless of the strategies chosen by the other player(s).
A strategy is **strictly dominated** for a player if there is another strategy available that yields strictly higher profits regardless of the strategies chosen by the other player(s). (Therefore a strictly dominated strategy is never played so it can be eliminated.)
The distinction between non-cooperative and cooperative games is determined by whether players are able to make binding commitments to each other – if so, the game is cooperative, otherwise it is non-cooperative.

The prisoner's dilemma

The prisoner's dilemma is one of the most well-known concepts in modern game theory. It is a paradox in decision analysis in which two individuals acting in their own self-interests do not produce the optimal outcome. The typical prisoner's dilemma is set up in such a way that both parties choose to protect themselves at the expense of the other participant. As a result, both participants find themselves in a worse state than if they had cooperated with each other in the decision-making process.

Source: https://www.investopedia.com/terms/p/prisoners-dilemma.asp

In a game-theoretic situation, players have to make a conjecture about what they think their rivals will do. A rational player should only play a **best response**. A strategy is a best response if

$$\pi_i(s_i, s_{-i}) \geq \pi_i(s'_i, s_{-i})$$

Rational players never play a strategy that is never a best response. **Never-best responses** are thus strategies that are never played (strictly dominated strategies) therefore can be eliminated. Through **iterative elimination** of never-best responses, we can arrive at the set of **rationalisable strategies**.
Unique prediction: when there is a single solution to a game.

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The Nash equilibrium

The Nash equilibrium is named after the mathematician John Forbes Nash Jr. (1928-2015). It states that, in terms of game theory, if each player has chosen a strategy, and no player can benefit by changing strategies while the other players keep theirs unchanged, then the current set of strategy choices and their corresponding payoffs constitutes a Nash equilibrium.

Put simply, Alice and Bob are in Nash equilibrium if Alice is making the best decision she can, taking into account Bob's decision while his decision remains unchanged, and Bob is making the best decision he can, taking into account Alice's decision while her decision remains unchanged.

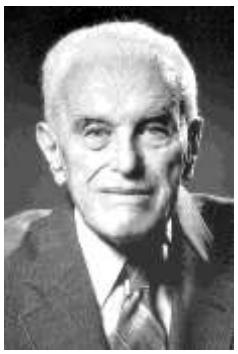
Nash proved that if we allow mixed strategies (where a pure strategy is chosen at random, subject to some fixed probability), then every game with a finite number of players in which each player can choose from finitely many pure strategies has at least one Nash equilibrium.

Source: https://en.wikipedia.org/wiki/Nash_equilibrium

The four reasons why there might be an obvious way to play the game are:

1. Focal points
2. Self-enforcing agreements
3. Stable social conventions
4. Rationality determines the obvious equilibrium

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1994
was awarded jointly to



John C. Harsanyi

John F. Nash Jr.

Reinhard Selten

"for their pioneering analysis of equilibria in the theory of non-cooperative games."

Source: https://www.nobelprize.org/prizes/economic-sciences/1994/summary/

Mixed strategies: a strategy is mixed if the player randomises over some or all of the strategies in his strategy set S_i. The Nash equilibrium involving mixed strategies still requires that no player can increase his payoff by unilaterally deviating.

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The **two objections to mixed-strategy Nash equilibrium** are:

1. People do not act randomly.
2. If a player does not choose the right probability distribution over his pure strategies, then his opponents will have an incentive to deviate.

Harsanyi observed that mixed strategies can be reinterpreted as arising because of uncertainty over the payoff of the opponent. Mixed strategies arise because a player is uncertain about the pure strategy choice of his rival.

Questions for self-study

1. Which is the simplest class of games in game theory?
2. What is payoff interdependency? And interdependent decision-making?
3. Please present the foundations and principles of game theory: the four basic elements of a game; the four types of games; two fundamental assumptions.
4. Which are the two distinguishing characteristics of static games of complete information? What is the normal form of such games?
5. What does the payoff matrix show? Please interpret Figures 7.1 and 7.2.
6. When is a strategy strictly dominant? Please present the Prisoner's Dilemma.
7. What is the distinction between non-cooperative and cooperative games?
8. When is a strategy strictly dominated? Please interpret Figures 7.3. and 7.4.
9. How is rationality of a player linked to payoff and best response? Which are never-best responses? What are rationalisable strategies? And unique prediction? What makes a Nash equilibrium?
10. Which are the two practical difficulties associated with the concept of Nash equilibrium?
11. How is Pareto optimality interpreted to Nash equilibria?
12. What are focal points and how are they related to multiple Nash equilibria?
13. When is a strategy mixed? Which are the two objections to mixed-strategy Nash equilibrium? What did Harsanyi observe in this respect?

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Chapter 8: Classic models of oligopoly

The **classic models of oligopoly** are **static** and consider competition between small numbers of firms, only over **output (Cournot)** or **price (Bertrand)**. In this chapter, these classic models are **reinterpreted in game-theoretic terms**. This can be done as there is payoff interdependency in them: the profit of one firm depends on the behaviour of its competitors.

8.1. Static oligopoly models

In static models of firm behaviour, repeated interaction between firms over time is deliberately eliminated.

The underlying structure of oligopoly pricing **resembles the Prisoner's Dilemma**. Because **the game is non-cooperative**, the equilibrium outcome is not the collusive outcome: oligopoly prices and profits are lower than those of a monopolist.

8.2. Cournot

The 1838 model of Augustine Cournot is a **simple static game in a duopoly** (i.e. two firms in a market). The rules/assumptions of the game are:

- Products are homogenous.
- Firms choose **output**.
- Firms compete with each other just once and make decisions simultaneously.
- There is no entry to the market.

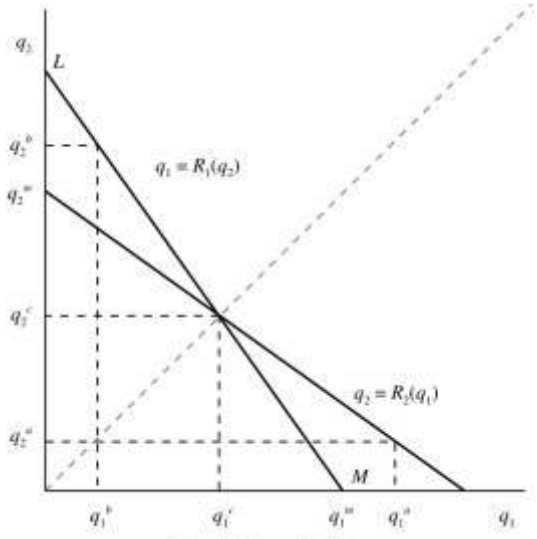

Figure 8.4 Cournot Equilibrium

The Cournot game is a **static game of complete information**. The Cournot equilibrium is the Nash equilibrium of the Cournot game. The Nash equilibrium outputs can be found using best-response functions.

The following observations can be made about the Cournot game:

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1. The Cournot equilibrium price will exceed the marginal cost of either firm.
2. The market power of a Cournot duopolist is limited by the market elasticity of demand.
3. Cournot markups are less than monopoly markups.
4. There is an endogenous relation between marginal cost and market share (firms with lower marginal cost will have greater market share, i.e. more efficient firms will be larger).
5. The greater the number of competitors, the smaller each firm's market share and less its market power.

The **Herfindahl-Hirschmann index (HHI)** shows market concentration. It can vary between 0 (perfect competition) and 1 (monopoly). Fewer firms and larger variation in market share increase the index, indicating a great degree of concentration.

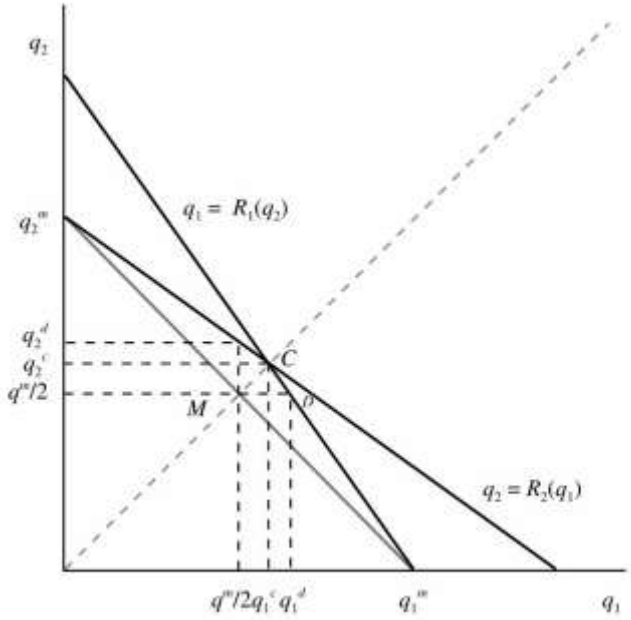

Figure 8.8 Cournot vs. Collusion

C: Cournot equilibrium (non-cooperative)
M: monopoly profit equally divided by the two firms (as an outcome of cooperation (collusion), the duopolists can act as a single monopoly)
Quantity: $Q_C > Q_M$
Price: $p_C < p_M$

Both firms are better off with *M* than with *C*. Therefore, firms have an **interest in colluding**. Is collusion sustainable? No, because each firm has an incentive to unilaterally deviate (cheat). In game-theoretic terms, the collusive agreement is not a Nash equilibrium.

Free-entry Cournot equilibrium: A firm considering entry will anticipate post-entry competition and profits. If

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profits from entry will be positive, firms will enter. The equilibrium number of firms is where the expected profit of the next entrant is negative.

8.3. Bertrand competition

Joseph Bertrand criticised Cournot (five years later) claiming that firms choose prices, not quantities and they have very strong incentives to undercut each other.
Static games where firms compete over **prices** are called Bertrand games. In the simple Bertrand game:

- Products are homogenous.
- Firms have the same unit cost of production.
- There are no capacity constraints.

The **Bertrand paradox**: the Nash equilibrium of the Bertrand game is: price equalling marginal cost ($P=MC$). Implications: 1) two firms are enough to eliminate market power, 2) competition between two firms results in complete dissipation of profits. (This is considered a paradox because we would not expect oligopoly pricing to yield the competitive outcome.)
Bertrand equilibrium with product differentiation (i.e. when the competing products are not perfect substitutes):

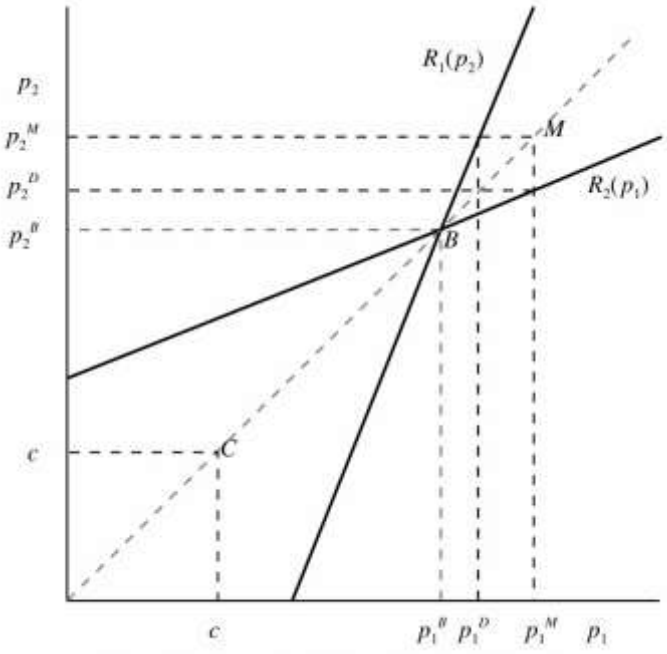

Figure 8.16 Bertrand Equilibrium with Product Differentiation

B: Nash equilibrium of the Bertrand game
p_1^D, p_2^D: prices under product differentiation
M: monopoly price
$p^B < p^D < p^M$

Capacity constraints can change the Bertrand game.

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8.4. Cournot vs. Bertrand

In case of homogenous products and no capacity constraints, the predictions of the Cournot and Bertrand games are very different.

Cournot equilibrium: firms have market power (prices exceed marginal cost) and their market power is decreasing in the number of competitors and the elasticity of demand.

Bertrand game: firms do not have market power, price equals marginal cost.

Which model is appropriate when?

Cournot: 1) when firms are capacity constrained and 2) investments in capacity are sluggish.

Bertrand: 1) there are constant returns to scale and 2) firms are not capacity constrained. (However, the static model is quite inappropriate.)

Questions for self-study

1. Please present the Cournot game. Please interpret Figure 8.4.
2. Please summarise the implications of the Cournot model.
3. What does the Herfindahl-Hirschmann index (HHI) show?
4. How do changes in the exogenous parameters of the model (a firm's marginal cost; a firm's marginal revenue; the number of firms in the industry) affect the Cournot equilibrium?
5. Please contrast the Cournot case with collusion in the market (Figure 8.8).
6. How does free entry change the Cournot model?
7. Please present the Bertrand game (assumptions, Nash equilibrium).
8. What does the Bertrand paradox say?
9. How do these extensions affect the Bertrand game: increasing returns to scale; constant but asymmetric unit costs?
10. What is the Nash equilibrium for imperfect substitutes? (Figure 8.14.)
11. Please explain the Bertrand equilibrium with product differentiation (Figure 8.16.).
12. How do capacity constraints affect the Bertrand game? Please interpret Figure 8.18.
13. Please contrast the Cournot and Bertrand cases. Which one is appropriate in what situation?

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Chapter 9: Game theory II

When issues of **commitment** and **credibility** are involved, we must move to the richer framework of dynamic games in order to sort out what strategies might occur in equilibrium.
Dynamic games: there is a sequence of moves, players move more than once.

9.1. Extensive forms

Dynamic games are typically defined by their **extensive forms** that:

1. Identifies the identity and number of **players**.
2. Identifies when each player can **move** or make a decision.
3. Identifies the **choices or actions** available to each player when it is their turn to move.
4. Identifies the **information** a player has about the previous actions taken by his opponents / about the history of the game.
5. Identifies the **payoffs** over all possible outcomes of the game.

Simple dynamic games can be illustrated by a **game tree**. A game tree has three elements:

1. **Decision nodes** that indicate a player's turn to move.
2. **Branches** that correspond to the actions available to a player at that node.
3. **Terminal nodes** with the payoffs for the players if that node is reached.

Information set: a group of nodes at which the player has common information about the history of the game and his available choices.

9.2. Strategies vs. actions and Nash equilibria

Actions: the choices available to a player when it is his turn to move.
Strategy: the plan of actions that the player will take at each of his decision nodes.

9.3. Noncredible threats

The concept of **subgame perfect Nash equilibrium (SPNE)** was introduced by Reinhard Selten.

Subgame: a smaller game embedded in the complete game.
SPNE: a strategy profile is a SPNE if the strategies are a Nash equilibrium in every subgame.

In a finite game of perfect information, the SPNE can be found through **backward induction**. The SPNE strategies are (1) complete-contingent plans of action and (2) specify choices that are optimal for every subgame.

9.4. Two-stage games

Two-stage games: in the first stage, player 1 alone gets to move. Then, in stage 2, player 1 and player 2 move simultaneously, knowing the choice of player 1 in the first stage.

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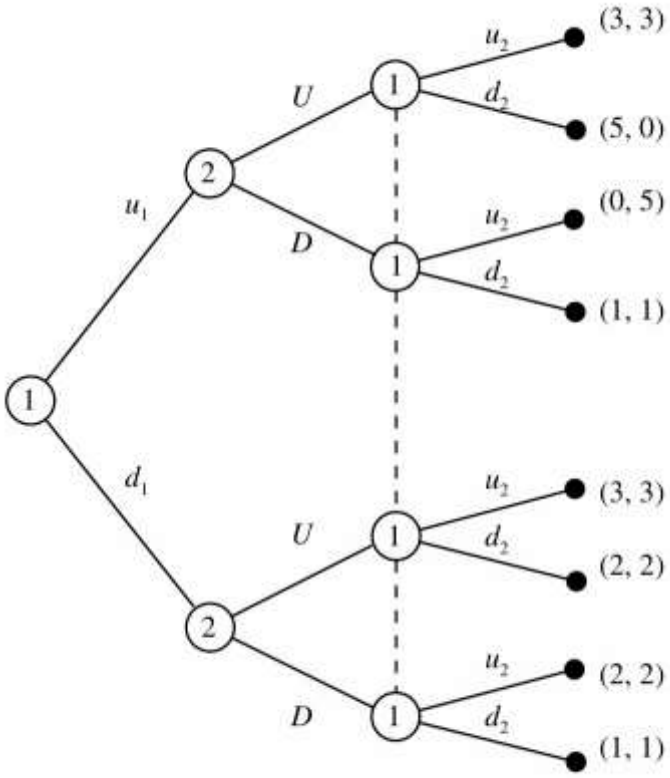

Figure 9.8 Two-Stage Game

stage 1: player 1 moves u_1 or d_1
stage 2: player 2 moves U or D and player 1 moves u_2 or d_2 simultaneously

Depending on the moves of the players in stages 1 and 2, we arrive at the respective terminal node (leaf) of the game tree. (The dashed line represents simultaneousness!)

9.5. Games of almost perfect information

Games of almost perfect information: a simple static game (called the **stage game**) is **repeated** (played) over and over. Players know the history of the game. The game can be repeated **finitely** or **infinitely**.
With repetition, players learn and cooperation becomes rewarding. (This is much more similar to real-world markets than static games!) Past actions of a rival can **trigger** a change in behaviour → **trigger strategy**.

Questions for self-study

1. Please present the extensive form of dynamic games.
2. What are the elements of a game tree?
3. What is an information set in relation to players of a game?

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4. What is the distinction between actions and strategies?
5. What is a subgame? Please explain the subgame perfect Nash equilibrium (SPNE) and the way to find it through backward induction.
6. Please describe the centipede game.
7. Please present the generic form of two-stage games; please interpret Figure 9.8.
8. What are the features of games of almost perfect information? What is the difference if such games are finitely or infinitely repeated?
9. Please interpret Figure 9.13 (finitely repeated Prisoners' Dilemma). What is a trigger strategy?

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Chapter 10: Dynamic models of oligopoly

An important implication of repeated games (that are good simulations of market interactions) is that cooperation among firms can yield gains to them through enhanced profits.
Collusion refers to firm conduct intended to *coordinate the actions of firms*.

10.1. Reaching an agreement

The questions ahead of firms are:

(1) What will industry output be?
(2) What will be the output of each firm?

The profits available are identified by the **profit-possibility frontier (PPF)**. It shows the maximum profits that can be earned by firm 2, given a specified level of profit for firm 1.

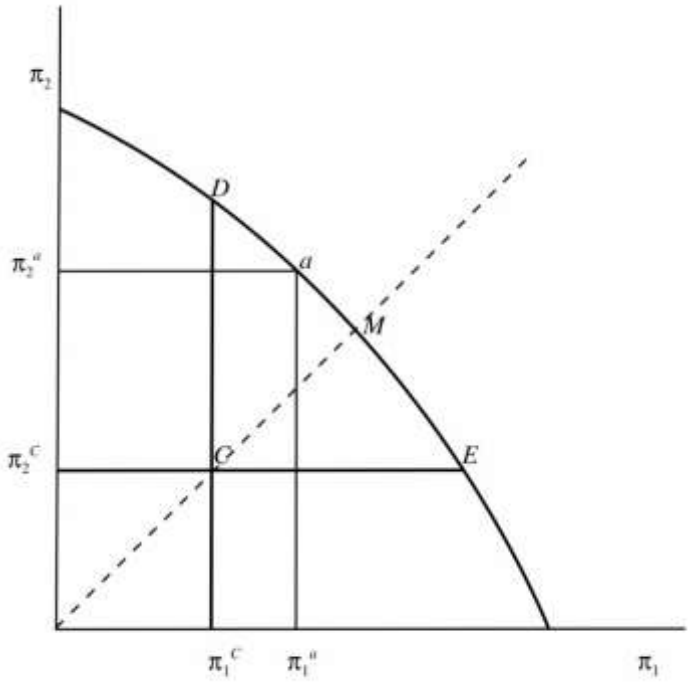

Figure 10.1 Profit-Possibility Frontier

Profits inside the frontier (e.g. *C*) are inefficient (from firms' perspective!)
Points outside the frontier are not feasible
M: monopoly profit (i.e. maximum industry profit) equally divided by the two firms
Area *DCE*: room for collusion

The outcome will depend on the *relative bargaining power* of the firms.
The *effect* of reducing competition on market power will *depend on*:

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(1) the market elasticity of demand (→ substitution to alternative products!),
(2) the relative number and size of participating firms,
(3) the extent of entry barriers.

Often, a group of firms that have *agreed to coordinate pricing and output* to increase profits are termed a **cartel**.
Tacit collusion occurs when firms are able to coordinate their behaviour simply by *observing* and *anticipating* their *rivals' pricing behaviour*.

> The Nash equilibrium to a *dynamic game* may result in a greater degree of coordination and higher industry profits than the Nash equilibrium to a *static game*.

Factors that complicate reaching an agreement:

(1) *cost asymmetries* (high-cost firms would prefer higher price and lower aggregate output → this can be mitigated though by so-called **side payments**),
(2) product heterogeneity,
(3) *innovation* (as it changes product characteristics, costs of production and demand),
(4) *incomplete information* (a firm better informed about its rival is incentivised to strategically use that information to get a better deal),
(5) *uncertainty* (regarding industry-wide conditions),
(6) asymmetries in preferences,
(7) *industry social structure* (whether there is a facilitator of such agreements),
(8) seller concentration,
(9) *enforcement* (the outcome of such agreements is not a Nash equilibrium so firms will be incentivised to deviate/cheat).

10.2. Stronger, swifter, more certain

Stigler (1968): theory of oligopoly should address the oligopolist's problem: *how to police or enforce a collusive agreement*.
The ability to police an agreement depends on the following:

(1) detection (of rival's cheating),
(2) speed of punishment,
(3) strength of punishment.

The motto of the oligopolist is (according to Stigler): **stronger, swifter, and more certain** (the punishment, the more likely a collusive agreement is sustainable).

10.3. Dynamic games

Credible punishment: it is in the interest of the firm threatening the punishment to actually carry out with its threat.

10.4. Supergames

In dynamic games, we must check all possible subgames to see if a firm has an

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incentive to unilaterally deviate. Subgames begin at each period. **Grim trigger strategies** are played by firms to sustain a collusive agreement.
Stigler's insight on "stronger, swifter, and more certain" punishments is supported by the theory of supergames. **Supergame**: an infinitely repeated game without discounting.

10.5. Factors that influence the sustainability of collusion

(1) public prices
(2) size of the cartel (the larger, the less likely to sustain)
(3) lumpy infrequent orders
(4) product differentiation
(5) cost conditions and capacity utilisation

> If a firm is capacity constrained or has sharply rising marginal costs, its ability to cheat or the profitability of cheating on a collusive agreement is limited. On the other hand, industries with excess capacity or flat marginal costs will find sustaining collusion difficult because of the incentive to cheat.

(6) elasticity of firm demand (elastic firm demand increases the payoff from cheating so makes sustaining collusion more difficult)
(7) multimarket contact (when firms compete against each other in multiple markets, e.g. tech giants)

10.6. Facilitating practices

Facilitating practices are elements of firm conduct that increase the likelihood of collusion, typically by (1) increasing the probability of detection, the speed and the severity of punishment, or by (2) decreasing the difficulties associated with reaching an agreement.
Facilitating practices:

(1) exchange of information,
(2) trade associations,
(3) price leadership and advance notice of price change,
(4) meeting-competition clauses (MCCs),
(5) most-favoured nation clauses (MFNs),
(6) multiproduct formula pricing (products are differentiated but the firms' range of products is not),
(7) delivered pricing (instead of FOB),
(8) resale price maintenance (RPM: supplier selling to retailer only if it charges the agreed higher price).

Questions for self-study

1. What does collusion refer to? And cartel? And tacit collusion?

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2. What does the profit-possibility frontier show?
3. What factors influence the effect of the reduction of competition on market power of firms?
4. Which are the structural conditions that complicate reaching an agreement?
5. What did Stigler propose in relation to the examination of oligopolies?
6. Which three factors will determine the ability to police an agreement?
7. What factors influence the sustainability of collusion?
8. What are the so-called facilitating practices in relation to collusion?

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Chapter 11: Product differentiation

The starting point for the analysis in this chapter is that *firms choose the attributes or characteristics of the products they produce and sell*.
Questions addressed:

1. Why do firms differentiate their products?
2. What determines the extent to which firms can and will differentiate their products?
3. What is the effect of product differentiation on entry barriers?
4. How do market outcomes in differentiated product markets compare with socially desirable outcomes?

11.1. What is product differentiation?

Products are differentiated (deliberately made different) by their **characteristics** or **attributes**.

Products are **horizontally differentiated** if consumers have heterogeneous preferences regarding the most preferred *mix of different attributes*.
Products are **vertically differentiated** if consumers unanimously agree on *which product or brand* is preferred.

11.2. Monopolistic competition

Two key assumptions of models of monopolistic competition are:

1. There is a *very large set of possible differentiated products* over which the preferences of consumers are defined.
2. The *preferences of consumers* over the set of all possible differentiated brands *are symmetric*.

Symmetric preferences: the representative consumer views all products within the set of differentiated products as close substitutes for each other and each product is an equally good substitute for products inside the group (but relatively poor substitutes to products outside the set). In other words, *the cross-elasticities of demand within the groups are significant and equal, but insignificant with products outside the group*. So, the **elasticity of substitution** is *constant and equal between any two products*.
Monopolistically competitive equilibrium: the equilibrium number of firms depends on the extent of scale economies and the elasticity of substitution.

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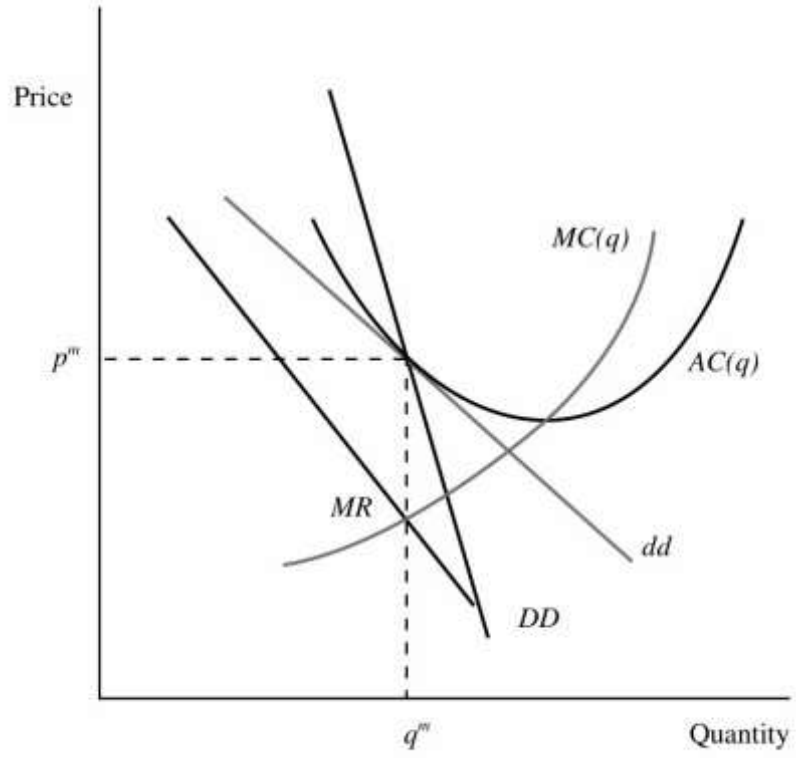

Figure 11.2 Monopolistically Competitive Equilibrium

D

D: demand curve for firm *i* if all firms in the industry change their price simultaneously (not fully elastic because of product differentiation)

dd: firm demand (shallower than *DD* because of monopolistic power over own product)

Firm produces where its *AC* curve is tangent to its *dd* (demand) curve.

Firm produces less than socially optimal quantity (q^m < the quantity where *AC(q)=MC(q)*) and price is higher than the socially optimal (p^m > the price where *AC(q)=MC(q)*).

What is the equilibrium number of firms? The **three notions of efficiency** in relation to product differentiation are:

1. **First best**: prices and number of products are chosen to maximise total surplus.
2. **Behavioural second-best**: prices are chosen to maximise total surplus subject to the constraint that firms break even.
3. **Structural second-best**: the regulator cannot choose prices so it chooses the number of firms to maximise total surplus.

11.3. Bias in product selection

So far, we have assumed symmetry in preferences. However, preferences can well be asymmetric. Under **asymmetric preferences**, there is a bias against

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products with relatively inelastic demands, and the market will also be biased against the introduction of products that have greater fixed costs.

11.4. Address models

Address models of product differentiation assume that consumers have preferences defined over characteristics or attributes of a product. Address models draft *'maps' of consumer preferences*.

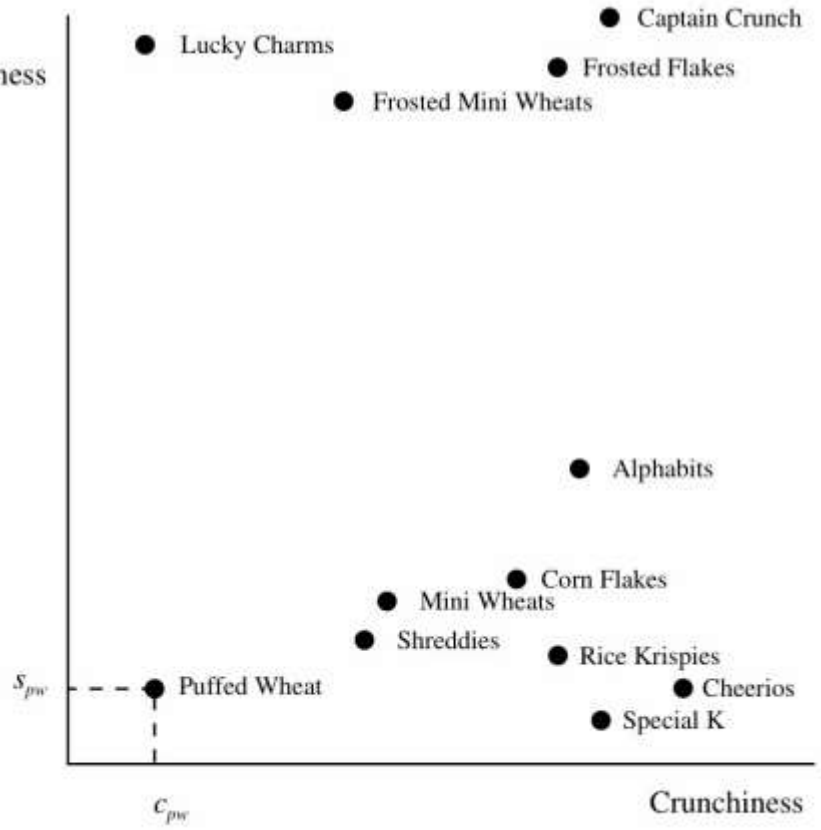

Figure 11.5 Breakfast Cereal Example of an Address Model

In address models we define attributes of products and we "place" consumer preferences in this "product space" defined by the different attributes (2 attributes: plane, 3 attributes: space, >3 attributes: vectors). Then we optimise the attributes of our product so that our consumers' "transportation costs" (=reaching the position of the product from their own position) are minimised overall.

Another expression for transportation costs is **mismatch costs** and it is expressing the "distance" of the product attributes from the attributes preferred by the consumer(s).

An important implication is that *competition may be localised*. In localised competition, firms compete with their direct neighbours only, not in the full product space.

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Hotelling's (1929) linear city

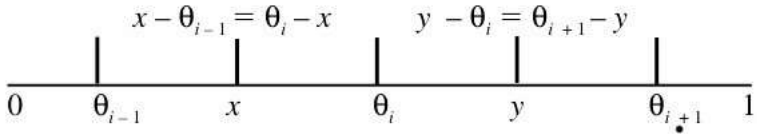

Figure 11.6 Linear Address Model

Hotelling's law

Hotelling's law is an observation in economics that in many markets it is rational for producers to make their products as similar as possible. This is also referred to as the *principle of minimum differentiation* as well as Hotelling's linear city model. The observation was made by Harold Hotelling (1895–1973) in the article "Stability in Competition" in Economic Journal in 1929.

Suppose there are two competing shops located along the length of a street running north and south, with customers spread equally along the street. Both shop owners want their shops to be where they will get most market share of customers. If both shops sell the same range of goods at the same prices then the locations of the shops are themselves the "products". Each customer will always choose the nearer shop as it is disadvantageous to travel to the farther.

For a single shop, the optimal location is anywhere along the length of the street. The shop owner is completely indifferent about the location of the shop since it will draw all customers to it, by default. However, from the point of view of a social welfare function that tries to minimise the distance that people need to travel, the optimal point is halfway along the length of the street.

Hotelling's law predicts that a street with two shops will also find both shops right next to each other at the same halfway point.

The street is a metaphor for product differentiation; in the specific case of a street, the stores differentiate themselves from each other by location. The example can be generalized to all other types of horizontal product differentiation in almost any product characteristic.

Source: https://en.wikipedia.org/wiki/Hotelling%27s_law

Importantly, if there is free entry into the "city", a **sequential entry game** will occur. Here, where early entrants can strategically affect later entrants' location decisions, the equilibrium is characterised not by minimum differentiation, but by **maximum differentiation**.

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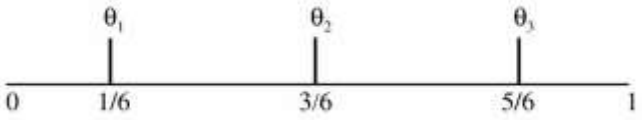

Figure 11.11 Sequential Entry Equilibrium with Three Firms

Figure 11.13 Efficient Location $N = 2$

Figure 11.14 Efficient Location $N = 4$

11.5. Strategic behaviour

There are three types of strategic behaviour associated with product differentiation:

- **Brand proliferation**: a behaviour exhibited by an incumbent monopolist involving *locating multiple brands* such that no niches of locations are available that will support profitable entry.
- **Brand specification**: an incumbent may find it more profitable to deter entry by *strategic choice of its product specification or location*.
- **Brand pre-emption**: to introduce brands prior to, or before, an entrant, thereby eliminating the possibility of profitable entry.

Questions for self-study

1. What is product differentiation? What is horizontal differentiation of products? And vertical?
2. Which are the two key assumptions of monopolistic competition? What do symmetric preferences mean and how are they related to cross-elasticities of demand?
3. Please explain the monopolistically competitive equilibrium (Figure 11.2). What does the equilibrium depend on? Which are the two interesting characteristics of the equilibrium?
4. Please present the three notions of efficiency in relation to product differentiation.
5. How does the situation change when preferences are asymmetric? What biases are identifiable in such markets of differentiated products?
6. Please present the tool of address models of product differentiation.

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What are mismatch costs in the model?

7. Competition can be localised in the product space – what does this mean?
8. Please present Hotelling's (1929) linear city model. What does the principle of minimum differentiation state?
9. In sequential entry games there is maximum differentiation – why?
10. There are three types of strategic behaviour associated with product differentiation: brand proliferation, brand specification, and brand pre-emption. Explain these.

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Chapter 12: Identifying and measuring market power

This chapter deals with **market power measurement** issues.

How would you measure the market power of a firm or its exercise in a market?
How would you measure the impact of different factors on the market power of a firm or its exercise in a market?

The **traditional approach (SCP)** relies on accounting data regarding profits and costs of firms. The **new approach (NEI/O)** uses comparative statistics to *simultaneously* estimate market power and marginal costs.

12.1. Structure, conduct, and performance

The **SCP approach** presumes that there is a **stable, causal relationship** between industry structure, firm conduct, and market performance.

12.2. The New Empirical Industrial Organisation

The characteristics of the **NEI/O approach** are:

- Accounting data on costs are not used as meaningful measures of marginal cost are considered unobservable.
- The focus is on estimating market power in a single (specific) industry.
- Firm behaviour is estimated based on the theoretical models of oligopoly.
- Market power is identified and estimated based on firm behaviour.

Questions for self-study

1. Please introduce the Structure-Conduct-Performance (SCP) approach of industrial organisation.
2. Please present the distinguishing features of the New Empirical Industrial Organisation (NEI/O) approach.

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Part IV: Strategic behaviour

Chapter 13: An introduction to strategic behaviour

In the previous chapters, firms took as given their market situation and tried to maximise their profits. In this part of the book, the prospective is broadened over the nature of competition between firms beyond simple price competition, and *non-price competition is also considered*. The view taken here is that non-price competition in oligopoly is *inherently strategic*.

13.1. Strategic behaviour

Important concepts related to strategic behaviour:

- **Threat**: a *penalty* imposed on a rival upon some action
- **Promise**: a *reward* imposed on a rival upon some action
- **Commitment**: *a credible threat or promise* (credible: it is in the player's best interest to actually carry out the threat/promise)
- **Strategic move**: one player's move *influencing* the choice of his rival in a manner that is favouring the (original) player himself by affecting the rival's expectations on how he (the player taking the move) will behave in the future

The *role of a strategic move* is to convert a threat or punishment into a commitment.
The **four elements** of a move (or action) **that make it strategic**:

1. Sequential moves (dynamic game)
2. Communication (game of perfect information)
3. Affects incentives (game-theoretic situation as there is payoff interdependence)
4. Rational expectations (presumption of both economics and game theory)

In relation to strategic behaviour, there are indirect and direct effects.

Indirect effects: the behaviour of rivals is changed because strategic moves change *their* expectations regarding *your* behaviour in the future.
Direct effects: strategic behaviour either changes the set of choices available to rivals or it affects rivals' payoffs.

Of course a strategic move could have both direct and indirect effects.
The study of strategic behaviour distinguishes between **strategic choices** and **tactical choices**. These differ in two respects: 1) *timing* and 2) *commitment*. Strategic choices must occur *prior to* tactical choices.
Commitment means that it must not be possible to change strategic decisions when tactical choices are being made.

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Figure 13.1 Decision Horizons

Strategic decisions are made on the longer time horizons but affecting short-run decisions (on quantity or price). The commitment value of *long-run decisions* arises because they *involve sunk costs*: investments will be made in assets. This "locks" firms into their strategic decisions.
Firms that act strategically will consider the impact of their long-run decisions on their competitors in the short run.

13.2. The Stackelberg game

The **Stackelberg game** is a sequential Cournot game, i.e. a *duopoly game in quantities* where firm 1 moves first (and thus has first-mover advantage).

> **First mover advantage**: in a two-stage game, the incumbent (firm 1) has the opportunity to divert the outcome in his favour by his move in the first stage.

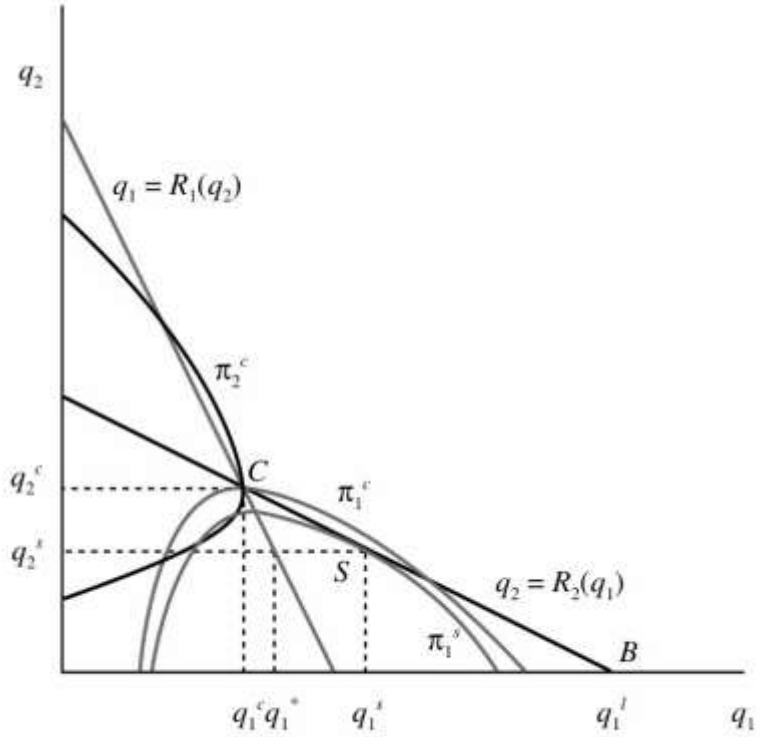

Figure 13.3 Stackelberg vs. Cournot

As the first mover has an advantage, $\pi_1 > \pi_2$ (on the other hand, $\pi_1^S > \pi_1^C$ but $\pi_2^S < \pi_2^C$), and player 1's market share is larger than that of player 2.
Stackelberg (joint) output is larger than Cournot (joint) output but still under the socially desirable (competitive) output.
S (Stackelberg equilibrium): where player 2's best response function ($q_2=R_2(q_1)$) is tangent to player 1's highest iso-profit curve (π_1^S).

A natural reinterpretation of the Stackelberg model is that firms do not choose quantities sequentially, but *capacities*.

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13.3. Entry deterrence

The Stackelberg model implicitly assumes that firm 1 would *accommodate entry* by firm 2. However, it may be able to *deter entry*.

> Consider point *B* in Figure 13.3 – at this level of output for firm 1, q_1^l, the optimal response for firm 2 is not to produce.

Entry deterrence: strategic behaviour on behalf of an incumbent resulting in the entrant's decision to stay out.

Entry accommodation: strategic behaviour on behalf of an incumbent accepting entry but aiming at maximising his own profit post-entry.

With *constant returns to scale*, it is not possible for firm 1 to deter entry of firm 2, exercise market power, and earn profits. With constant returns to scale, there is no cost disadvantage associated with small-scale production. However, if there are *economies of scale*, then profitable entry deterrence will be possible for the incumbent.

Incumbent will engage in the strategy (deter / accommodate entry) that yields him higher profit in the future.

13.4. Introduction to entry games

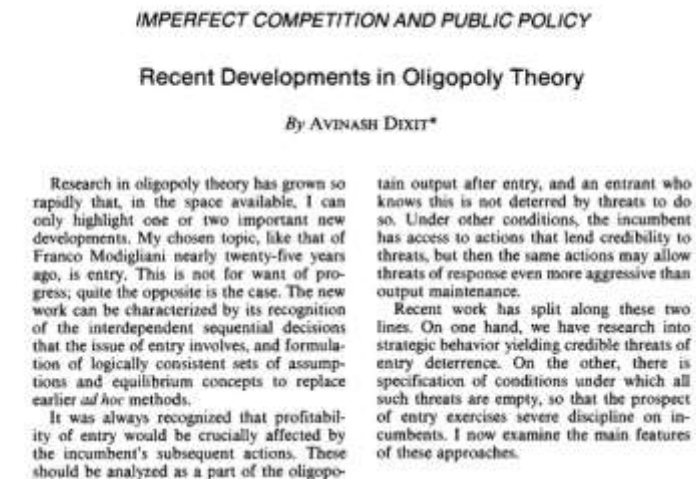
The rationale behind entry games is that monopoly pricing may not be attractive since the *monopoly profits earned would attract entry and competition*.

> The decision to enter depends on the *entrant's expectations* of the post-entry equilibrium and its post-entry profits – both of which *depend on the behaviour of the incumbent*. This provides the incumbent with an opportunity to *signal* aggressive post-entry behaviour. **The monopolist limits price and profits in order to deter entry**.

The trade-off for firm 1 is between 1) maximising short-run profits by charging the monopoly price and 2) limiting entry to preserve some profits in the long run.

Post-entry, the entrant should expect that the incumbent will maximise its profits given that the market structure is now a duopoly. This will typically involve some accommodation.

The stylised entry game was presented by Dixit in 1982.



IMPERFECT COMPETITION AND PUBLIC POLICY

Recent Developments in Oligopoly Theory

By Avinash Dixit*

Research in oligopoly theory has grown so rapidly that, in the space available, I can only highlight one or two important new developments. My chosen topic, like that of Franco Modigliani nearly twenty-five years ago, is entry. This is not for want of progress; quite the opposite is the case. The new work can be characterized by its recognition of the interdependent sequential decisions that the issue of entry involves, and formulation of logically consistent sets of assumptions and equilibrium concepts to replace earlier *ad hoc* methods.

It was always recognized that profitability of entry would be crucially affected by the incumbent's subsequent actions. These should be analyzed as a part of the oligopo-

tain output after entry, and an entrant who knows this is not deterred by threats to do so. Under other conditions, the incumbent has access to actions that lend credibility to threats, but then the same actions may allow threats of response even more aggressive than output maintenance.

Recent work has split along these two lines. On one hand, we have research into strategic behavior yielding credible threats of entry deterrence. On the other, there is specification of conditions under which all such threats are empty, so that the prospect of entry exercises severe discipline on incumbents. I now examine the main features of these approaches.

Dixit, Avinash (1982): Recent Developments in Oligopoly Theory. *The American Economic Review*, Vol. 72, No. 2, Papers and Proceedings of the Ninety-Fourth Annual Meeting of the American Economic Association (May, 1982), pp. 12-17.

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
www.u-szeged.hu
www.szechenyi2020.hu

		Entrant: In	Entrant: Out
Incumbent	Accommodate	(π^d, π^d)	$(\pi^m, 0)$
	Fight	(π^w, π^w)	$(\pi^m, 0)$

Figure 13.7 Stylized Entry Game in Normal Form

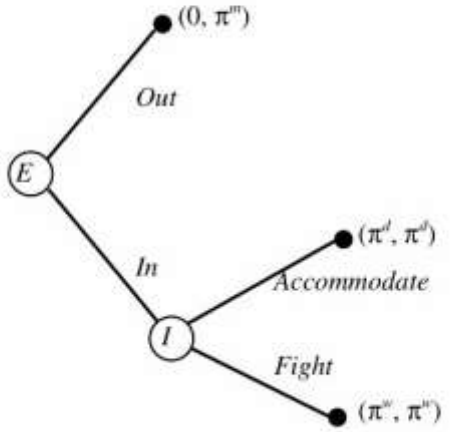


Figure 13.8 Stylized Entry Game: Extensive Form

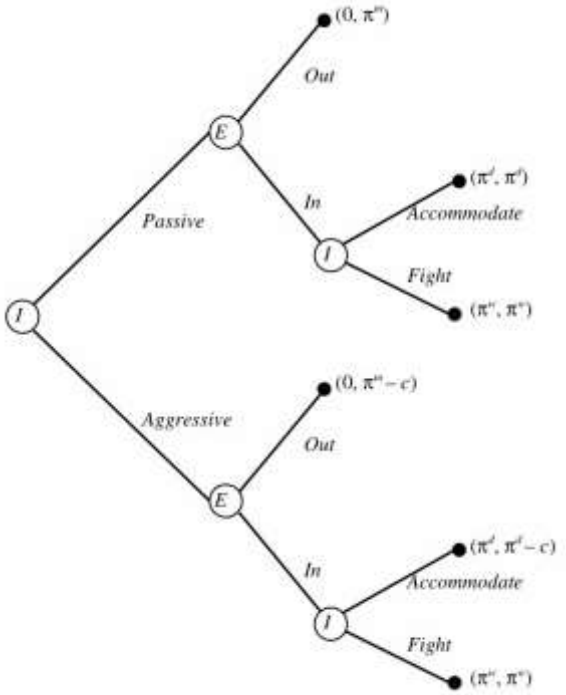


Figure 13.9 Entry Game with a Strategic Move

Player 1: incumbent (I) whose choices are: *accommodate entry or fight* (try to deter) it.
Player 2: entrant (E) whose choices are: *enter (in) or stay out (out)*.
π^m: monopoly profit
π^d: duopoly profit (for each of the two duopolists)
π^w: profit in a "war" (when incumbent fights).
There are four possible outcomes (see matrix).
Extensive form (Figure 13.8.): player 1 (incumbent) moves first but because game is solved with backward induction, we put entrant ahead of incumbent in the extensive form.
Figure 13.9.: Upper branch of game tree (incumbent is passive about entry) is the same as the game above. Lower branch of game tree (incumbent is aggressive about entry) includes a sunk cost (c) that occurs for the incumbent in any case.
The rational choice of players and thus the outcome of the entry game will depend on the relations between the various payoffs (profits) in the various outcomes.

Questions for self-study

1. What is a threat? A promise? A commitment? A strategic move? How are these related?
2. Which are the four elements of a move (or action) that make it strategic?
3. Which are the direct effects of strategic moves? And the indirect effects?

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
www.u-szeged.hu
www.szechenyi2020.hu

4. What is the distinction between tactical and strategic choices?
5. Please present the decision horizons (Figure 13.1.). What types of decisions are made in the respective horizons? How are short and long run related in respect of strategic decisions?
6. Please present the Stackelberg game. In what is it distinguished from the Cournot game?
7. What is entry accommodation? And entry deterrence?
8. What is an entry game? Please explain the stylised entry game in Figures 13.7. (normal form) and 13.8. (extensive form). Please explain Figure 13.9. (stylised entry game with a strategic move).

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
www.u-szeged.hu
www.szechenyi2020.hu

Chapter 14: Entry deterrence

In relation to (potential) entry, it is important to distinguish between entry barriers and entry deterrence.

An **entry barrier** is a *structural characteristic* of a market that protects the market power of incumbents by making entry unprofitable.

Profitable **entry deterrence**, i.e. preservation of the market power and monopoly profits, *by incumbents* typically depends on these structural characteristics and the behaviour of incumbents post-entry.

14.1. The role of investment in entry deterrence

Incumbent may *invest in capacity*. Excess capacity is a *signal* of *post-entry aggression*.

> **Dixit's model of entry deterrence** is a two-stage game. In the first stage, the incumbent (player 1) is able to invest in capacity (k_1) which is a *sunk expenditure*. In the second stage, entrant (player 2) observes incumbent's move and makes a decision (entry or stay out). Upon entry, there is an entry cost (f). The strategic decision is that of firm 1's (incumbent's) on the investment (i.e. choice of capacity). **Only an undertaken investment (k_1 actually occurring) makes the threat of entry deterrence credible for player 2**.

In such a situation, the task for firm 1 (the incumbent) is to *set the optimal scale of capacity investment*. There are three cases depending on the extent of fixed costs and firm 2's profits:

1. **Blockaded monopoly**: monopolist does not have to worry about entry as it will not happen (due to structural characteristics of the market).
2. **Stackelberg**: profits for firm 2 are positive and entry occurs. The best firm 1 can do is to optimally accommodate firm 2.
3. **Strategic entry deterrence** or **strategic accommodation**: the profits for firm 2 are either positive or negative. In this case, firm 1 *influences the outcome by a strategic move (investment).*

Entry deterrence is possible because the capacity investment in the first stage by the incumbent is a sunk expenditure. This provides it with a mechanism to commit to the limit output in the post-entry quantity game.

The **game-theoretic model of entry deterrence** implies two necessary requirements for *profitable strategic entry deterrence* when output is homogenous and both firms have the same cost function:

1. the ability of incumbents to reduce their marginal cost post-entry by *making sunk expenditure*;
2. the existence of *economies of scale* in the industry.

In the Dixit model, the incumbent invests before the entrant, changing the profitability of entry.

14.2. Contestable markets

Perfectly contestable market is a market where entry is free and exit is costless (thus market power cannot be sustained).
The following *conditions* are *sufficient* for a market to be **perfectly contestable**:

- all producers, actual and potential, have access to the same technology;
- the technology may be characterised by economies of scale;
- there is no entry lag (i.e. an entrant can enter and instantaneously produce at any scale);
- the incumbents response time is greater than the exit time of the entrant.

Feasible industry configuration: a situation where output for each firm and market price is such that firms at least break even and the market clears (i.e. supply equals demand).
Sustainable industry configuration: feasible, and an entrant with access to the same technology as the incumbent(s) cannot enter by charging lower price and serve either all or a fraction of demand at its lower price.
In a perfectly contestable market, there are no barriers to entry. This suggests that *sunk expenditures can create entry barriers*. The incumbent's sunk costs are already committed to the industry while all of the entrant's investments are still variable.
Barriers to entry limit contestability therefore incumbents are interested in raising and/or maintaining them, thus keeping competition out of the market.

14.3. Entry barriers

The *condition of entry* is defined by *entry barriers* to which three factors can contribute:

1. economies of scale;
2. product differentiation;
3. absolute cost advantages.

In the absence of entry barriers, incumbents are not expected to be able to exercise market power in the long run. Strategic behaviour on behalf on incumbents can nevertheless raise the height of entry barriers.

Questions for self-study

1. What does profitable entry deterrence depend on?
2. Please present Dixit's model of entry deterrence.
3. What is blockaded monopoly? What is optimal accommodation?
4. How are capacity investments linked to entry deterrence? And economies of scale?
5. When is a market considered contestable?

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
www.u-szeged.hu
www.szechenyi2020.hu

6. Please explain the concepts of feasible industry configuration and sustainable industry configuration.
7. How are contestability and barriers to entry related?
8. Please briefly present the main structural barriers to entry.

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
www.u-szeged.hu
www.szechenyi2020.hu

Chapter 15: Strategic behaviour: Principles

Strategic behaviour is analysed in the framework of **two-stage games**. The essential feature of the strategic move (stage 1 of the two-stage game) is the degree of **commitment**.

This chapter considers only **asymmetric competition**, i.e. competition where *only one firm (firm 1) can make a strategic investment to obtain an advantage*.

15.1 Two-stage games

In the **first stage** of a two-stage game, the incumbent firm (firm 1) typically *makes an investment* in an asset that is sunk and that affects future payoffs. The investment can be in capacity but also in research and development or advertising.

The investment is **strategic** as it affects *both players' payoff in the second stage*.

> Implication: the firm undertaking the investment in the first stage has a *first-mover advantage* and can thus *influence* the outcome *in his own favour*.

Subgame perfection requires that the outcome be a Nash equilibrium in the appropriate variable. The potential for strategic behaviour arises because the Nash equilibrium in the second stage will depend on the investment by firm 1 in the first stage.

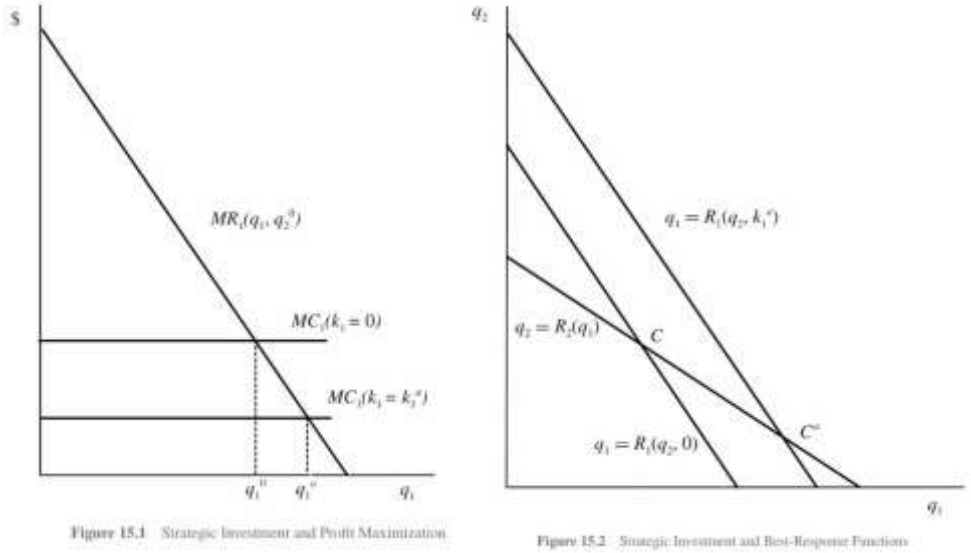


Figure 15.1 Strategic Investment and Profit Maximization

Figure 15.2 Strategic Investment and Best-Response Functions

Figure 15.2: the investment shifts the equilibrium *to the right of the Cournot equilibrium point* along firm 2's best response function. This will *increase firm 1's profits*. By investing in cost-reducing development, firm 1 is able to secure such a change, realising a *larger market share* and a *larger share of industry profits in equilibrium*. So there are two reasons for firm 1 to invest in k_1:

1. he can thus reduce production costs (*direct effect*);
2. he can thus enjoy a larger market share and larger profits (*strategic effect*).

The fact that investment in k_1 *decreases* the profits and output of firm 2 means that **investment makes firm 1 "tough"**.

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
www.u-szeged.hu
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When **best-response functions** of quantities are **downward-sloping**, we talk about **strategic substitutes**.

For strategic substitutes, in order to *induce the rival to reduce its output*, the incumbent firm has to find some way of committing to *increase its own output*.

Next case:

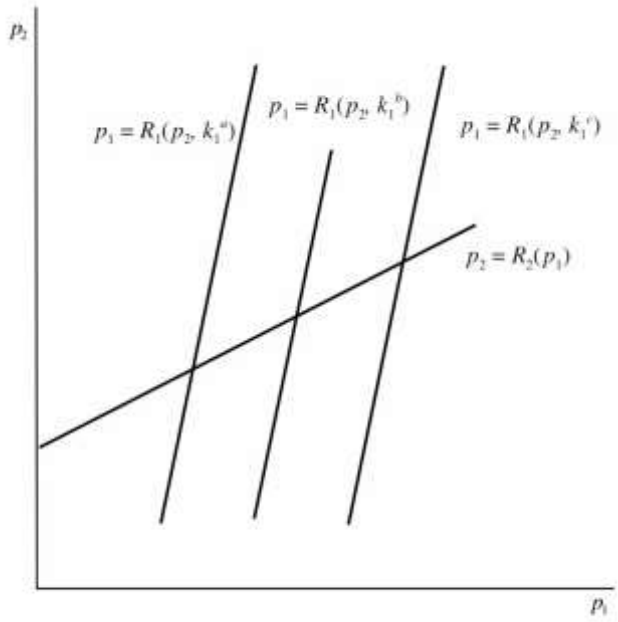

Figure 15.3 Strategic Investment and Bertrand Competition

Firms produce **differentiated products**, and they compete by choosing **prices** (*Bertrand*).

The **best-response functions** slope **upward**.

Investment is undertaken in cost reduction by firm 1. (ATTENTI/ON: $k_1^a > k_1^b > k_1^c$!)

The effect of investment, k_1, is to **shift** firm 1's best response **to the left**.

When **best-response functions** (of prices) are **upward-sloping**, we talk about **strategic complements**.

In this case, *investment results in lower prices* so firm 1 has an *incentive to underinvest* in cost reduction. However, investment makes firm 1 *"tough"* again because it *makes its rival worse off* (too).

The *strategic effect* is *underinvestment* that shifts the equilibrium *to the right* along firm 2's best response function, which then *increases profits for both firms*. In this sense, the interests of the two firms are complementary.

15.2 Strategic accommodation

Firm 1 (the strategic / incumbent firm) may be either *unable* or *uninterested* in driving rivals out of the market or deterring future entry. In this case, the **incumbent accepts entry**. Accommodation *occurs* when *entry deterrence is more costly for incumbent than accepting entry*.

Nevertheless, *through strategic investment, firm 1 can influence post-entry market setup*. This makes accommodation **strategic**.

Strategic entry accommodation: incumbent accepts entry but, in response, makes *decisions on quantity or price* so that his post-entry profit is maximised.

$$\frac{d\pi_1}{dk_1} + \frac{d\pi_1}{dx_1}\frac{dx_1}{dk_1} + \frac{d\pi_1}{dx_2}\frac{dx_2}{dk_1}$$

Equation (15.16) on p.565.

k_1: capacity investment (on behalf of firm 1)

π_1: profit (of firm 1)

x_i: an attribute (typically q or p)

The effect of k_1 on π_1:

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
www.u-szeged.hu
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$\frac{d\pi_1}{dk_1}$ direct effect

$\frac{d\pi_1}{dx_1}\frac{dx_1}{dk_1}$ indirect effect

$\frac{d\pi_1}{dx_2}\frac{dx_2}{dk_1}$ strategic effect

In the case of **strategic substitutes**, increasing firm 1's x_1 (typically quantity), the same attribute of firm 2 (x_2) will *decrease*.
In the case of **strategic complements**, the *reaction functions slope upward* so when firm 1 *increases* its choice of x_1 (typically price), firm 2's best response will be to *increase* his choice *also*.

Table 15.1 Classification Scheme for Two-Stage Strategic Competition in the Accommodation Case

	Tough	Soft
Strategic Substitutes	Top Dog	Lean-and-Hungry Look
Strategic Complements	Puppy Dog	Fat Cat

15.3 Strategic entry deterrence

Strategic investment is often used to make the entry of rivals unprofitable.
Strategic entry deterrence: incumbent invests in (typically) capacity with the aim to deter entry even if thus quantity is increased and price is decreased – that is the "price" of entry deterrence. So, there is a trade-off between the advantages of monopoly rents and the costs of securing them.
The *purpose* of entry deterrence (on behalf of incumbent) is to *enjoy a stream of monopoly profits in the future*.
In the case of **strategic substitutes**, deterrence requires a **top dog strategy** (i.e. overinvestment in capacity).
In the case of **strategic complements**, deterrence also requires a **top dog strategy** (i.e. invest enough in cost reduction to shift its best response function inwards/left).

15.4 The welfare effects of strategic competition

From a public policy point perspective, it is important to consider the **effects of strategic competition on overall economic efficiency**.
The overall efficiency is the overall result of the various elements of effects. In other words, the **net welfare effect** is the simple sum of the effects on the respective parties.
Three relevant parties can be affected by strategic competition: 1) the strategic

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
www.u-szeged.hu
www.szechenyi2020.hu

firm; 2) the rival firm; and 3) the consumer.
The strategic firm invests because it is in its best interest (otherwise it would not do so) so the effect on him is positive (he will definitely be better off as a result of his investment).
For **the rival firm**:

- In the case of *strategic substitutes*, he will be worse off (as firm 1 grabs market share at the expense of his rival).
- In the case of *strategic complements*, he will also be better off (through the higher prices achieved by underinvestment).
- In the case of *strategic entry deterrence*, he does not appear in the market.
- In the case of *strategic accommodation*, he may be made better or worse off.

For **consumers**:

- strategic competition in strategic *substitutes* results in *decrease in price* (through investment in cost-reduction) which results in *higher consumer surplus*
- strategic competition in strategic *complements* results in *increase in price* (through underinvestment) which results in *lower consumer surplus*

Questions for self-study

1. In a two-stage game, how is investment in the first stage related to the Nash equilibrium in the second stage? What is the implication of this relation?
2. Please present the case of competition between strategic substitutes.
3. Please present the case of competition between strategic complements.
4. When does strategic accommodation occur? How does is take place in the case of strategic substitutes? And in the case of strategic complements?
5. Please present the four types of strategic competition based on Table 15.1.
6. What is the purpose of entry deterrence? How does is take place in the case of strategic substitutes? And in the case of strategic complements?
7. What actors are affected by strategic competition? How is the welfare effect of strategic competition calculated?

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
www.u-szeged.hu
www.szechenyi2020.hu

Chapter 16: Strategic behaviour: Applications

This chapter studies several examples of strategic interaction.

16.1 Learning by doing

Learning by doing: with cumulative production growing, average total cost is decreasing (so *learning economies* are realised).

> Learning economies are observable even when there are no economies of scale in an industry.

The **learning curve** presents the (inverse hyperbolic) relation between cumulative output and average total cost of production (ATC).

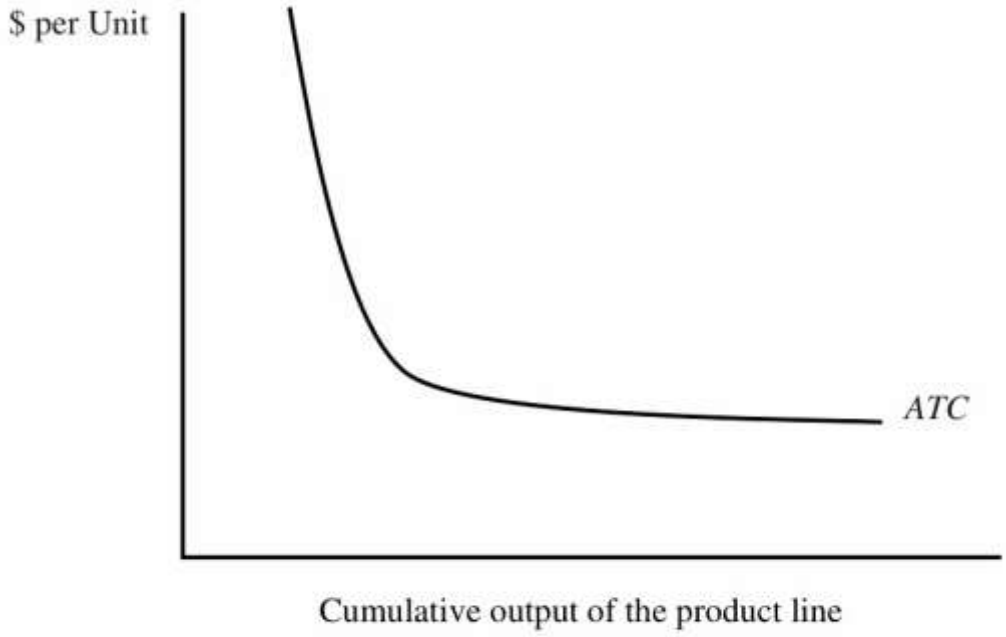

Figure 16.1 Learning By Doing and Average Costs

'Race down the learning curve': a firm (an incumbent) may want to produce more (than demand would imply) in the initial phase in order to reach lower average total cost (ATC) levels earlier in order to realise learning economies. It does so with a strategic objective, i.e. to keep others out of the market.

Strategic learning game: incumbent(s) producing more in the initial period(s) in order to realise learning economies with the aim to improve own position and make rivals worse off.

By accelerating the scale of early production, the strategic firm races down its learning curve, squeezing the market share and profits of any potential entrant. *If this is carried out to the extent where post-entry profit of entrant becomes non-positive, entry is deterred.*

16.2 Switching costs

Switching cost refers to the cost incurring at the existing customer when (s)he wants to switch to another producer. Switching costs thus divide consumers into two groups:

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
www.u-szeged.hu
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- new consumers that have never used the product and thus would have to incur the learning cost;
- old or experienced consumers who have already incurred these costs but still might stay with the producer (e.g. through a software package update).

Installed base of customers: existing customers of a firm who are locked in by the switching cost if they switched to the product of rival firm.

In the game played against the installed base of customers, the firm finds itself in a game of strategic substitutes and thus a top-dog equilibrium.

16.3 Vertical separation

Vertical separation happens when a firm decides to vertically disintegrate (along the value chain / from a supplier/distributor). It is **strategic** if its aim is to achieve higher prices in the future (so it is a fat cat game as both are better off afterwards).

16.4-5 Tying and bundling

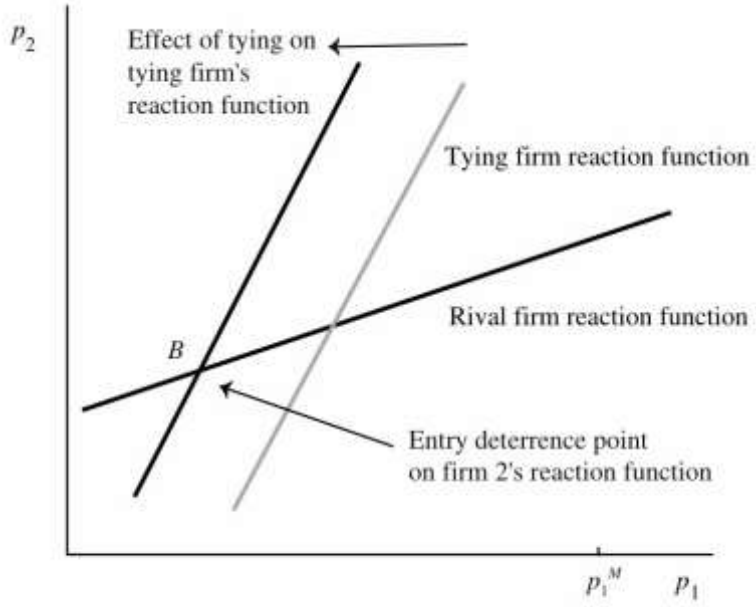

Figure 16.4 Strategic Analysis of Tying

Strategic tying and bundling are *games in prices* so tying shifts the best response function of the tying firm *to the left*.

16.7 Managerial incentives

As managers may pursue different objectives (i.e. to maximise managerial utility) than those of owners (i.e. profit maximisation), a strategic opportunity opens up: through structuring of incentives, managers may be motivated to pursue objectives that improve the owners' payoffs in the oligopoly game. This is another approach to the issue of delegation.

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
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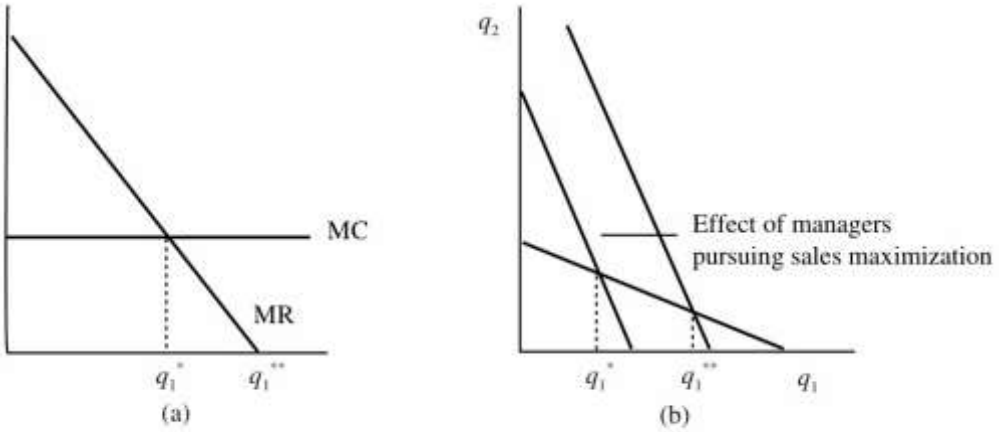

Figure 16.6 Strategic Managerial Compensation

16.8 Research and development

Competition in R&D is one of the most vigorous and important forms of strategic competition. It is a quantity game (i.e. increasing market share through cost-reducing R&D).

Investment in cost-reducing R&D makes the investing firm tough, so we have a top dog equilibrium, in which the strategic firm will overinvest in R&D so as to capture a larger share of industry profits in equilibrium.

Questions for self-study

1. What does the concept of 'learning by doing' refer to in Industrial Organization?
2. What does the learning curve present? What does the expression 'race down the learning curve' refer to?
3. Please present the strategic learning game. Which type of strategic competition does it correspond to in the case of competition in quantities? And in the case of competition in prices?
4. How can learning result in entry deterrence?
5. What do we call switching costs? When do they occur? What strategic relevance do they have?
6. Please explain the expression 'installed base of customers'. How can they be strategically manipulated? Which type of strategic competition does it correspond to?
7. What is vertical separation?
8. Please explain tying and bundling (including the explanation of Figure 16.4.).
9. How are managerial incentives linked to firms' strategic competition? What is delegation in this context?
10. Please briefly present how research and development can be a form of strategic competition.

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
www.u-szeged.hu
www.szechenyi2020.hu

Chapter 17: Advertising and Oligopoly

Besides providing information, **advertising** often aims to alter tastes (informational and persuasive advertising). This is problematic for economics because it is usually assumed that tastes are static, fix – without this assumption the demand curve might not be stable but changing and shifting. Consequently, measuring surplus is not straightforward and so the welfare effects of price changes might not be possible to determine. Another issue is that advertising often affects tastes through social group membership.

Economist distinguish between **normative** and **positive models of advertising**. The former tries to capture the welfare effects of advertising, the latter aims to investigate its structural effects in oligopoly equilibrium.

17.1 Normative vs. Positive Issues: The Welfare Economics of Advertising

Consider a monopoly where the demand is given by *DD* curve (see Fig 17.1), and *MC=AC*. Let's assume that the demand curve shifts outward due to advertising (*D'D'* curve). The total profit of the monopolist increased by the shaded area ($\Delta\Pi$): it sells additional *q'- q* product at *p'* price, *(q-q')*p'* and is able to charge higher price on the existing quantity *(p'-p)*q*. Dixit and Norman (1978) suggest that the welfare effects of advertising can be evaluated either on the basis of pre- or post-advertising preferences. Using pre-advertising preferences, the welfare effect of any increase in output is just the dark shaded area in the figure.

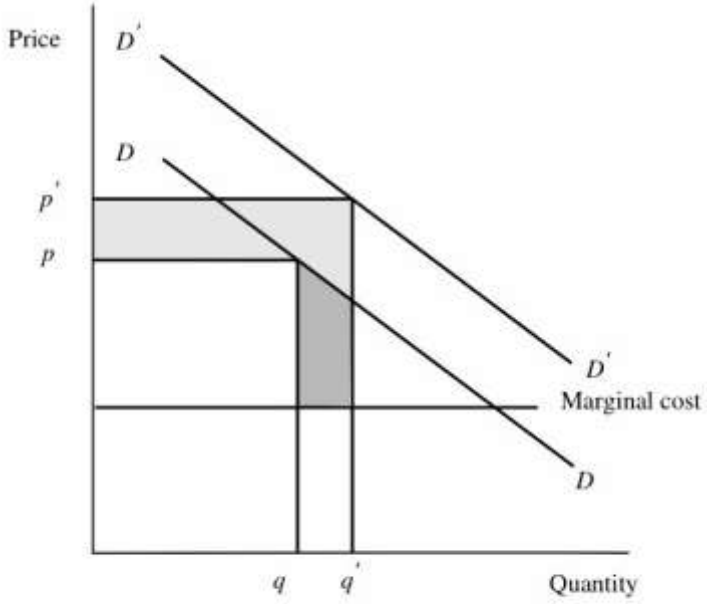

Figure 17.1 Advertising and Welfare: The Monopoly Case

If the shift of demand curve is small, the total change in welfare is the total shaded area minus the dark shaded area:

$$\Delta W_0 = \Delta\Pi - q^*\Delta p$$

From this, it can be observed that in order the advertising to be socially efficient it must be profitable. Moreover, the monopolist will increase advertising to the point where the profit increment is equal to the additional cost of advertising.

Szegedi Tudományegyetem
Cím: 6720 Szeged, Dugonics tér 13.
www.u-szeged.hu
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That is, decreasing advertising from this point by a small amount would result in higher welfare.

17.2 Positive Issues: Theoretical Analysis of Advertising and Oligopoly

Advertising can act as a barrier to entry, that is, it is a sunk cost needed to enter the market (it can be thought of as a required investment to reach minimal recognition). Therefore, an increase in the exogenous sunk cost leads to increased concentration (smaller number of firms in equilibrium)

Advertising as an Endogenous Sunk Cost

It is also possible to model advertising costs as endogenously determined by the competition between firms. To do so, John Sutton suggested that firms play a 3-stage game. In stage 1, firms decide whether to enter the market (with fix entry costs) or stay out. In stage 2, firms set their sunk advertising expenditure. This in turn determines the quality of the product perceived by consumers. The advertising costs now are not constant but an increasing function of (perceived) quality. In stage 3, firms set their quantity given their advertising expenditure. The outcome of the model is that all firms make the same choices in terms of advertising level, quality, and quantity (symmetric equilibria).

Cooperative and Predatory Advertising

Another important distinction between advertising costs is the following:

Cooperative advertising: increases demand for all firms in the industry.

In this case each firm's advertising yields a positive externality on the other firms, which the advertising firm will not take into account when choosing the profit-maximising level of advertising. Therefore, the total advertising is undersupplied in equilibrium from the perspective of the whole industry.

Predatory advertising: attracts away customers from other firms.

In this case the externality is negative and total advertising is excessive from the perspective of the industry.

17.3 Advertising and Strategic Entry Deterrence

By reducing post-entry profits, the incumbent can deter entry by making a binding commitment to heavy post-entry advertising or to very aggressive competition after entry.

17.4 A More General Treatment of Strategic Advertising: Direct vs. Indirect Effects

Consider a market with two firms, where the demands are given as follows:

$$P^1(q_1, q_2, A) = Z_1(A) - bq_1 + dq_2$$
$$P^2(q_1, q_2, A) = Z_2(A) + dq_1 - eq_2$$

Where A is the advertising made by Firm 1. It is assumed that A shifts the demand curve for Firm 1 outward and inward for Firm 2 (predatory advertising). In equilibrium, Firm 1's profit is the following:

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$$\pi_1 = \pi_1\{p_1[Z_1(A), Z_2(A)], p_2[Z_1(A), Z_2(A)]\}.$$

The effect of A on the profit is the following:

$$\frac{d\pi_1}{dA} = \frac{d\pi_1}{dp_2}\frac{dp_2}{dZ_1}\frac{dZ_1}{dA} + \frac{d\pi_1}{dp_2}\frac{dp_2}{dZ_2}\frac{dZ_2}{dA}$$

The first term is called **indirect effects**, because it changes the demand curve through the strategic response to the rival. The second term of the right-hand side is known as **direct effects**, since it works through shifting the rivals demand curve. These effects in a price space are illustrated in Fig 17.4. Firm 1 is able to increase its demand (shifting the reaction function to the right) and simultaneously reducing its rival's demand (shifting its reaction function downwards). In the post-advertising equilibrium, p_1 is increased and p_2 is decreased.

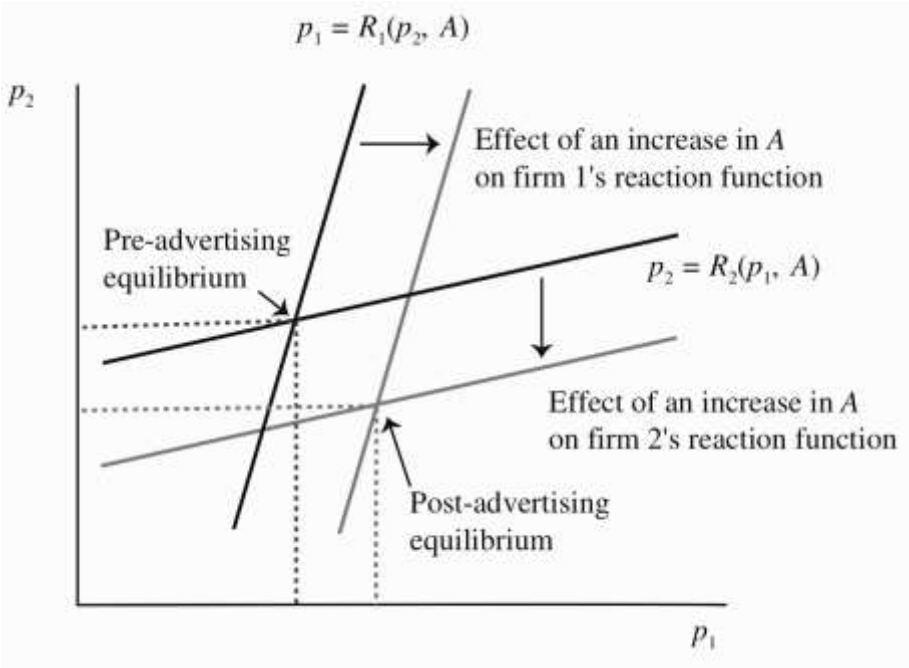

Figure 17.4 Direct and Indirect Strategic Effects of Advertising

17.5 Positive Issues: Advertising and Oligopoly Empirics

With certain products advertising might involve economies of scale, therefore economies of scale for production plus advertising costs can be more extensive than they would be if there were no advertising. The level of output required for production at an efficient scale increases when average advertising costs are added to the average production costs. As a result, the opportunities for national and global advertising might contribute to the increase in concentration in certain industries.

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Questions for self-study

1. What is the objective of advertising? Why is it difficult to address advertising through economics?
2. Please interpret Figure 17.1.
3. Please present the three stages of the game of advertising as an endogenous sunk cost.
4. What is the distinction between cooperative advertising and predatory advertising? (How do these correspond to the two basic types of strategic competition?)
5. How can advertisement be used to deter entry?
6. Which are the direct and indirect effects of strategic advertising? Please interpret Figure 17.4.
7. What effects can advertising have on market structure?

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Chapter 18: Research and Development

In the 1950s, **Robert Solow**'s work on economic growth implied that innovation, technological progress is the main reason factor behind growth, not the accumulation of capital and/or labour.

Joseph Schumpeter introduced the idea of "creative destruction" to economics. According to this, the process of change and innovation destroys old markets and creates new ones, therefore the equilibrium properties of markets are less important than disequilibrium ones (market clearing properties of price convergence).

Schumpeter postulated that innovation was not incentivized efficiently in perfect competition and monopoly (or the lure of becoming a monopoly) was a favourable market structure for technological progress.

18.1 A Positive Analysis: Strategic R&D

One way to model the research and development activity as it lowers production costs: to put it simply, *spending more money leads to lower marginal costs*. In a duopoly setting, the innovator reaction function is shifted to the right after innovation, resulting in a more profitable equilibrium for it. Since investment in innovation makes the firm "tough", and the Cournot model is of strategic substitutes, this competition is a "top dog". If both firms can innovate then the situation can be described as Prisoner's Dilemma: both firm overinvest in innovation such that their profits are lower compared to the pre-innovation situation.

18.2 Market Structure and Incentives for R&D

Starting question: what is the relationship between different market structures and the incentive to innovate? It is assumed here again that innovation lowers marginal costs.

An innovation is **drastic** if the new, post-innovation monopoly price is lower than the pre-innovation marginal cost. For small, non-drastic innovations, the new price is higher than the initial marginal cost.

The social value of innovation is the total surplus if price would equal marginal cost both pre and post-innovation (V_s). This is illustrated by the shaded area in Fig 18.2. This can be compared to the amount surplus appropriated in perfect competition and monopoly.

If the market before innovation is perfect competition, then the innovator, through the lower marginal cost, can capture the whole market (this surplus is denoted by V_c, and is the darker shaded area in Fig 18. 2).

If the market is a monopoly prior the innovation and the innovator is the monopolist, then it will retain its monopoly position and is able to increase the rent (V_m).

It can be shown that $V_m < V_c < V_s$. This means that a monopolist gains less from innovation than a firm from a competitive industry.

The reason is that the monopolist is already earning a rent, with the new technology, it is able to maintain it and lower the marginal costs, while the firm from competitive market can become a new monopolist. This result is known as the **replacement effect**.

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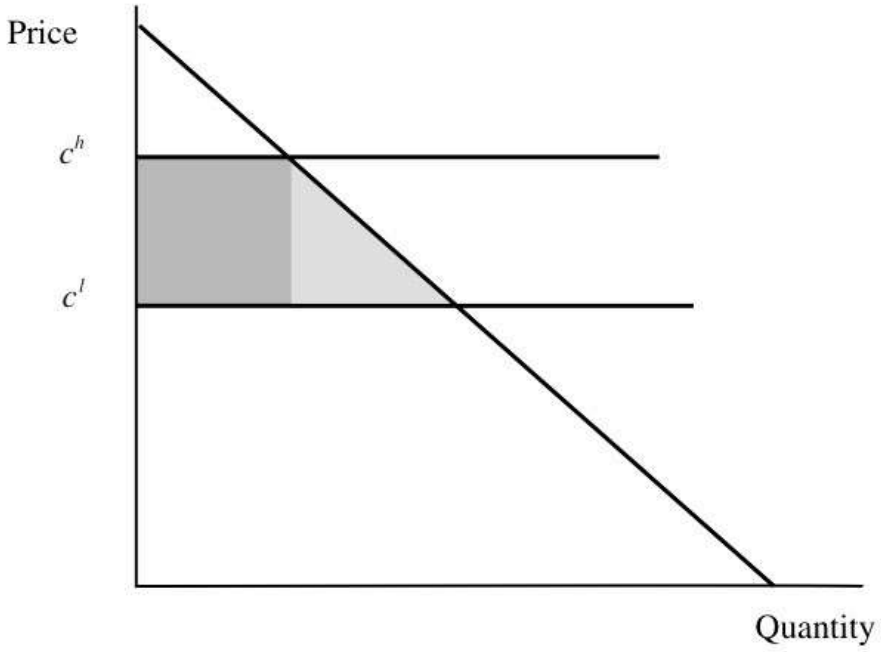

Figure 18.2 Incentives for a Process Innovation with Constant Costs

So far it was assumed that the innovator either makes the investment in innovation or no one else does it. In real world markets though, there is a competition for innovation and patents, that is, if a firm does not achieve it, some other probably will. Therefore, failing to innovate or acquiring a patent, a monopolist can lose its position and can become a high-cost incumbent. So, we can say that there is a **market for innovation**.

In contrast to the earlier analysis, in this situation a monopolist's incentive can be higher to innovate: the incumbent can maintain its position and rents, and that is greater than the total duopoly rents which would be shared among the entrant and incumbent if the former innovates. This is the **efficiency effect**.

Patent races

The above framework can be further extended by adding a time dimension. If several firms are able to develop the same technology or innovation, there is a race between them to acquire the patent. The patent in turn would grant a monopoly to the winner.

We can conceive that the time required by R&D process depends on the amount of investment, that is, the more resources (capital, labour) is allocated to the development, the less time it takes to succeed. This is illustrated in Fig 18.5 (where *d* and *T(d)* denote investment cost and time to successful development, respectively).

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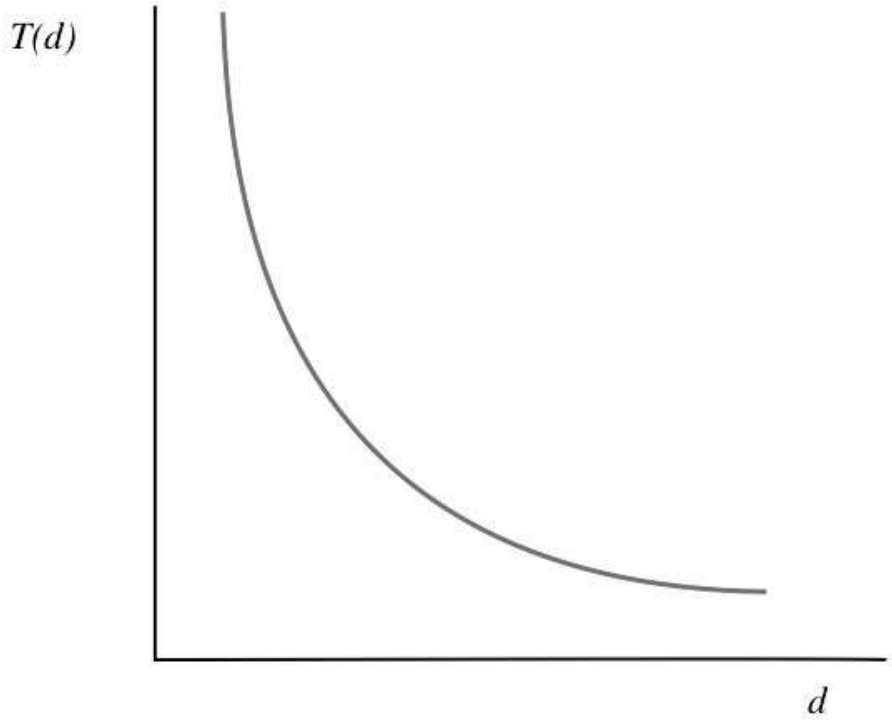

Figure 18.5 The Time-Cost Trade Off for Innovation

Thus, the optimal choice of *d* is where the *present value of V* (the additional surplus generated by the innovation) minus *d* is maximal. If there is competition for the patent, each firm is willing to spend a little more than the others to win the race, up to the point where the cost of innovation is equal to the gain (present value of *V*).

The models we studied so far have considered R&D as a deterministic process: a given investment yields innovation at a given date. However, the innovation expenditure does not guarantee research success, it can only make its *probability* higher.

In models of R&D process that are **stochastic** (not deterministic) there can be both an efficiency and a replacement effect.

18.3 Normative Analysis: The Economics of Patents

The purpose of innovation is to acquire new knowledge. But knowledge is a **public good**, that is, other agents (firms, consumers) cannot be excluded from consumption or use (non-excludability) and their use or consumption do not reduce the amount available for others (non-rival consumption).

In the context of innovations, this means that if firms without investment in R&D might be able to just copy other firms' technology, thereby reducing the marginal cost and/or introducing new products without incurring investment expenditures. This would in turn dramatically decrease firms' incentive to innovate.

Patents were introduced to solve this incentive problem by granting a monopoly for the innovator for a certain, limited period of time. During this period,

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the innovator can charge a higher price for the product and can recover the R&D costs and gain some surplus.

Questions for self-study

1. What did Solow say about technical change?
2. What did Schumpeter say about creative destruction? Nevertheless, what was Schumpeter's most famous postulate?
3. When is R&D considered strategic? In what is strategic R&D similar to the Prisoner's Dilemma?
4. When is innovation considered drastic?
5. Please explain Arrow's replacement effect in relation to innovation.
6. What is the 'market for innovation'?
7. Please explain the efficiency effect of innovation. How does it contrast the replacement effect?
8. Please explain how R&D can become "the race to be first".
9. Why is it wiser to approach R&D in stochastic models than in deterministic ones?
10. Knowledge is a public good – what does this imply?
11. What is the objective of the patent system?

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Appendix

Practical Exercises

1. Bring 2-2 real-world examples of the basic market structures: 1) competitive market, 2) oligopoly, 3) monopoly.
2. Please bring 2-2 examples for first-degree, second-degree and third-degree price discrimination others than those mentioned by the book and/or in class and describe them shortly in your own words. (They can be real-life or imagined examples but cannot be copied from online teaching materials on price discrimination.)
3. Bring 5-5 real-world examples for 1) search goods and 2) quality goods other than those mentioned by the book and/or in class and describe them shortly in your own words.
4. Show 2-2 real-world cases of firms signalling quality by 1) reputation, 2) commitment.
5. Bring 5-5 real-world examples for 1) tying and 2) bundling.
6. Please present an imaginary case of adverse selection.
7. Present an imagined market research supporting the introduction of a new product applying a two-dimensional address model. (Mathematical solution is welcome but not expected.)
8. Imagine that you are a seller of a product, of which consumers distinguish two different attributes. You are about to enter the market and you conduct market research to best position your product along the two attributes. Please graphically simulate an address model where the outcome of your market research exhibits localised competition.
9. Please present the four types of strategic competition and bring real-life or imagined-but-realistic examples for each of them (2 examples per type).
10. Please bring 2 real-life or imagined-but-realistic examples for firms strategically generating switching costs.

Game Theory and Strategic Behaviour Practice Problems

Exercise 1. Two firms (Smith and Brown) decide whether to design the computers they sell to use large or small floppy disks. Both players will sell more computers if their disk drives are compatible. If they both choose for large disks the payoffs will be 2 for each. If they both choose for small disks the payoffs will be 1 for each. If they choose different sizes the payoffs will be −1 for each.

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Step 1: Constructing the Payoff Matrix

		Brown	
		Small	Large
Smith	Small	1, 1	-1, -1
	Large	-1, -1	2, 2

Step 2: Finding best responses

Starting with **Smith**:

If Brown plays 'Small', Smith's best response is 'Small' (the payoff is 1, if Large would be played, the payoff is -1), It is indicated by red colour

If Brown plays Large, Smith's best response is Large, it is indicated by red colour.

Now, we find **Brown's best responses**

If Smith plays Small, Browns best response is Small and it is indicated by blue colour.

If Smith plays Large, Brown's best response is Large and it is indicated by blue colour.

		Brown	
		Small	Large
Smith	Small	**1**, **1**	-1, -1
	Large	-1, -1	**2**, **2**

Step 3. Finding Nash Equilibrium. (Small, Small) and (Large, Large) strategies are both Nash Equilibria because in these cases both players' strategy is a best response to the other player's strategy.

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Exercise 2. The welfare game. This game models a government that wishes to aid a pauper if he searches for work but not otherwise, and a pauper who searches for work only if he cannot depend on government aid, and who may not succeed in finding a job even if he tries. The payoffs are 3,2 (for government, pauper) if the government aids and the pauper tries to work; −1,1 if the government does not aid and the pauper tries to work; −1,3 if the government aids and the pauper does not try to work; and 0,0 in the remaining case.

Step 1. Payoff Matrix

		Pauper	
		Work	Not
Government	Aid	3, 2	-1, 3
	No Aid	-1, 1	0, 0

Step 2. Best Responses.

Government:

If the pauper plays Work, Government plays Aid (red)

If pauper plays Not (means he does not try to work), Government plays No aid (red).

Pauper:

If Government plays Aid, Pauper plays Not (blue).

If Government plays No Aid, pauper plays Work (blue).

		Pauper	
		Work	Not
Government	Aid	**3**, 2	-1, **3**
	No Aid	-1, **1**	**0**, 0

Step 3. Finding Nash Equilibria. No Nash Equilibria in pure strategies. There are no pair of strategies where both are best replies.

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Exercise 3. Wage game. Each of two firms has one job opening. Suppose that firm i (i = 1, 2) offers wage w_i, where $0 < ½*w_1 < w_2 < 2*w_1$ and $w_1 = w_2$. Imagine that there are two workers, each of whom can apply to only one firm. The workers simultaneously decide whether to apply to firm 1 or firm 2. If only one worker applies to a given firm, that worker gets the job; if both workers apply to one firm, the firm hires one worker at random (with probability 1/2) and the other worker is unemployed (and has a payoff of zero).

Step 1. Payoff Matrix.

		Worker 2	
		Firm 1	Firm 2
Worker 1	Firm 1	1/2*w1, 1/2*w1	w1, w2
	Firm 2	w2, w1	1/2*w2, 1/2*w2

Step 2. Best responses. Red and blue colours indicate Worker 1 and Worker 2's best responses, respectively.

		Worker 2	
		Firm 1	Firm 2
Worker 1	Firm 1	1/2*w1, 1/2*w1	**w1**, **w2**
	Firm 2	**w2**, **w1**	1/2*w2, 1/2*w2

Step 3. Nash Equilibria. There are 2 Nash Equilibria in pure strategies (when the workers apply for different firms).

Exercise 4. Marketing game. Two firms sell a similar product. Each percent of market share yields a net payoff of 1. Without advertising both firms have 50% of the market. The cost of advertising is equal to 10 but leads to an increase in market share of 20% at the expense of the other firm. The firms make their advertising decisions simultaneously and independently. The total market for the product is of fixed size.

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Step 1. Payoff matrix

		Firm 2	
		Advertise	Not
Firm 1	Advertise	-10, -10	10, -20
	Not	-20, 10	0, 0

Step 2. Best responses. Again, red and blue colours indicate Firm 1 and Firm 2's best responses, respectively.

		Firm 2	
		Advertise	Not
Firm 1	Advertise	**-10**, **-10**	**10**, -20
	Not	-20, **10**	0, 0

Step. Nash Equilibria. (Advertise, Advertise) is the only pure Nash Equilibrium. That means that both firms will advertise, although their market share will remain unchanged.

Exercise 5. Strict Domination

Consider the following game

	W	**X**	**Y**	**Z**
T	6, 6	4, 4	1, 2	8, 5
B	4, 5	6, 6	2, 8	4, 4

(a) Which pure strategy of player 1 or player 2 is strictly dominated by a pure strategy?

Player 1. We compare the possible payoffs from playing T or B.

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If player 2 plays W, player 1 payoff is 6 if she is playing T, and 4 if B is played (6>4).

If Player 2 plays X, player 1 payoff is 4 if she is playing T, and 6 if B is played (4<6).

And so on => Player 1 (Row player) strategies are not dominated.

Player 2 (Column Player). Z strategy is strictly dominated by W strategy. Since 6>5 AND 5>4.

Therefore, if player 1 assumes that player 2 is rational, he knows that Player 2 will never play Z. The Z strategy can be eliminated and the resulting payoff matrix is the following:

	W	**X**	**Y**
T	6, 6	4, 4	1, 2
B	4, 5	6, 6	2, 8

(b) Find all pure Nash equilibria of this game.

Step 1. Best responses (red and blue colours indicate best responses for Player 1 and 2, respectively)

	W	**X**	**Y**
T	**6**, **6**	4, 4	1, 2
B	4, 5	**6**, 6	**2**, **8**

Step 2. 2 Pure Nash equilibria: (T, W) and (B, Y)

Exercise 6. Consider the following game

	W	**X**	**Y**	**Z**
A	5, 4	4, 4	4, 5	12, 2
B	3, 7	8, 7	5, 8	10, 6
C	2, 10	7, 6	4, 6	9, 5
D	4, 4	5, 9	4, 10	10, 9

Find the Nash equilibria of this game.

1 step. Finding strictly dominated strategies.

Player 1. C is strictly dominated by B because 3>2 and 8>7 and 5>4 and 10>9. So Player 2 knows that Player 1 never plays C (assuming Player 1 is rational). The resulting payoff matrix is the following:

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	W	X	Y	Z
A	5, 4	4, 4	4, 5	12, 2
B	3, 7	8, 7	5, 8	10, 6
D	4, 4	5, 9	4, 10	10, 9

Player 2. Note that Y is a strictly dominant strategy for Player 2, that is, regardless of Player 1's choice, Player 2 is always better off playing Y.

	Y
A	4, 5
B	5, 8
D	4, 10

Player 1 plays B, so the only Nash Equilibria in pure strategies is (B, Y).

Extensive Form

Real world games are usually not one shot games, players move sequentially (some players might move more often than others). Therefore a decision tree representation can be useful.

An **action** is a possible move of a player at an information set.

A **strategy** is a *complete plan to play the game*.

Information set: a group of nodes at which the player has common information about the history of the game and his available choices.

Exercise 7. Consider the following game in extensive form.

What are the strategies of the players?

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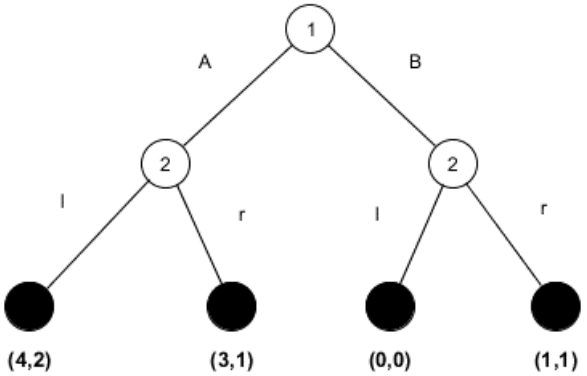
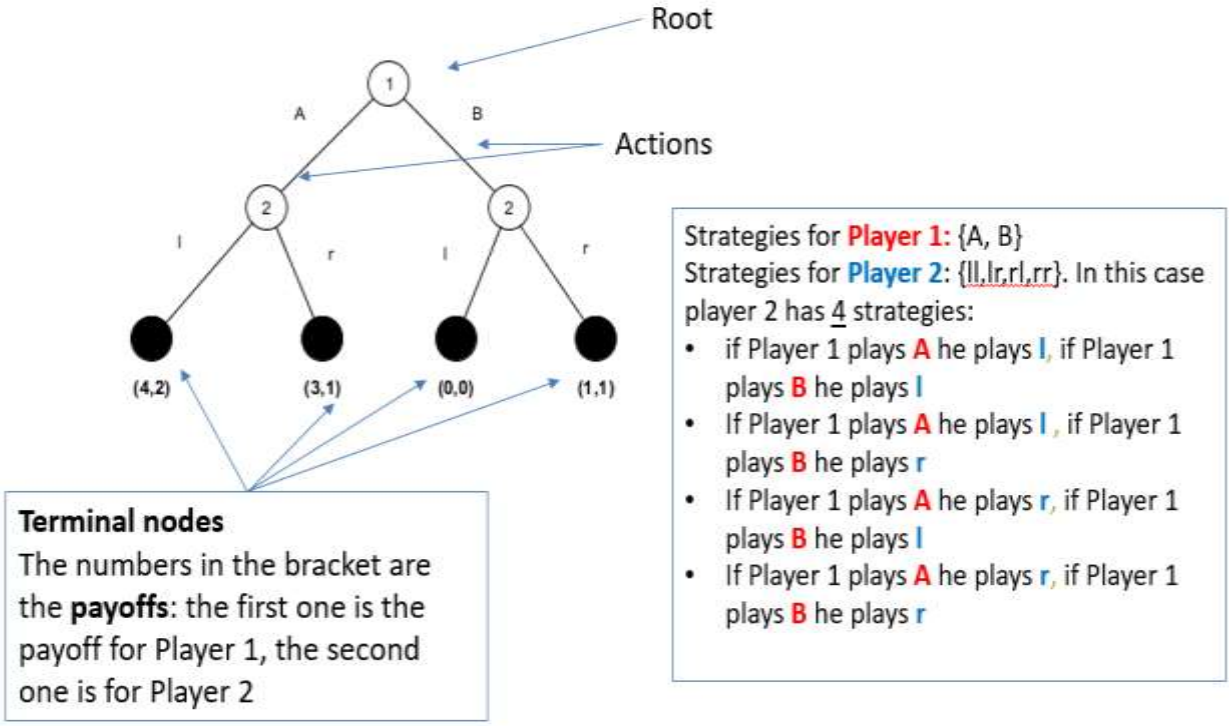


Solution:



Strategies are useful because the game in extensive form can be reduced to a one-shot game:

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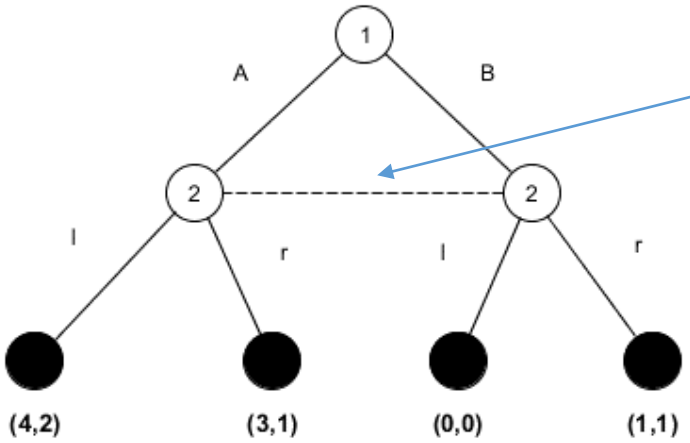
	ll	lr	rl	rr
A	4, 2	4, 2	3, 1	3, 1
B	0, 0	1, 1	0, 0	1, 1

This means that, for example, If Player 1 plays strategy A, and Player 2 plays strategy ll, it leads to the first terminal node, and the payoff is (4,2)

Now, consider the following game in extensive form (based on the previous one)



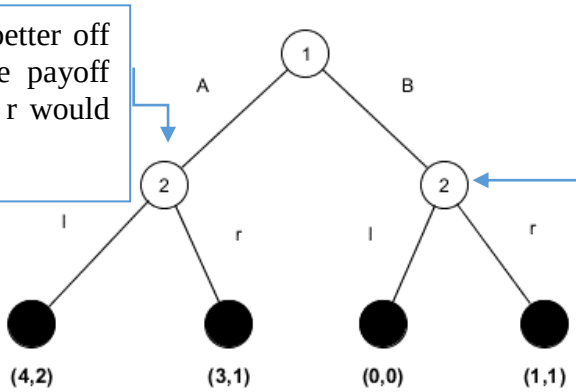
The 2 nodes are connected with a dashed line. It means they are in the same information set.
It means that when Player 1 has reached one of the nodes in the information set, Player 2 does not know which of these nodes he is in. Because he does not observe the action played by Player 1.
=> Imperfect information

Strategies for Player 1: {A, B}
Strategies for Player 2: {l,r}. In this case Player 2 has 2 strategies: he can no longer condition his action on Player 1's action.

Backward induction

Main idea: we start with nodes preceding the terminal nodes and turn them into terminal nodes by choosing the optimal action. Consider again the game with perfect information.

Player 2 is better off playing l, the payoff is 2. Playing r would yield 1.



Here, **Player 2**'s optimal action is playing r (1>0). Player 2s optimal strategy is therefore (lr)

The resulting reduced game:

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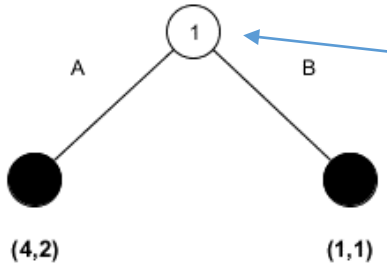


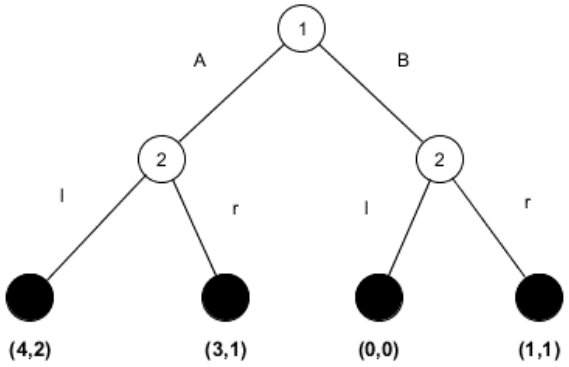
It is clear that **Player 1** now chooses A and the payoff is 4 instead of playing B with payoff 1.

We obtained the **backward induction equilibrium**: (A, lr)

A **subgame** is any part of the game tree, starting at a single decision node (trivial information set) of a player.

This game has 3 subgames: the entire game; the 2 games starts at the nodes preceding the terminal nodes.

Subgame perfect Nash equilibrium (SPNE): a strategy combination that induces Nash Equilibrium at every subgame



We saw that the game has 2 Nash equilibria in pure strategies (A, ll) and (A, lr).
(A, ll) is not subgame perfect Nash equilibrium: at the subgame which starts at the node when Player 1 plays B, the strategy of player 2 is playing l there, which is not optimal.

(A, lr) is a Subgame Perfect Nash Equilibrium. We saw that it is backward induction equilibrium as well. **Backward induction leads to subgame perfect equilibrium in perfect information games.**

Exercise 8. Each game in extensive form leads to a unique game in strategic form. The converse, however, is not true. Consider the following game and find two different games in extensive form with this game as strategic form:

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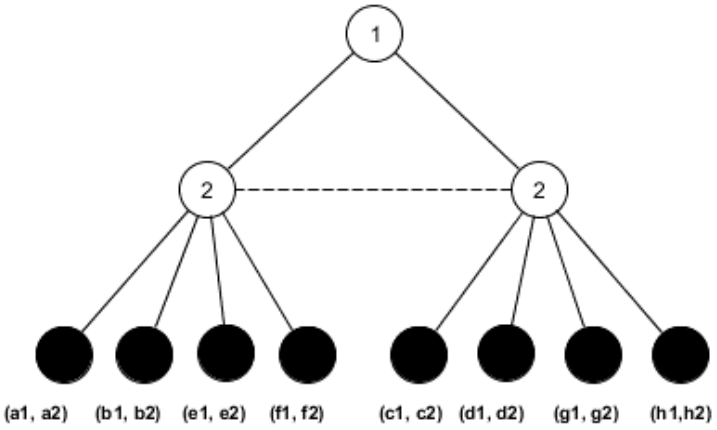
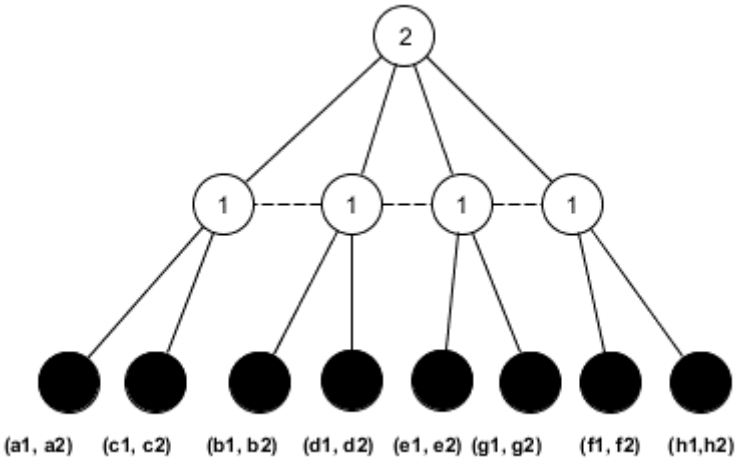
a1, a2	b1, b2	e1, e2	f1, f2
c1, c2	d1, d2	g1, g2	h1, h2

Solutions (other solutions are possible)





Exercise 9. Counting Strategies. Consider the following simplified chess game. White moves first. Black observes White's move and then makes its move. Then the game ends in a draw. Determine the strategy sets of White and Black. How many strategies does Black have?

Solution. White has 20 possible moves, hence 20 strategies (8 pawn, each can

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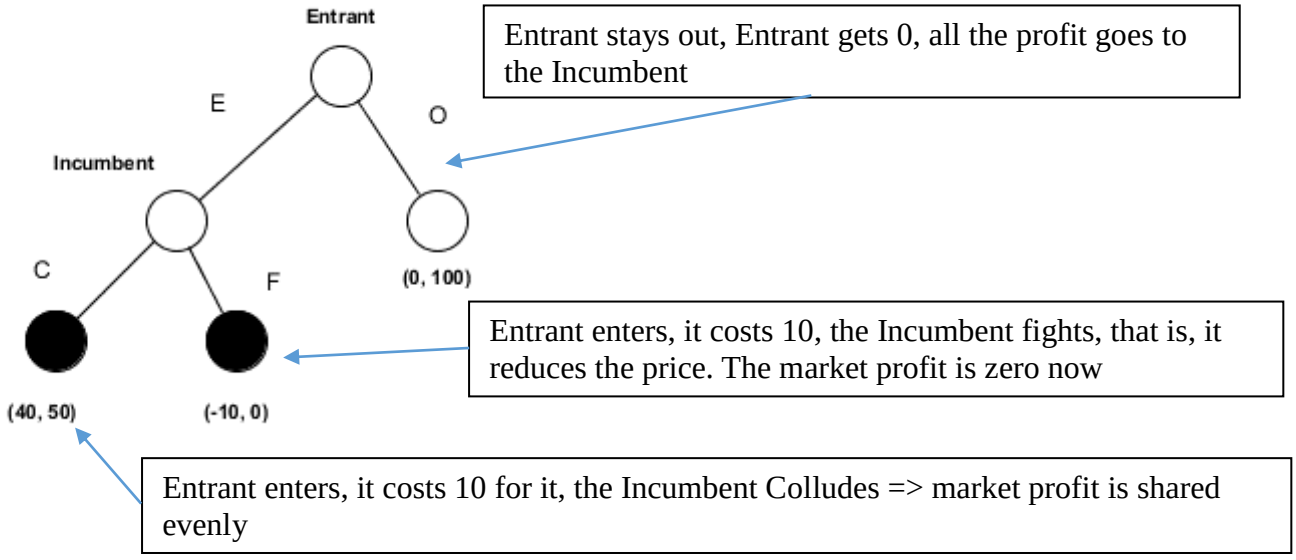
move either 1 or 2 blocks; 2 knights each can "jump" to either left or right).

Now, chess is a perfect information game, so every move of white leads to a singleton, a distinct information set of Black, containing a single decision node. At every such node, black has 20 possible moves. So there are 20^{20} strategies for Black.

Exercise 10. Entry Deterrence. There are two firms, the entrant and the incumbent. The entrant decides whether to Enter (E) the market (in which currently the Incumbent operates only) or to Stay Out (O). If the entrant enters, the incumbent can Collude (C) with him, or Fight (F) by cutting the price drastically. The payoffs are as follows. Market profits are 100 at the monopoly price and 0 at the fighting price. Entry costs 10. Collusion shares the profits evenly. (Note: this exercise will be revisited and expanded later during the course).

(a) Write down the game in extensive form.



(b) Write down the strategic form of this game.

		Incumbent	
		Collude	Fight
Entrant	Entry	40, 50	-10, 0
	Stay out	0, 100	0, 100

(c) Determine the Nash equilibria (in pure strategies).

- There are 2 Nash equilibria: (Entry, Collude) and (Stay out, Fight). (Note: you should be able to find them by now).

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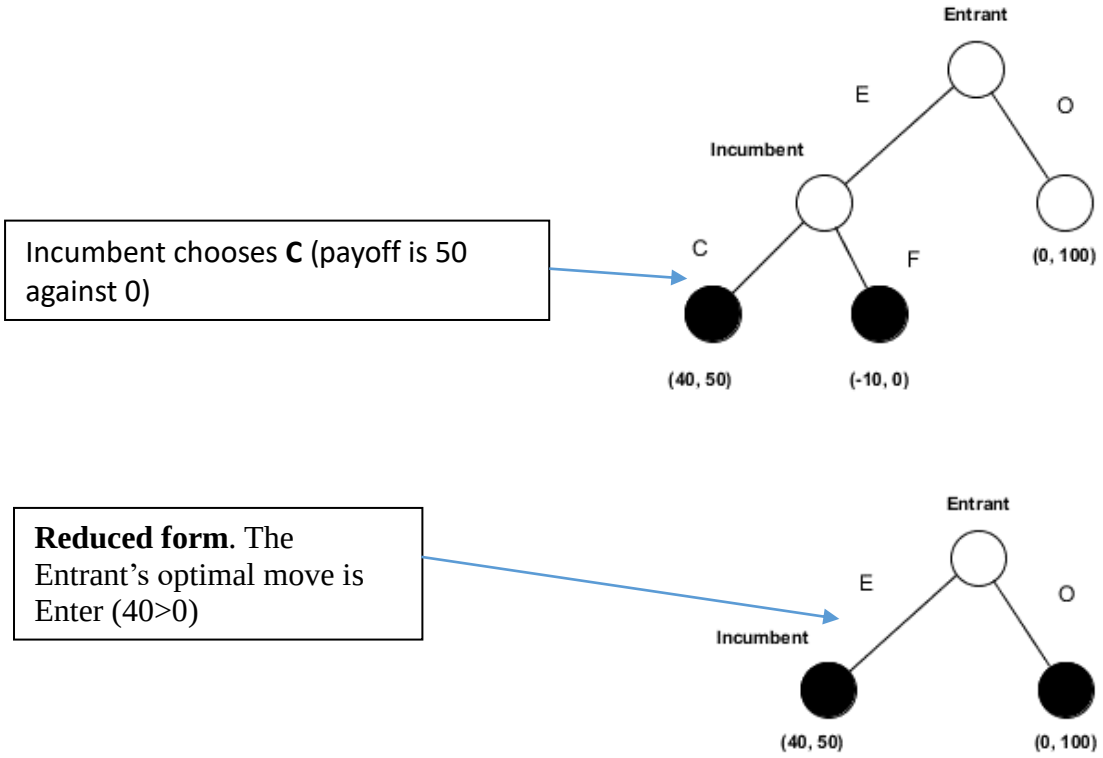
(d) Which one is the backward induction equilibrium?



The SPNE is (Entry, Collude).

The game has 2 Nash equilibria, but using the *Backward Induction* we can find the SPNE. The firm Entrant knows that if it does enter the market, the Incumbent will Collude, since that is the optimal choice. Therefore, the Incumbent's strategy to Fight if the Entrant plays Entry is **not credible.**

Exercise 11. Stackelberg equilibrium. Consider the following market. There are 2 firms (Firm 1 and Firm 2), homogeneous product, and they face the same cost function, C.

The inverse demand function: $P=100 - Q$.

Cost functions: $C_i = 2 \times q_i + 6$ (where i=1,2)

Firm 1 gets to determine its output first (q_1), Firm 2 observes that and determines its output (q_2).

The equilibrium output ($Q^* = q_1 + q_2$) can be calculated with backward induction. That is, we calculate q_2 first and q_1 after.

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Step 1. We determine Firm 2's best response function.

Profit of Firm 2:

$$\Pi_2 = Pq_2 - 2q_2 - 6 = (100 - q_1 - q_2)q_2 - 2q_2 - 6$$

The profit maximising first-order condition: $\partial \Pi_2 / \partial q_2 = 0$

$100 - q_1 - 2 - 2q_2 = 0 \Rightarrow q_2 = (100 - q_1)/2$ (this is Firm 2's best response function to the decision made by Firm 1).

Now, since Firms 1 sets the output first (q_1) it can derive Firm 2's best response function, therefore Firm 1 can take the above equation into account when determines q_1.

Profit of Firm 1:

$$\Pi_1 = Pq_1 - 2q_1 - 6 = (100 - q_1 - q_2)q_1 - 2q_1 - 6 =$$

$$[100 - q_1 - (100 - q_1)/2]\, q_1 - 2q_1 - 6 =$$

$$100\, q_1 - q_1^2 - 50q_1 + (\tfrac{1}{2})q_1^2 - 2q_1 - 6 \quad .$$

$$\partial \Pi_1 / \partial q_1 = 100 - 2q_1 - 50 + q_1 - 2$$

Profit maximising condition:

$$100 - 2q_1 - 50 + q_1 - 2 = 0$$

$$q_1 = 48 \Rightarrow q_2 = (100 - q_1)/2 = 26$$

So, the total output, $Q^* = q_1 + q_2 = 48 + 26 = 74$, hence $P = 100 - 74 = 26$.

Profit of Firm 1: $\Pi_1 = Pq_1 - 2q_1 - 6 = 26*48 - 2*48 - 6 = 1146$.

Profit of Firm 2: $\Pi_2 = Pq_2 - 2q_2 - 6 = 26*26 - 2*26 - 6 = 618$.

Exercise 12. Capacity investment Consider the following 2 stage game: Firm 1 is currently operating in the market (incumbent) and Firm 2 is considering the entry. Initially, they face the same cost function. During the first stage the incumbent has the option to make investment to reduce the costs in the second stage. Firm 2 observes that and decides whether to enter the market. In the second stage they play a Cournot game, that is, the firms determine their output quantity simultaneously.

Inverse demand function: $P = 12 - Q$ ($Q = q_1 + q_2$)

Cost function: $C = 6q_i + 1$ (where i=1,2)

The investment would cost 7.5 and reduce the marginal cost of Firm 1 to 4 ($C_1 = 4q_1 + 1$).

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Should Firm 1 invest in capacity?

No investment case:

Let's assume first that Firm 1 does not invest. In stage 1 Firm 1 is a monopolist (q_2=0):

$$\Pi_1 = Pq_1 - 6q_1 - 1 = (12 - q_1 - q_2)q_1 - 6q_1 - 1 = 6q_1 - q_1^2 - 1$$

First order condition of profit maximisation:

$$6 - 2q_1 = 0 \Rightarrow q_1 = 3 \Rightarrow P = 12 - 3 = 9 \Rightarrow \mathbf{\Pi_1} = 9*3 - 6*3 - 1 = \mathbf{8}$$

If Firm 2 does not enter the market Firm 1 realise the same profit in stage 2: 8.

If Firm 2 enters, they play a Cournot-game, and they face the same cost function. We have to determine the firms' best response functions:

$$\Pi_1 = Pq_1 - 6q_1 - 1 = (12 - q_1 - q_2)q_1 - 6q_1 - 1 = 6q_1 - q_1^2 - 1 - q_1q_2$$

$$\Pi_2 = Pq_2 - 6q_2 - 1 = (12 - q_1 - q_2)q_2 - 6q_2 - 1 = 6q_2 - q_2^2 - 1 - q_1q_2$$

After profit maximisation we get:

$$q_1 = (6 - q_2)/2$$

$$q_2 = (6 - q_1)/2$$

Solving the system of equations yields: $q_1 = q_2 = 2 => Q = 4 \Rightarrow P = 12 - 4 = 8 \Rightarrow \mathbf{\Pi_i = 3}$

Investment case:

Now we investigate what happens if the incumbent does invest in capacity:

In stage 1 Firm 1 incurs 7.5 additional cost, so its profit is reduced to **0.5** (8-7.5).

If Firm 2 does not enter, in stage 2 Firm 1 remains a monopolist but faces a new cost function:

$C_1 = 4q_1 + 1$

$$\Pi_1 = Pq_1 - 4q_1 - 1 = (12 - q_1 - q_2)q_1 - 4q_1 - 1 = 8q_1 - q_1^2 - 1$$

$$8 - 2q_1 = 0 \Rightarrow q_1 = 4 \Rightarrow P = 12 - 4 = 8 \Rightarrow \mathbf{\Pi_1 = 15}$$

If Firm 2 enters the profit functions are the following (please note that this case is an example of a Cournot game where the firms face *different* cost functions):

$$\Pi_1 = Pq_1 - 4q_1 - 1 = (12 - q_1 - q_2)q_1 - 4q_1 - 1 = 8q_1 - q_1^2 - 1 - q_1q_2$$

$$\Pi_2 = Pq_2 - 6q_2 - 1 = (12 - q_1 - q_2)q_2 - 6q_2 - 1 = 6q_2 - q_2^2 - 1 - q_1q_2$$

Best response functions:

$$q_1 = (8 - q_2)/2$$

$$q_2 = (6 - q_1)/2$$

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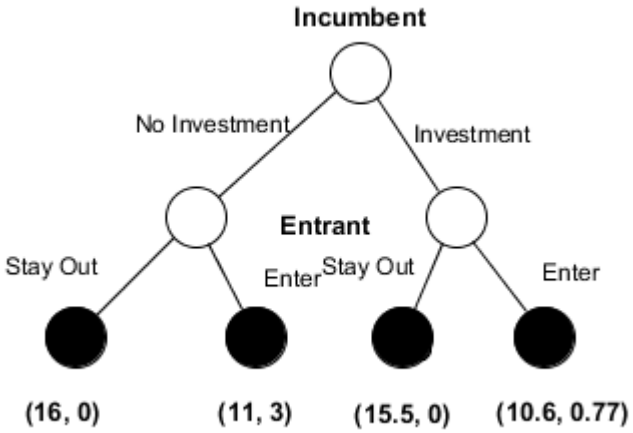
Solving the system of equations yields: $q_1 = 3\ 1/3$, $q_2 = 1\ 1/3$ => $P = 12 - 4\ 2/3 = 7\ 1/3$ => $\mathbf{\Pi_1} = Pq_1 - 4q_1 - 1 = \mathbf{10.1}$ $\mathbf{\Pi_2 = 0.77}$

The game has the following extensive form:



It is clear from the extensive form that Firm 2 (Entrant) chooses to enter the market (3>0 and 0.77>0), and so Firm 1 makes the investment. It is also evident that Firm 1 would not make the investment in the absence of entry threat (its profit is 16 in this case).

Sources of game-theoretic problems:

Exercise 1 and 2.: Rasmusen, E. (2006). *Games and Information: An Introduction to Game Theory*. Wiley-Blackwell

Exercise 3: Gibbons, R. (1992). *A Primer in Game Theory*. Prentice-Hall

Exercise 4-6, 8.: Peters, H. (2008). *Game theory. A Multi-Leveled Approach*. Springer, London.

Exercise 12.: Carlton, D. W. – Perloff, J. M. (2005). *Modern Industrial Organization*. Pearson, New York .

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