



SIXTH EDITION

MANAGERIAL ECONOMICS

IVAN PNG



Managerial Economics

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The book provides truly useful economics for managers. In the words of one professor, "I can use your book for serious conversation with adult students."

Ivan Png is a Distinguished Professor in the School of Business and Department of Economics at the National University of Singapore. Previously, Dr. Png was a faculty member at the Anderson School, University of California, Los Angeles (1985–1996) and the Hong Kong University of Science and Technology (1993–1996), and Visiting Professor at the Cornell Dyson School (2016). His book, *Managerial Economics*, has been published in multiple editions and adapted into Chinese (traditional and simplified characters). He is the Principal Investigator of a S\$4.75 million project, SPIRE (Service Productivity and Innovation Research), funded by the Social Sciences Research Council, Singapore, 2017–2022.

“This book is full of engaging real-world examples that will help bring economic concepts to life for business students. Each chapter starts with an interesting motivating case, and additional entertaining examples are presented throughout. As a textbook, it provides a comprehensive coverage of relevant microeconomics topics with explanations that are intuitive, clear and concise.”

Jaimie Lien, *Assistant Professor, Chinese University of Hong Kong*

“Ivan Png’s book has an engaging selection of international business case studies combined with fundamental microeconomics tools. Concepts are presented in an intuitive way, the exercises explore them in depth, and the supplementary materials provide a richer learning experience. Any student of business with an interest in economics should start from this book.”

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“I have been using Ivan Png’s book for 14 years for MBA teaching in Hong Kong and Shanghai. Light in mathematics and calculation, it is very user-friendly, a rare feature among numerous textbooks in the market on managerial economics. The many up-to-date examples from the Asia Pacific region make it particularly relevant for MBA students from the region.”

Wen Zhou, *Associate Professor, University of Hong Kong*

Managerial Economics

Sixth edition

Ivan Png

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Preface

Managerial economics is the science of directing scarce resources in the management of a business or other organization. This book presents tools and concepts from managerial economics that practicing managers can and do use. It

- emphasizes simple, practical ideas,
- focuses on application to business decision-making,
- integrates current business and economic issues and practice from all over the world,
- provides conceptual rigor without mathematical complexity.

This book is aimed at business students as well as practitioners. Accordingly, it is deliberately written in a simple and accessible style. It presents a minimum of technical jargon, complicated figures, and highbrow mathematics. It starts with the very basics and does not presume any prior knowledge of economics. While the mathematics is minimal, the economics is rigorous. The application of economic concepts to business practice will challenge even readers with some background in economics.

Besides the managerial focus, two features are worth emphasizing. First, the same principles of managerial economics apply globally. Reflecting this unity, the book includes applications throughout the world. Second, the book uses illustrations from both consumer and industrial markets. The reasons are simple: a customer is as likely to be another business as a human being, and likewise for suppliers.

For most readers, this may be their only formal book on economics. Accordingly, the book eschews sophisticated theories and models, such as indifference curves and production functions, which are more useful in advanced economics courses. Further, the book recognizes that many topics traditionally covered by managerial economics textbooks are now the domain of other basic management courses. Accordingly, the book omits linear programming and capital budgeting.

Regarding language, this book refers to businesses rather than firms. Realistically, many firms are involved in a wide range of businesses. In economics, the usual unit of analysis is a business, industry, or market rather than a firm. Also, the book refers to buyers and sellers rather than consumers and firms, since in most markets, demand and supply do not neatly divide among households and businesses. To cite just two examples, in the market for telecommunications, the demand side consists of businesses and households, while in the market for human resources the supply side comprises households and businesses. Outsourcing has reinforced this diversity of suppliers.

Managerial economics is a practical science. Just as no one learns cooking or tennis simply by watching a professional, so no one can learn managerial economics merely by reading this book. Every chapter of this book includes progress checks, and review and discussion questions. The progress checks and review questions are to help the reader check and reinforce the chapter material. Readers should practice their new-found skills on these checks and questions. The discussion questions are intended to challenge, provoke, and stretch. They will be useful for class and group discussions.

Key features

- Simple, practical ideas for business decision-making.
- Easy to read, with minimal technical jargon, figures, and mathematics.
- Up-to-date vignettes and illustrations from around the world – behavioral biases, technology, climate change, pandemics, globalization.
- Every chapter is reinforced with progress checks, review questions, and discussion questions.
- Complete instructor's supplements – transparency masters, answers to discussion questions, casebank, and testbank.

Organization

This book is organized into three parts. Following the Introduction, Part I presents the framework of perfectly competitive markets. Chapters 2–5 are the basis of managerial economics. These are presented at a very gradual pace, accessible to readers with no prior background in economics.

The book gathers pace in Parts II and III. These are relatively self-contained, so the reader may skip Part II and go directly to Part III. Part II broadens the perspective to situations of market power, while Part III focuses on the issues of management in imperfect markets. Chapter 13 on regulation is the only chapter in Part III that depends on understanding Part II.

A complete course in managerial economics would cover the entire book. For shorter courses, there are three alternatives. One is a course focusing on the economics

of strategy, which would comprise Chapters 1–9. Another alternative focuses on the economics of organization, comprising Chapters 1–5 and 10–12. The third alternative focuses on strategy and organization, and would comprise Chapters 1 and 6–12.

Website

Online support for this book can be found at www.routledge.com/cw/png. The site contains additional cases and applications, as well as updates and corrections to the book. The site also contains a link to resources for instructors, including transparencies, answers to discussion questions, a testbank, and a casebank.



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About the author

Ivan Png is a Distinguished Professor in the School of Business and Department of Economics at the National University of Singapore. Previously, he was a faculty member at the Anderson School, University of California, Los Angeles (1985–1996) and the Hong Kong University of Science and Technology (1993–1996).

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His book, *Managerial Economics*, has been published in multiple editions and adapted into Chinese (traditional and simplified characters). He is the Principal Investigator of a S\$4.75 million project, SPIRE (Service Productivity and Innovation Research), funded by the Social Sciences Research Council, Singapore, 2017–2022.

Dr. Png speaks English and Chinese (Mandarin). He is married to Ms. Joy Cheng. They have two sons, Max and Lucas.



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CHAPTER 1

Introduction to managerial economics

LEARNING OBJECTIVES

- Appreciate the objective of managerial economics.
- Understand value added and economic profit.
- Apply total benefit and total cost to decide participation.
- Apply marginal benefit and marginal cost to decide extent.
- Appreciate the effect of bounded rationality on decision-making.
- Understand the vertical and horizontal boundaries of an organization.
- Distinguish competitive markets, market power, and imperfect markets.

1.1 What is managerial economics?

Amazon.com is a multinational company which offers retailing, cloud computing, and online advertising services. One of its major consumer services is Amazon Prime, a bundle that includes free shipping on consumer purchases, discounts on groceries, as well as video, music, games, and books. In March 2014, Amazon raised the price of Prime from US\$79 to US\$99 per year, then, in April 2018, raised the price again to US\$119. What if Amazon were to increase the price again? How would that affect sales, revenue, and profit? How does “free shipping” help Amazon in competing against other retailers?

Amazon operates a worldwide network of warehouses as well as a fleet of cargo jets to support its retail businesses. What services should it perform in-house, and what should it buy from others? In 2019, Amazon and non-governmental organization Global Optimism launched the Climate Pledge, by which businesses commit to net zero carbon emissions by the year 2040. Why should a for-profit business indulge in climate policy?

Managerial economics: The science of cost-effective management of scarce resources.

All of these are questions of managerial economics. **Managerial economics** is the science of cost-effective management of scarce resources. Wherever resources are scarce, managers can make more cost-effective decisions by applying the discipline of managerial economics. The decisions may concern customers, suppliers, competitors, or the internal workings of the organization. All organizations, whether profit-oriented businesses, non-profit organizations, or households would gain from better use of scarce resources.

Amazon has limited financial, human, and physical resources. Amazon managers seek to maximize the financial return from these limited resources. They must organize the business, manage demand and costs, set prices, compete against online and traditional competitors, and plan for the future. By applying the principles of managerial economics, Amazon managers would make better decisions and conceive more effective long-term strategy.

Managerial economics consists of three branches: competitive markets, market power, and imperfect markets. Accordingly, this book is organized into three parts. Before introducing the three branches of managerial economics, let us first develop some background – the meaning of value added, how to make decisions, and organizational boundaries.

1.2 Value added

For the most part, this book takes the viewpoint of a profit-oriented business, while also considering the management of non-profit organizations and households. The primary goal of a profit-oriented business is to maximize profit. Indeed, the aim of business strategy is to deliver sustained profit above the competitive level.

Accordingly, an essential concept for managerial decision-making is *economic profit*. To appreciate the concept of economic profit, consider the basic equation of managerial economics:

$$\begin{aligned} \text{Value added} &= \text{Buyer benefit} - \text{Seller cost} \\ &= \text{Buyer surplus} + \text{Seller economic profit}. \end{aligned} \quad (1.1)$$

Value added: Buyer benefit less seller cost. Comprises buyer surplus and economic profit.

This equation states that **value added** is the difference between buyer benefit and seller cost. It is only to the extent that businesses deliver benefit to buyers that exceeds the cost of production that they *create* value. Equation (1.1) is basic to all organizations – whether profit-oriented, non-profits, or households. To create value, an organization must deliver benefit that exceeds cost. If the delivered benefit is less than the cost of production, then value is destroyed. In that case, society would be better off without production of the good or service.

Referring to Figure 1.1, value added is shared by buyer and seller. The buyer gets some part of the value added in *buyer surplus*, which is the difference between the buyer's benefit and their expenditure. The seller gets the other part of the value added

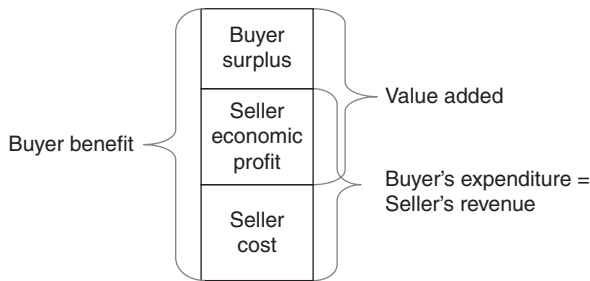


Figure 1.1 Value added

in *economic profit*, which is the difference between the revenue that the seller receives (equal to the buyer's expenditure) and the cost of production.

The larger is the value added, the larger is the amount to be shared by buyer and seller. For profit-oriented businesses, that means the potential for economic profit is greater!

The concept of value added applies to governments and non-profits as well. Suppose that the government provides free healthcare. Since the healthcare is free, the government receives no revenue. While the government incurs an economic loss on the service, that does not mean that it is making a mistake. The healthcare provides a benefit.

Referring to Figure 1.1, the value added is the buyer benefit minus the cost of provision. So long as the benefit exceeds the cost, the service adds value. The question of value added is distinct from that of how the service should be provided – whether commercially or non-commercially.

Progress check 1A. Explain the relation among the following: buyer benefit, seller cost, value added, buyer surplus, and economic profit.

National Health Service

In England, the National Health Service (NHS) provides subsidized healthcare to a population of 56.3 million. The NHS employs over 1.5 million people to deliver service at hospitals and clinics across the country.

The NHS charges a fixed fee for prescriptions, and also charges for dental treatment and eye tests. It does not charge for consultations or medical treatment. In the financial year 2019–2020, the NHS earned operating income of £2.2 billion, while incurring expenses of £125.4 billion and an economic loss of £123.2 billion.

The government covered most of the loss through a subsidy of £122.8 billion. The NHS carried forward the remaining loss of £400 million to the following year.

While the NHS incurs an economic loss, it still creates value so long as buyer surplus exceeds economic loss. However, buyer surplus is not readily quantifiable.

1.3 Decision-making

The two fundamental decisions in business can be stated simply as participation (“which”) and extent (“how much”). Which market to enter? How much to invest? Which products to sell? How much to produce? Which R&D strategy to follow? How much to spend on R&D? Which job to take? How many hours to work?

The decision on participation resolves into analyzing the total benefits and costs. The decision on extent resolves into analyzing the marginal benefits and costs.

To explain, consider the following example. Angela works as an analyst at a fixed after-tax salary of \$70,000 per year. On average, she works 50 hours a week. Another firm has offered her an analyst job for \$40 after-tax per hour. Should she switch to the new firm?

In deciding whether to continue with her current job or switch, Angela should consider the total earnings and total costs of each alternative. Yet, Angela’s total earnings and total costs at the new job depend on how many hours she would work.

So she must first decide, if she takes the new job, *how much* to work. In this decision, Angela should consider the marginal earnings and marginal cost of each additional hour. The **marginal value** of a variable with respect to some factor is the change in the variable associated with a unit increase in the factor.

Marginal value:

The change in the variable associated with a unit increase in a factor.

If she takes the new job, Angela should work up to the point that her marginal earnings per hour equal her marginal cost per hour. To understand why, suppose that her marginal earnings exceed her marginal cost. Then she should work more. The additional earnings would exceed the additional cost. By contrast, if her marginal earnings are less than her marginal cost, then she should work less. The reduction in earnings would be less than the reduction in cost.

In the new job, Angela’s marginal earnings would be \$40 per hour. Suppose that she would work 40 hours a week. On the basis of 50 weeks a year, she would earn $40 \times 40 \times 50 = \$80,000$. This would exceed her current earnings.

However, the higher earnings do not mean that she should take the new job. Angela must also consider the total costs of the two jobs, for instance, the commuting time and expenses. In deciding *which* job to take, she should compare the *total* surplus (total earnings minus total cost).

Average value:

The total value of the variable divided by the total quantity of the factor.

Closely related to the total is the concept of *average*. Generally, the **average value** of a variable with respect to some factor is the total value of the variable divided by the total quantity of the factor. Angela could also choose the job according to the average surplus.

Generally, the marginal value of a variable may be less than, equal to, or greater than the average value. The relation between the marginal and average values with respect to some factor depends on whether the average value is decreasing, constant, or increasing with respect to the factor.

Progress check 1B. Suppose that the offer from the new firm is \$25 per hour. Should Angela reject?

Amazon Prime: free shipping

Amazon's Prime service provides subscribers with free shipping on selected consumer purchases. For Prime members, the marginal cost of goods that qualify for free shipping is just the price of the item. This would be less than the cost of the similar item at another online retailer that does not offer free shipping. Essentially, by persuading consumers to pay upfront for Prime membership, Amazon has given itself a pricing advantage in competing against other retailers.

1.4 Bounded rationality

Managers are human and as such are subject to *bounded rationality*. Typically, managerial economics theories assume that individuals make decisions rationally, in the sense that they always choose the alternative that maximizes the difference between benefit and cost.

However, people do not always behave rationally, and indeed, they make systematic errors in decisions. Human beings behave with bounded rationality (less than full rationality) because they have limited cognitive abilities and cannot fully exercise self-control. The boundedly rational decisions lead to systematic mistakes in the scenarios that follow.

To the extent that individuals are subject to bounded rationality, the role for managerial economics is even larger than when individuals are fully rational. The techniques of managerial economics help to correct systematic biases in individual decision-making as well as show how to make better overall decisions.

Sunk-cost fallacy

A sunk cost is a cost that has already been incurred and cannot be recovered. Sunk costs do not affect forward-looking benefits or costs, and should not affect rational decisions. Yet, the sunk-cost fallacy is the tendency to consider sunk costs in decision-making.

Psychologists Hal Arkes and Catherine Blumer gave discounts at random to people buying season subscriptions at the Ohio University Theater. The researchers then monitored the attendance of the subscribers. Consumers who paid the regular price attended more plays than those who received the unanticipated discounts.

Rationally, the marginal benefit and marginal cost of attending another play should not depend on the price that the subscriber paid. At the point of deciding whether to attend a play, the subscription price was a sunk cost. Yet, the experiment showed that consumers who had incurred a larger sunk cost tended to consume more.

Status quo bias

Status quo bias is a preference for the current situation. The individual takes reference from the current situation, and perceives any change from the current situation as a loss.

Behavioral economists Jack Knetsch and Jack Sinden randomly gave students either A\$2 cash or a lottery ticket. The students who received A\$2 cash could buy lottery tickets for A\$2, and half did so. The students who received lottery tickets could sell the tickets for A\$2 in cash, but only a quarter did so.

Rationally, the benefit and cost of the lottery ticket should not depend on whether the student received cash or the lottery ticket. Then, the proportions of students buying vis-à-vis keeping the tickets should be the same. However, the experiment revealed that the proportions differed. Individuals tended (perhaps out of sheer inertia) to prefer the status quo.

Anchoring

Anchoring is the tendency to over-rely on pre-existing or early information in making decisions. The decision-maker gives insufficient consideration to later information.

Behavioral economists Amos Tversky and Daniel Kahneman posed the multiplication problem

$$8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = ?$$

to one group of students and the problem

$$1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 = ?$$

to another group. The researchers did not give the students enough time to complete the calculation.

Mathematically, the answers to the two problems are identical, 40,320. However, in reality, the median estimates were 2,250 in the former group of students and 512 in the latter. Pressed for time, the students anchored on the first few numbers that they could calculate. Hence, those who saw larger numbers first guessed the answer to be larger than those who saw smaller numbers first.

Progress check 1C. What is bounded rationality and what problems does it cause?

Driving in Singapore

The Singapore government aims to encourage commuters to travel by public transport rather than in private cars. It discourages driving by limiting the registration of new cars and auctioning the licenses, and also by charging for road use during peak hours.

Licenses, which allow the owner to operate a car for ten years, fluctuate in price with demand conditions and the quota of licenses. At the time of writing, the auction prices of licenses were S\$48,002 and S\$60,001 for smaller and larger cars respectively.

For the buyer of a new car, the auction price of a license is a sunk cost. In particular, the auction price does not affect the marginal cost of driving.

Management scholars Teck Ho, Ivan Png, and Sadat Reza studied the effect of fluctuations in license prices on owner behavior. Those who bought cars when licenses were more expensive drove more. Empirically, government policy between 2009 and 2013 which increased the cost of buying cars resulted in car buyers driving 5.6% more. Apparently, car buyers were prone to the sunk-cost fallacy.

1.5 Organization

Throughout this book, we will take the viewpoint of an organization, which may be a business, non-profit, or household. Managers of all such organizations face the same issue of how to effectively manage scarce resources. Since our analysis focuses on the organization, we first must identify its boundaries. We briefly discuss this issue here, while leaving the detailed analysis to Chapters 6 and 12.

Vertical boundaries:

Delineate activities closer to or further from the end user.

Organizational boundaries

The activities of an organization are subject to vertical and horizontal boundaries. The **vertical boundaries** of an organization delineate activities closer to or further from the end user. By contrast, the **horizontal boundaries** of an organization are defined by the organization's scale and scope of operations. Scale refers to the rate of production or delivery of a good or service, while scope refers to the range of different items produced or delivered.

Horizontal

boundaries: Defined by the scale and scope of the organization's operations.

In online business-to-consumer retailing, the value chain runs from the manufacturer of the goods such as books and clothing to the retailer to the delivery provider to the end user. The end users are consumers.

Consider two online retailers. Suppose that one ships goods through its own warehouses and delivery service, while the other ships goods through a third-party delivery service. With regard to vertical boundaries, the retailer that ships goods through its own warehouses and delivery service is more *vertically integrated* than the other which ships goods through a third-party delivery service.

With regard to horizontal boundaries, an online retailer that sells 40,000 books per month is operating on a larger *scale* than one which sells 400 per month. An online retailer that sells books as well as clothing is operating with a larger *scope* than one that specializes in books.

In the production of motorcars, the vertical chain runs from the production of raw materials, to manufacturing of batteries, motors, vehicle bodies, and other components, to assembly into vehicles, and finally, to distribution to end users. The end users include households and businesses such as car rental agencies and taxi operators.

With regard to vertical boundaries, a car manufacturer that produces batteries is more vertically integrated than one that buys batteries from others. As for horizontal boundaries, a car manufacturer that also manufactures trucks is producing with a larger scope than one that specializes in cars.

Amazon.com: horizontal and vertical growth

Jeff Bezos founded Amazon.com in 1994 to sell books through the Internet in the United States. Horizontally, Amazon.com expanded its retail business in product range and geography to sell a wide range of goods and services, including digital entertainment, pharmaceuticals, and groceries across the world.

Online retailers like Amazon.com use geographically spread data centers to serve customers and suppliers. Amazon.com decided to set up its own data centers and computing services. Besides using these for its own business, Amazon.com uses them to provide cloud computing services to external customers.

In logistics, Amazon.com set up warehouses and acquired a fleet of cargo jets to ship goods to consumers. Data centers, warehouses, and cargo jets expanded Amazon.com's vertical boundaries.

Outsourcing:

Purchase of services or supplies from external sources.

Outsourcing

Outsourcing is the purchase of services or supplies from external sources. It is the opposite of vertical integration, and affects the vertical boundaries of the organization.

If an online retailer outsources the shipping of goods to a third-party delivery service, then it is shrinking its vertical boundaries. Similarly, if a car producer outsources the manufacturing of batteries, it is shrinking its vertical boundaries.

The costs of transport and communications, and barriers to trade and investment have declined over time. These trends have stimulated the growth of outsourcing across international borders. Financial institutions in advanced economies outsource customer service to call centers in the Philippines. Technology companies in the United States outsource manufacturing to contractors in China and Taiwan. Chapter 12 on incentives and organization discusses outsourcing in detail.

Progress check 1D. Explain the difference between the vertical and horizontal boundaries of an organization.

1.6 Markets

One concept of managerial economics – the market – is so fundamental that it appears in the names of each branch of the discipline. A **market** consists of buyers and sellers who communicate with one another for voluntary exchange. In this sense, a market is not limited to any physical structure or particular location. The market extends as far as there are buyers or sellers who can communicate and trade at relatively low cost.

Market: Buyers and sellers who communicate with one another for voluntary exchange.

With the decline of the costs of transport and communications, and barriers to trade, the markets for many goods and services have expanded to global scale. Growers of flowers in Colombia, Ecuador, Ethiopia, and Kenya export roses, carnations, and chrysanthemums to Europe and North America. Tutors living in Canada and the United States offer online English lessons to students in China.

Consider, for instance, the market for cut roses. Increases in the supply in Colombia or Ethiopia would affect the global price of cut roses. And that change in price would reverberate to buyers and other sellers throughout the world.

In markets for consumer products, the buyers are households and sellers are businesses. In markets for industrial products, both buyers and sellers are businesses. Finally, in markets for human resources, the buyers are businesses and sellers are households.

By contrast with a market, an **industry** consists of businesses engaged in the production or delivery of the same or similar items. For instance, the motorcar industry consists of all manufacturers of motorcars, and the battery industry consists of all manufacturers of batteries. Members of an industry can be buyers in one market and sellers in another. The motorcar industry is a buyer in the battery market and a seller in the motorcar market.

Industry: Businesses engaged in production or delivery of the same or similar items.

Spotify and TikTok

Conventionally, publishers of music and videos produced their entertainment on physical media such as CDs and DVDs, and distributed them to consumers through wholesalers and retailers.

By contrast, publishers of digital entertainment can sell directly to consumers through the Internet. The markets for digital entertainment services are truly global and are limited only by the bandwidth of Internet access and government regulation.

In the digital entertainment industry, Spotify and TikTok are notable for their huge scale. At the time of writing, Spotify served 356 million users, including 158 million paid subscribers, while TikTok served over 800 million active users worldwide.

Competitive markets

The market for cut roses includes many competing producers and buyers. How should a producer respond to an increase in the price of water, a drop in the price of roses, or a change in labor laws? How will these changes affect buyers?

The basic starting point of managerial economics is the model of competitive markets. This applies to markets with many buyers and many sellers. The market for cut roses is an example of a competitive market. In a competitive market, buyers provide the demand and sellers provide the supply. Accordingly, the model is also called the *demand–supply model*.

The model describes the systematic effect of changes in prices and other economic variables on buyers and sellers. Further, the model describes the interaction of these changes. In the example of cut roses, the model can describe how growers should adjust prices when the price of water increases, the price of roses drops, and labor laws change. These changes affect all growers. The model also describes the interaction among the adjustments of the various growers and how these affect buyers.

Part I of this book presents the model of competitive markets. Chapter 2 begins with the demand side, considering how buyers respond to changes in prices and income. Next, Chapter 3 develops quantitative methods that support precise estimates of changes in economic behavior. Then, Chapter 4 looks at the supply side of the market, considering how sellers respond to changes in the prices of products and inputs. Chapter 5 brings demand and supply together and shows that the outcome of market competition is efficient.

Market power

In a competitive market, an individual manager may have little freedom of action. Key variables such as prices, scale of operations, and input mix are determined by

market forces. The role of a manager is simply to follow the market and survive. Not all markets, however, have so many buyers and sellers to be competitive.

Market power is the ability of a buyer or seller to influence market conditions. A seller with market power will have relatively more freedom to choose suppliers, set prices, and use advertising to influence demand. A buyer with market power will be able to influence the supplies of goods and services that it purchases.

Market power: The ability of a buyer or seller to influence market conditions.

A business with market power must determine its horizontal boundaries. These depend on how its costs vary with the scale and scope of operations. Accordingly, businesses with market power – whether buyers or sellers – need to understand and manage their costs.

In addition to managing costs, sellers with market power need to manage their demand. Three key tools in managing demand are price, advertising, and policy toward competitors. What price maximizes profit? A lower price boosts sales, while a higher price brings in higher margins. What is the best way to compete with other businesses?

Part II of this book addresses all of these issues. We begin by analyzing costs (Chapter 6), then consider management in the extreme case of market power, where there is only one seller or only one buyer (Chapter 7). Next, we discuss pricing policy (Chapter 8), and strategic thinking (Chapter 9).

Imperfect markets

Businesses with market power have relatively more freedom of action than those in competitive markets. Businesses will also have relatively more freedom of action in markets that are subject to imperfections. A market may be **imperfect** in two ways: when one party directly (rather than through a market) conveys a benefit or cost to others, or when one party has better information than others. The challenge is to resolve the market imperfection.

Imperfect market: One party directly conveys a benefit or cost to others, or one party has better information than others.

Water resources illustrate the direct imposition of costs on others. If one farmer draws more water, there is less for others. Farmers might compete to draw water, which would degrade the resource and could even destroy it. The challenge is to resolve such competition.

The market for residential mortgages illustrates differences in information. Applicants for mortgages better know their ability and willingness to repay than potential lenders. The challenge for lenders is resolving the informational differences so that they can provide loans in a cost-effective way.

Differences in information can cause a market to be imperfect. Imperfection can arise within an organization, where some members have better information than others and interests diverge. Accordingly, another issue is how to structure incentives and organization.

Part III of this book addresses all of these issues. We begin by considering the sources of market imperfections – where one party directly conveys a benefit or cost to others (Chapter 10) and where one party has better information than others (Chapter 11). Then we study the appropriate structure of incentives and organization

(Chapter 12). Finally, we discuss how government regulation can resolve market imperfections (Chapter 13).

Progress check 1E. Distinguish the three branches of managerial economics.

Key takeaways

- Managerial economics is the science of cost-effective management of scarce resources.
- Value added is the difference between buyer benefit and seller cost, and comprises buyer surplus and economic profit.
- In decisions on participation, compare the total benefit and total cost.
- In decisions on extent, compare the marginal benefit and marginal cost.
- In decision-making, take care to avoid systematic biases, including the sunk-cost fallacy, status quo bias, and anchoring.
- The vertical boundaries of an organization delineate activities closer to or further from the end user.
- The horizontal boundaries of an organization are defined by the scale and scope of operations.
- Businesses with market power must manage their costs, pricing, advertising, and relations with competitors.
- Businesses in imperfect markets should act strategically to resolve the imperfection.

Review questions

1. Explain the difference between value added and economic profit.
2. Consider a charity that gives free meals. Since the charity receives no revenue while meals are costly, do the free meals mean that the charity is destroying value?
3. Maggie works ten hours a day at a supermarket. The store pays \$10 per hour for a basic eight-hour day and \$15 per hour for overtime. What are Maggie's (a) marginal pay and (b) average pay?
4. Explain the difference between the marginal and average values.

5. In decisions on participation, managers should compare the total benefit and total cost. True or false?
 6. In deciding how many hours to work, why should a worker compare the marginal earnings and marginal cost of each hour?
 7. Why do individuals act with bounded rationality?
 8. Describe the vertical boundaries of your local cable television provider. In what ways could the vertical boundaries be expanded or reduced?
 9. Describe the horizontal boundaries of your university. In what ways could the horizontal boundaries be expanded or reduced?
 10. In the context of manufacturing Apple iPhones, explain the concepts of outsourcing and vertical integration.
 11. Explain the difference between: (a) the market for electricity; and (b) the electricity industry.
 12. In every market, all buyers are consumers and all sellers are businesses. True or false?
 13. What is another name for the model of competitive markets?
 14. What distinguishes a manufacturer with market power from one without market power?
 15. Should managers operating in an imperfect market: (a) set high prices to make up for the imperfection; or (b) act strategically to resolve the imperfection?
-

Discussion questions

1. The Hong Kong Hospital Authority provides healthcare at subsidized prices through a network of hospitals and clinics. In the financial year 2019–2020, the Authority earned fees and charges of HK\$4.8 billion while incurring expenses of HK\$76.9 billion. The government paid the Authority a subsidy of HK\$71.3 billion.
 - (a) What is the economic profit of the Hospital Authority?
 - (b) What is the minimum benefit that the Hospital Authority must provide to add value?
 - (c) Some critics might argue that, since the Hospital Authority is losing money, it should be shut down. Please explain why or why not.
 - (d) The waiting times for some specialist services are quite long. Should the government increase the subsidy so that the Hospital Authority can expand its staff and facilities?
2. At the time of writing, Amazon.com offered Prime, a bundle that includes free shipping on consumer purchases, discounts on groceries, as well as video, music, games, and books, at a price of US\$119 per year. The price of the Harry Potter paperback box set was US\$50.33 with free shipping.

- (a) From the viewpoint of an Amazon Prime subscriber, compare the marginal cost of buying the Harry Potter box set from Amazon vis-à-vis a competing retailer that charges for shipping.
 - (b) Suppose that Amazon Prime subscribers are subject to the sunk-cost fallacy. How would that affect their demand to buy products from Amazon vis-à-vis competing retailers?
 - (c) By default, Amazon has set membership of Prime to automatically renew. This auto renewal takes advantage of a behavioral bias. Explain which one.
 - (d) Considering your answers to (a)–(c) above, explain how the Prime service gives Amazon an advantage over competitors.
3. The Singapore government discourages driving by limiting the registration of new cars and auctioning the licenses. Each license allows the owner to operate a car for ten years. The prices of licenses fluctuate with demand conditions and the number of licenses.
 - (a) Classify and explain the following as decisions of participation or extent. (i) Whether to buy a new car; (ii) How much to drive the car.
 - (b) How would the price of a new car license affect the decision on whether to buy a new car?
 - (c) How would the price of a new car license affect the marginal cost of driving and the decision on how much to drive the car?
 - (d) People who bought cars when licenses were more expensive drove more. How would you explain such behavior?
4. Uber Technologies provides ride hail, delivery, and freight booking services. In 2019, it served customers through the Google Cloud Platform, Amazon Web Services, as well as its own cloud computing facilities. In late 2020, Uber sold its self-driving car division to Aurora Innovation which specializes in self-driving technologies for cars and trucks.
 - (a) Apply the concepts of vertical integration and (dis)integration to explain: (i) Uber's operation of its own cloud computing facilities, and (ii) Uber's sale of the self-driving car division.
 - (b) Apply the concept of outsourcing to explain Uber's use of the Google Cloud Platform and Amazon Web Services.
 - (c) Consider each of Uber's decisions on (i) cloud computing and (ii) development of self-driving technology. Explain whether it is a decision on participation or extent.
5. Historically, fresh flowers in northern Europe were supplied by local growers. Producers had to grow flowers in heated greenhouses to meet demand in winter, such as on Valentine's Day. Now, European consumers buy roses, carnations, and chrysanthemums produced in Colombia, Ecuador, Ethiopia, and Kenya.
 - (a) The liberalization of airline regulation allowed the entry of new airlines and increased flights. How did that affect the market(s) for fresh flowers?

- (b) How did the development of more fuel-efficient and larger aircraft affect the market(s) for fresh flowers?
 - (c) Compare the advantage of South American and East African growers over European growers in winter vis-à-vis other seasons.
6. In January 2021, the Brexit agreement for the UK to leave the European Union (EU) came into effect. From then, the movements of goods, services, and people between the UK and EU were subject to national and European laws and regulations.
- (a) How would Brexit affect the supply of services by London investment bankers to EU member countries such as France and Germany?
 - (b) How would Brexit affect the market power of French and German investment bankers?
 - (c) UK and EU member countries apply different laws and regulations on the production and sale of goods and services. How would Brexit affect the degree of imperfection in the markets for goods and services?
7. The Australian national electricity transmission grid links eastern and southern states – Queensland, New South Wales, Australian Capital Territory, Victoria, South Australia, and Tasmania. The national grid does not connect with regional grids in Western Australia and the Northern Territory. In the wholesale electricity market, producers of electric power sell to distributors which then sell to retailers of electric power. In the retail electricity market, retailers sell to industrial and residential users.
- (a) In 2005, Basslink connected the island of Tasmania to the electricity grid in the other eastern and southern states. How did Basslink affect the boundaries of electricity markets in Australia?
 - (b) Transmitting electric power over long distances is costly. Western Australia and the Northern Territory are far from the other states. Could that explain why their grids are not connected with the national grid?
 - (c) State governments allow only one company to distribute electricity in each geographical area. Comment on the market power of that company.
 - (d) Apply the concept of vertical integration to explain the merger of a producer of electric power with a distributor.

You are the consultant!

In your organization or personal experience, identify and explain any decisions that have been systematically biased by: (a) the sunk-cost fallacy, (b) status quo bias, or (c) anchoring. Explain how the organization or you could have achieved a better outcome by controlling the bias.

Progress check answers

- 1A. Value added = buyer benefit – seller cost = buyer surplus + seller economic profit.
- 1B. Angela should compare the marginal earnings and marginal cost in the new job, decide how much she would work in the new job, and then compare the total earnings and total costs in the current and new jobs.
- 1C. Bounded rationality is the idea that there are limits to rationality when individuals make decisions. It can result in suboptimal decision-making: for instance, individuals may erroneously count sunk costs, display a tendency to stick to the status quo, or rely excessively on a specific piece of information when making decisions.
- 1D. The vertical boundaries delineate activities closer to or further from the end user. By contrast, the horizontal boundaries are defined by the organization's scale and scope of operations.
- 1E. The three branches of managerial economics are competitive markets, market power, and imperfect markets.

Review answers

- 1. Value added is the difference between buyer benefit and seller cost. Economic profit is the difference between seller revenue and seller cost.
- 2. Value added is the difference between buyer benefit and seller cost (not the difference between seller revenue and seller cost). So, even though the charity receives no revenue, it need not be destroying value. For the free meals to create value, the buyer's benefit must exceed the seller's cost. In this example, the recipients of the meals are the "buyers," though they buy the meals at a price of zero. The charity is the seller.
- 3. (a) Maggie's marginal pay from ten hours of work is \$15 per hour, since she is paid \$15 for an additional hour worked from nine hours to ten hours.
(b) Maggie's average pay is her total pay divided by her total hours worked. This can be expressed as $(8 \times \$10 + 2 \times \$15)/10 = \$110/10 = \11 . Therefore, her average pay is \$11 per hour.
- 4. The average value of a variable with respect to some factor measures the total value of the variable divided by the total quantity of the factor, whereas the marginal value measures the change in the variable associated with a unit increase in the factor. The relation between marginal and average values with respect to some factor depends on whether the average value is decreasing, constant, or increasing with respect to the factor.

5. True.
6. The decision of how many hours to work is one of extent. By comparing the marginal earnings (benefit) and marginal cost of each hour, the worker maximizes her net benefit from working, i.e., total benefit minus total cost. As long as marginal earnings exceed marginal cost, it is in the worker's interest to work longer hours, and vice versa.
7. People act with bounded rationality because they have limited cognitive ability and lack self-control.
8. With regard to vertical boundaries, a local cable TV provider that produces TV programs is more vertically integrated than a local cable TV provider that buys TV programs from others.
9. A university that merges with a hospital is expanding its horizontal boundaries. A university that shuts some of its faculties down is shrinking its horizontal boundaries.
10. When Apple engages a contractor in China to manufacture iPhones, Apple is outsourcing, i.e., vertically disintegrating. If Apple were to manufacture the iPhones, it would be vertically integrating (upstream).
11. (a) The electricity market includes buyers and sellers. (b) The electricity industry consists of sellers only.
12. False. In business-to-business markets, buyers are businesses. In human resource markets, sellers are human beings.
13. Demand and supply model.
14. A manufacturer with market power can influence conditions of demand and/or supply.
15. (b).

Discussion answers

1. (a) Economic profit = HK\$4.8 billion - HK\$76.9 billion, which is a loss of HK\$72.1 billion.
 (b) Value added = buyer benefit - seller cost. For value added ≥ 0 , the hospital needs buyer benefit $\geq$ seller cost, or buyer benefit $\geq$ HK\$76.9 billion.
 (c) Not necessarily. The Hospital Authority can still be value adding, rather than value destroying, if buyer benefit exceeds the seller cost of HK\$76.9 billion. Evidence to the contrary is needed for critics to make a convincing case that the Hospital Authority should be shut down.
 (d) The government should only increase its subsidy if it assesses that the marginal value added from the expansion of staff and facilities, i.e. marginal buyer benefit minus marginal seller cost, is positive.

If the marginal buyer benefit (e.g., earlier detection of conditions and increased patient satisfaction) is higher than the marginal seller cost (e.g., higher payroll expenditures), then the increase in subsidy would increase value added and should be undertaken.

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PART I

Competitive markets



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CHAPTER 2

Demand

LEARNING OBJECTIVES

- Appreciate why buyers purchase more at lower prices.
- Distinguish consumer demand for normal products and inferior products.
- Appreciate the impact on demand of changes in the prices of substitutes and complements.
- Appreciate the effect of the output of the item being produced on business demand for inputs.
- Appreciate the concept of buyer surplus.
- Apply package deals and two-part pricing to extract buyer surplus.

2.1 Introduction

Based in Indonesia and Singapore respectively, Go-Jek and Grab are the Southeast Asian counterparts of Uber and more. Calling themselves “super apps,” Go-Jek and Grab not only provide ride hail and delivery services, like Uber, but have also expanded into financial services and e-commerce.

Uber introduced its ride hail service to Singapore in 2013, followed by Grab. Uber and Grab competed intensely on price through wide and intensive promotions and discounts. Meanwhile, between 2013 and 2017, Singapore’s dominant taxi operator, Comfort Delgro, shrunk its fleet by one quarter from 16,600 to 13,340 taxis.

In early 2018, Uber decided to exit Singapore and other Southeast Asian markets. Uber traded its businesses for 27.5% of Grab’s shareholding. Later the same year, Go-Jek launched its app in Singapore. Go-Jek president Andre Soelistyo committed to “bringing choice back to the ride-hailing market in Singapore.”

In 2020, Grab earned revenue of US\$1.6 billion from 25 million transactions served by over 5 million drivers and 2 million merchants. The outbreak of Covid-19 reduced ride hail revenues by 6% from the previous year but increased delivery revenues 350%.

How did the price war between Grab and Uber affect taxi operators like Comfort Delgro? After Uber’s exit, how did the reduction in promotions and discounts affect Grab? Why did the Covid-19 pandemic reduce Grab’s revenues from ride hail but raise its revenues from deliveries?

This chapter introduces the concept of a demand curve, which describes the quantity demanded of an item as a function of its price and other factors. Next, we consider how demand depends on income, the prices of complementary and substitute products, and advertising. Businesses can use the model of demand to plan their strategy.

The concept of demand explains why the price war between Grab and Uber caused Comfort Delgro to shrink its fleet of taxis. The concept explains how Uber’s exit from the Singapore market and the reduction in promotions and discounts affected Grab. It also explains why the Covid-19 pandemic reduced Grab’s ride hail revenues but increased its delivery revenues.

2.2 Individual demand

To understand how a price cut will affect sales, we need to know how the cut in price will affect the purchases of the individual buyers and, generally, how an individual’s purchases depend on the price of the item. The *individual demand curve* provides this information: it is a graph that shows the quantity that the buyer will purchase at every possible price.

Construction

Let us construct Angela’s demand for rides. We must ask Angela a series of questions that elicit her responses to changes in price. We first ask: “How many rides would you take each month at a price of \$20 per ride?” Suppose that Angela’s answer is: “None.” (Strictly, we pose the question holding “other things equal,” because Angela’s decision may depend on other factors, such as her income.)

We then pose similar questions to Angela for other possible prices for a ride: \$19, \$18, ..., \$1, and \$0. At each price, Angela says how many rides she would take a month. Table 2.1 presents this information and represents Angela’s demand for rides.

Table 2.1 Individual demand

Price (\$ per ride)	Quantity (rides per month)
20	0
19	1
18	2
...	...
0	20

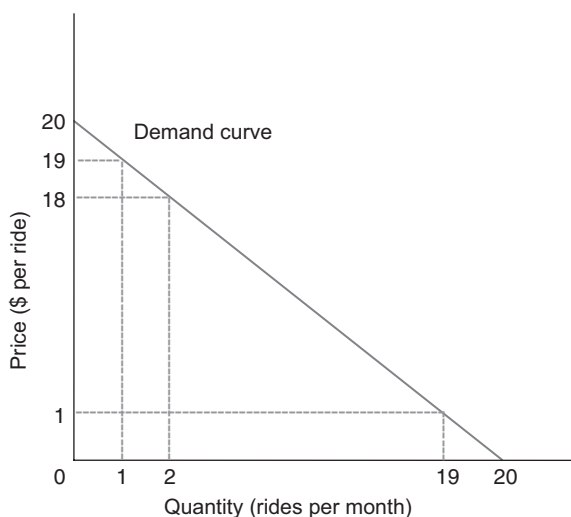


Figure 2.1 Individual demand curve

(Assuming that the consumer's demand curve is a straight line, we can draw the demand without filling all the rows of the table.)

Next we graph the information from Table 2.1 as shown in Figure 2.1. We represent the price of rides on the vertical axis and the quantity in rides a month on the horizontal axis. (Note that demand and supply curves do not follow the scientific convention of representing the independent variable, price, on the horizontal axis and the dependent variable, quantity, on the vertical axis.)

At a price of \$20, Angela says that she would not take any rides, so mark the point with the price equal to \$20 and quantity of rides equal to zero. Continuing with the information from Table 2.1, mark every pair of price and quantity that Angela reports. Joining these points then yields Angela's demand curve for rides.

Knowing Angela's demand curve, a ride hail operator can predict how Angela will respond to changes in its price. For instance, if presently the operator charges \$12 per ride, Angela will buy eight rides a month. If the operator reduces its price to \$11, it knows that Angela will increase consumption to nine rides a month. By contrast, if the operator raises its price to \$13 per ride, Angela would cut back to seven rides a month.

Marginal benefit

The individual demand curve shows the quantity that the buyer will purchase at every possible price. Let us now consider the individual demand curve from another perspective.

Referring to Angela's demand curve in Figure 2.1, we can use the curve to determine how much Angela would be willing to pay for various quantities of rides. Specifically,

the curve shows that she is willing to pay \$19 per ride for one ride a month. Further, it shows that Angela is willing to pay \$18 per ride for two rides a month, and so on.

Generally, if the number of rides is larger, the price that Angela is willing to pay is lower. Equivalently, at a lower price, Angela is willing to buy a larger quantity. These two related properties of a demand curve reflect the principle of diminishing marginal benefit.

Marginal benefit:

The benefit provided by an additional unit.

Diminishing marginal benefit:

Each additional unit provides less benefit than the preceding unit.

Any item that a consumer is willing to buy must provide some benefit. We measure the benefit in monetary terms. The **marginal benefit** is the benefit provided by an additional unit of the item. The marginal benefit of the first ride is the benefit from one ride a month. Similarly, the marginal benefit of the second ride is the additional benefit from taking a second ride each month.

By the principle of **diminishing marginal benefit**, each additional unit of consumption provides less benefit than the preceding unit. In Angela's case, this means that the marginal benefit of the second ride is less than the marginal benefit of the first ride, the marginal benefit of the third ride is less than the marginal benefit of the second ride, and so on.

Accordingly, the price that an individual is willing to pay will decrease with the quantity purchased. Hence, the demand curve will slope downward. This is a general property of all demand curves: the lower the price, the larger will be the quantity demanded. The fundamental reason for the downward slope is diminishing marginal benefit.

Progress check 2A. Suppose that the operator presently charges \$11 per ride. By how much must the operator cut the price for Angela to increase her consumption by three rides a month?

Preferences

The procedure for constructing a demand curve relies completely on the consumer's individual preferences. The individual decides how much he or she wants to buy at each possible price. The demand curve then displays information in a graphical way.

Consumers may have different preferences and hence their demand curves will differ. One person may like to eat red meat while another is a vegetarian. Further, demand curves will change with changes in the consumer's preferences. As a person grows older, her demand for rock videos and extreme sports will decline, while her demand for healthcare and cruise ship holidays will increase.

Deliveroo: discount vouchers

Founded in London, Deliveroo delivers food and groceries in the United Kingdom and Ireland, as well as ten other countries. At the time of writing, it served 7.1 million consumers with an average of 3.3 orders per month,

and derived about half of its revenues and orders from the United Kingdom and Ireland.

In May 2021, Deliveroo offered a voucher for 20% discount on a purchase of at least £15 at specific Subway restaurants. The discount voucher targets people who had consumed to a level at which their marginal benefit is close to the regular Subway price. Since their marginal benefit is close to the regular price, they would not buy more. However, the discount would reduce the price of additional items and might persuade such consumers to buy more.

Why was the discount limited to purchases of at least £15? This is a way to target the discount and induce additional consumption. By contrast, if there was no minimum purchase, then all consumers would pay less, including those who do not increase consumption. Then Deliveroo and Subway would simply reduce their profit from such consumers without increasing their purchases.

2.3 Demand and income

We have discussed how Angela's demand for rides varies with the price of rides. For businesses, it is also useful to appreciate the effect of other factors that affect demand. An important factor is income. If Angela gets a raise, how would that affect her demand for rides?

Income changes

Suppose that Angela's income is presently \$50,000 a year. Table 2.1 and Figure 2.1 represent Angela's demand for rides with an income of \$50,000 a year.

We then ask Angela a series of questions. These questions probe the effect of changes in income as well as price: "Suppose that your income is \$40,000 a year. How many rides would you buy a month at a price of \$20 per ride?" We then repeat the question with other possible prices and tabulate the information.

Suppose that Table 2.2 represents Angela's answers. We also represent this information in Figure 2.2. Marking the pairs of prices and quantities, and joining the points, we have Angela's demand curve with an income of \$40,000 a year.

Angela's demand curve for rides with \$40,000 income lies to the left of her demand curve with \$50,000 income. At every price, the quantity demanded with \$40,000 income is less than or equal to the quantity demanded with \$50,000 income.

Referring to Figure 2.1, if the price of rides drops from \$8 to \$7 per ride, while Angela's income remains unchanged at \$50,000 a year, we trace Angela's response by moving *along* her demand curve from the \$8 level to the \$7 level.

By contrast, referring to Figure 2.2, if her income falls from \$50,000 to \$40,000, while the price remains at \$8 per ride, we represent Angela's response by *shifting* the

Table 2.2 Individual demand with lower income

<i>Price (\$ per ride)</i>	<i>Quantity (rides per month)</i>
20	0
19	0
...	0
10	0
9	2
8	4
...	...
0	20

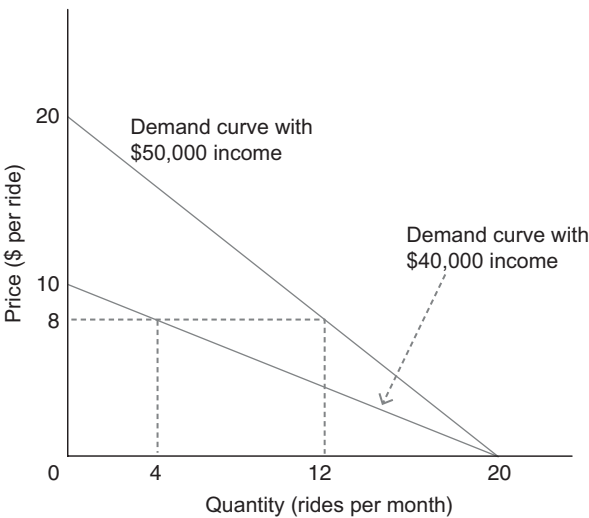


Figure 2.2 Individual demand curve with lower income

entire demand curve to the left. The essential reason for this difference is that the figure, having just two axes, does not explicitly represent the buyer’s income.

Let us understand the difference in graphical representation between a change in price and a change in income in another way. On Figure 2.2, at the \$8 level, mark two quantities: a quantity of 12 rides a month when Angela’s income is \$50,000, and another quantity of four rides a month when Angela’s income is \$40,000.

Can we join these points to form a demand curve? The answer is definitely “no,” because each point corresponds to a different income and different demand curve. A demand curve shows how a buyer’s purchases depend on changes in the price of some item, holding income and other factors unchanged. Accordingly, for each of the points, there is a separate demand curve.

In general, we represent a change in the price of the item by a movement *along* the demand curve. By contrast, we represent a change in income or any factor other than the price of the item by a *shift* in the entire demand curve.

Normal and inferior products

When Angela's income drops from \$50,000 to \$40,000 a year, her demand for rides shifts to the left. As Angela's income falls, her demand for rides also falls. By contrast, if her income were to rise, her demand would increase.

Let us compare Angela's demand for rides with her demand for bus travel. If Angela's income falls, it is quite possible that she will substitute cheaper forms of travel for more expensive ones. In particular, the drop in her income may lead to an increase in her demand for bus travel.

By contrast, when Angela's income increases, we can expect her to switch away from cheaper forms of travel and toward more expensive alternatives. So, as her income rises, Angela's demand for bus travel will fall.

Goods and services can be categorized according to the effect of changes in income on demand. If the demand for an item increases as the buyer's income increases, while the demand falls as the buyer's income falls, then the item is a **normal product**. Equivalently, the demand for a normal product is positively related to the buyer's income.

Normal product:

Demand is positively related to buyer's income.

By contrast, the demand for an **inferior product** is negatively related to the buyer's income. This means that the demand falls as the buyer's income increases, while the demand increases as the buyer's income falls.

Inferior product:

Demand is negatively related to buyer's income.

For Angela, ride hail is a normal product, while bus travel is an inferior product. Generally, broad categories of products tend to be normal, while particular products within the categories may be inferior. Consider, for instance, the broad category of commuting. While commuting as a category is a normal product, bus travel may be an inferior product.

The distinction between normal and inferior products is important for business strategy. When the economy is growing and incomes are rising, the demand for normal products will rise, while the demand for inferior products will fall. By contrast, when the economy is in recession and incomes are falling, the demand for normal products will fall, while the demand for inferior products will rise.

The distinction is also useful in international business. The demand for normal products is relatively higher in richer countries, while the demand for inferior products is relatively higher in poorer countries. For instance, in developed countries, relatively more people commute to work by car than bus. The reverse is true in poorer countries.

Progress check 2B. Draw a curve to represent an individual consumer's demand for bus travel. (a) Explain why it slopes downward. (b) How will a drop in the consumer's income affect the demand curve?

Uber and Go-Jek: cars and motorbikes

Uber and Go-Jek were established in the same year, 2010, but on opposite sides of the world. Garrett Camp and Travis Kalanick founded Uber as a mobile app to hail cars in San Francisco. Nadiem Makarim and Michaelangelo Moran founded Go-Jek as a call center to book motorcycle taxis (ojeks) in Indonesia. Five years later, they upgraded Go-Jek into a mobile app encompassing ride hail by motorcycle or car, delivery, as well as e-commerce.

The differences in income between San Francisco and Jakarta may explain why Uber started with cars and Go-Jek with motorbikes. American consumers earn more than Indonesians and are willing to pay more for travel. In Jakarta and elsewhere in Asia, motorcycle taxis offer more economical transport than four-wheeled taxis. Moreover, when traffic is congested, motorbikes may be faster than cars.

2.4 Other factors in demand

Individual demand may depend on other factors besides the price of the item and the buyer's income. The other factors may include the prices of related products, advertising, durability, season, and location. Here, we discuss the prices of related products and advertising, as well as a particular factor in business demand, production.

Complements and substitutes

Suppose that Angela uses ride hail to meet dates. How would an increase in the price of restaurant meals affect Angela's demand for rides? A change in the price of restaurant meals will affect Angela's purchases of rides at all prices of rides. Hence, it would shift the entire demand curve.

Suppose that presently the price of restaurant meals is \$20. Figure 2.3 represents Angela's demand curve for rides when the price of restaurant meals is \$20.

We next construct Angela's demand when the price of restaurant meals is \$25. To do so, we ask Angela how many rides she would take at various ride prices if the price of restaurant meals were \$25. Figure 2.3 shows the new demand curve: when the price of restaurant meals is higher, the demand curve for rides is further to the left, implying that demand is lower.

Generally, related products can be classified as either complements or substitutes according to the effect of an increase in the price of one product on the demand for the other. Two products are **complements** if an increase in the price of one causes the demand for the other to fall. By contrast, two products are **substitutes** if an increase in the price of one causes the demand for the other to increase.

For Angela, restaurant meals and rides are complements. The more restaurant meals she consumes, the more rides she will want. Hence, if the price of restaurant

Complements: An increase in the price of one causes a fall in the demand for the other.

Substitutes: An increase in the price of one causes an increase in the demand for the other.

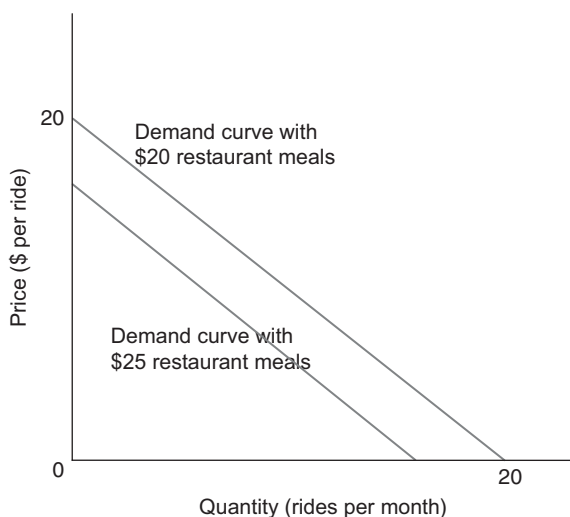


Figure 2.3 Individual demand curve with more expensive complement

meals is higher, causing her to consume fewer restaurant meals, she will take fewer rides.

How would an increase in taxi fares affect Angela's demand for ride hail? Instead of traveling by ride hail, Angela could travel by taxi. Accordingly, these two products are substitutes. If there is an increase in taxi fares, Angela's demand for ride hail would increase and the demand curve would shift to the right.

Generally, a demand curve will shift to the left if there is either an increase in the price of a complement or a fall in the price of a substitute. By contrast, a demand curve will shift to the right if there is either a fall in the price of a complement or an increase in the price of a substitute.

Progress check 2C. Referring to Figure 2.1, how would a fall in the price of restaurant meals affect the original demand curve?

Covid-19 and the demand for Grab services

Following the outbreak of Covid-19 in early 2020, the Singapore government imposed a partial lockdown called a "circuit breaker" to control the spread of the disease. Only essential workers were allowed to attend at workplaces. All other workers and students were required to work from home. The government also prohibited eating in restaurants. Restaurants were only allowed to sell food for takeaway or delivery.

With the massive shift to work from home, the demand for ride hail dropped sharply, and so reduced Grab's revenues from ride hail. However, as people shifted to working from home, they switched from eating in restaurants to buying food by delivery, which increased Grab's delivery revenue.

NIO: batteries as a service

Electric cars and electricity are complements. Yet, unlike gasoline stations, charging points are not ubiquitous. With current technology, the limited capacity of batteries has given rise to range anxiety – the driver's worry that the batteries would run out before reaching a charging point. Another concern is the time taken to charge batteries. Enter premium electric car manufacturer NIO's Power Swap. Enabled by over 1,300 patented technologies, NIO Power Swap offers an ultimate and exclusive power service experience. It takes only three minutes to swap a fully charged battery.

Advertising

Advertising expenditure is another factor in demand. For instance, Angela's demand for rides may depend on advertising by the operator. Generally, an increase in the seller's advertising will increase the buyer's demand. We represent this by shifting the buyer's demand curve to the right.

Advertising may be informative or persuasive. Informative advertising communicates information to potential buyers and sellers. For instance, ride hail operators list their services and fares on their websites, which serve to inform potential customers.

Persuasive advertising aims to influence consumer choice. Ride hail operators may use advertising to retain the loyalty of existing customers and attract customer of other brands to switch.

Business demand

Ride hail service and restaurant meals are consumer goods. Consumers buy them for final consumption or usage. By contrast, booking systems and restaurant equipment are industrial goods. Businesses buy them to use as inputs in the production of other goods and services. In any economy, the majority of economic transactions are business-to-business sales.

The business demand for an item is similar to consumer demand in that it depends on the price of the item, and the prices of complements and substitutes. One factor

which is unique to business demand is production. If a restaurant produces more meals, it will need more meat and vegetables, supplies like cooking oil and detergent, and furniture and equipment. Conversely, if a restaurant produces fewer meals, it will need fewer ingredients, supplies, and equipment.

The way in which business demand depends on production is similar to the way in which consumer demand for normal goods depends on buyer income. Just as consumer demand for normal goods increases with higher buyer income, business demand for inputs tends to increase with higher production.

2.5 Buyer surplus

Recall that the individual demand curve shows the quantity that the buyer will purchase at every possible price. The demand curve also shows the maximum amount that a buyer is willing to pay for each unit of the item.

The perspective of “willingness to pay” is important for pricing policy as it shows the maximum that the buyer is willing to pay. Importantly for businesses, the maximum that the buyer is willing to pay is also the maximum that the seller can charge. We will explain two pricing schemes to extract the maximum that the buyer is willing to pay, and so maximize the seller’s profit.

Benefit

The demand curve shows the buyer’s marginal benefit from each unit. Using this information, we can calculate the buyer’s **total benefit**, which is the benefit provided by all the units that the buyer consumes. The total benefit is the marginal benefit from the first unit plus the marginal benefit from the second unit, and so on, up to and including marginal benefit from the last unit that the buyer purchases.

Total benefit: The benefit provided by all the units that the buyer consumes.

A buyer’s total benefit is the maximum that the buyer is willing to pay. Graphically, the total benefit is represented by the area under the buyer’s demand curve up to and including the last unit consumed.

Let us calculate Angela’s total benefit from eight rides a month. Her total benefit is the area under her demand curve up to and including eight rides a month. In Figure 2.4, this is area $Obcd = \frac{1}{2} (\$8 \times 8) + \$12 \times 8 = \$128$. So, the maximum that Angela would be willing to pay for eight rides a month is \$128.

Benefit and expenditure

Suppose that the price of a ride is \$12. Then Angela buys eight rides a month. As already calculated, her total benefit would be \$128. Angela, however, needs to pay only $\$12 \times 8 = \96 , which is less than her total benefit.

The difference between a buyer’s total benefit from some consumption and her actual expenditure is the **buyer surplus**. At the price of \$12 per ride, Angela’s buyer surplus is $\$128 - \$96 = \$32$.

Buyer surplus: The difference between the buyer’s total benefit from some consumption and actual expenditure.

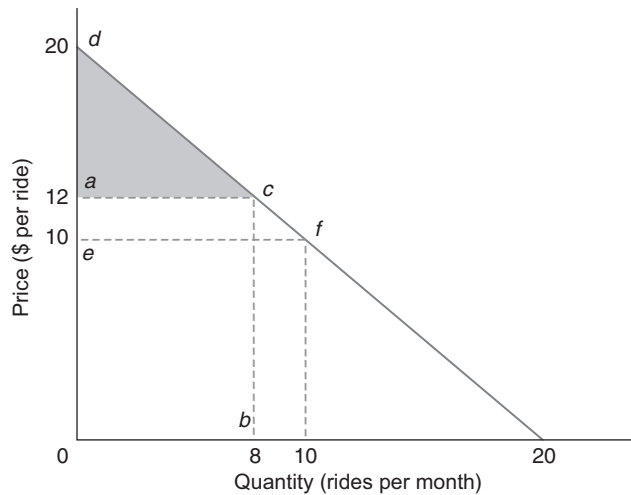


Figure 2.4 Individual buyer surplus

Referring to Figure 2.4, at the price of \$12, her expenditure on eight rides a month is represented by the area $Obca$ under the \$12 line up to and including eight rides a month. Hence, Angela's buyer surplus is the difference between the area $Obcd$ which represents total benefit and the area $Obca$ which represents expenditure, or the area acd between her demand curve and the \$12 line.

Generally, provided that purchases are voluntary, a buyer must get some surplus. If not, he or she would not buy. The maximum that a seller can charge is the buyer's total benefit. If a seller tries to charge more, then the buyer will walk away.

Progress check 2D. Suppose that the price of rides is \$8. On Figure 2.4, mark Angela's buyer surplus.

Price changes

Referring to Angela's demand for rides, at the price of \$12, Angela buys eight rides a month, and her buyer surplus is area acd . Now suppose that the price drops to \$10. Then Angela will increase her travel from eight to ten rides a month. Her buyer surplus will increase by area $efca$: she gets the eight original rides at a lower price, and she travels more.

Generally, a buyer gains from a price reduction in two ways. First, the buyer gets a lower price on the quantity that she would have purchased at the original higher price. Second, she will buy more, gaining buyer surplus on each of the additional purchases. The extent of the second effect depends on the buyer's sensitivity to the price reduction. The greater the increase in purchases, the larger will be the buyer's gain from the price reduction.

Similarly, a buyer loses from a price increase in two ways – the buyer must pay a higher price, and will buy less.

Package deals and two-part pricing

A seller who has complete flexibility over pricing maximizes profit by charging each buyer just a little less than her total benefit. Practically, this can be implemented in two ways – through package-deal pricing and two-part pricing.

Let us explain these pricing policies in the context of Angela's demand for ride hail, shown in Figure 2.4. If the ride hail operator charges a price of \$12, Angela will buy eight rides a month. As calculated above, Angela would derive total benefit of \$128, spend \$96, and get buyer surplus of \$32. The ride hail operator would earn revenue of \$96.

Suppose that the ride hail operator offers Angela a package deal of eight rides a month at \$127 with no other alternative. A **package deal** is a pricing scheme comprising a fixed payment for a fixed quantity of consumption. If Angela bought the package deal, she would consume eight rides a month and get buyer surplus of $\$128 - \$127 = \$1$. Since there is no other alternative, Angela would buy this package.

The ride hail operator would earn \$127 in revenue, which is almost one-third more than the revenue from the original \$12 pricing policy. The package deal enables the operator to soak up almost all of Angela's buyer surplus. Since Angela's consumption is the same under the original and package-deal pricing, the operator's cost would be the same. So, its profit would definitely be higher.

The ride hail operator could also extract Angela's buyer surplus through two-part pricing. A **two-part price** is a pricing scheme comprising a fixed payment and a charge based on consumption.

Suppose that the ride hail operator offers a two-part plan comprising a \$31 monthly charge and a charge of \$12 per ride. Referring to Figure 2.4, if Angela bought this package, she would buy eight rides a month and her total benefit would be \$128. She would pay the \$31 monthly charge and ride charges of $8 \times \$12 = \96 . Hence, her buyer surplus would be $\$128 - \$31 - \$96 = \1 .

Just like the package deal, the two-part price enables the ride hail operator to soak up most of the consumer's buyer surplus. The operator would earn \$127 in revenue and the cost would be the same as under the original \$12 pricing policy.

Providers of many services, including banking, car rentals, telecommunications, and Internet access, make use of package deals and two-part pricing. They also combine the two pricing techniques such that the monthly charge covers a specified quantity of "free" usage, while requiring the user to pay a charge for additional use.

Package deal:

A pricing scheme comprising a fixed payment for a fixed quantity of consumption.

Two-part price:

A pricing scheme comprising a fixed payment and a charge based on consumption.

Progress check 2E. Explain the differences between a package deal and two-part price.

Telstra Mobile

Telstra is Australia's largest provider of mobile telecommunications services. In May 2021, it offered two SIM-only contract plans for mobile telecommunications. The small plan provided 40 gigabytes of data usage at a subscription charge of A\$55 per month, while the medium plan provided 80 gigabytes of data at a subscription charge of A\$65 per month.

Under the small plan, the price of data was $A\$55/40 = A\1.375 per gigabyte. Relative to the small plan, the medium plan provided an additional 40 gigabytes of data for just A\$10, or 25 cents per gigabyte. The lower price for additional data usage is consistent with the principle of diminishing marginal benefit.

By offering two package deals with different quantities of data, Telstra can extract some buyer surplus from both small and medium users. Consumers with small demand would prefer the small plan. To ensure that consumers with larger demand buy the medium plan, Telstra must design the small and medium plans so that those consumers prefer the medium plan.

2.6 Market demand

For strategy, marketing, and other purposes, businesses might plan on the basis of the entire market rather than individual customers. Then, they need to understand the demand of the entire market.

Market demand curve: A graph of the quantity that all buyers will purchase at every possible price.

The **market demand curve** is a graph of the quantity that all buyers will purchase at every possible price. The market demand curve is constructed in a similar way to the individual demand curve. To construct the market demand for an item, ask each potential buyer the quantity that they would buy at every possible price. Then, at each price, add the individual quantities to get the quantity that the market as a whole will demand (see Appendix 2.A).

The properties of the market demand curve are similar to those of the individual demand curve. As each buyer's marginal benefit diminishes with the quantity of consumption, the market demand curve slopes downward. Equivalently, at a lower price, the market as a whole will buy a larger quantity.

The market demand depends on the other factors that affect individual demand. The market demand for a consumer good depends on buyers' incomes, the prices of related products, and advertising. The market demand for a business input depends on the production of the business and the prices of related products.

The market buyer surplus is the difference between the buyers' total benefit from consumption and the buyers' actual expenditure. Graphically, it is the area between the market demand curve and the price line.

Progress check 2F. What are the properties of a market demand curve?

Grab, Uber, and taxi services

Ride hail is a substitute for other personal transport services including taxis. Grab and Uber discounted so deeply that it was cheaper for university students to travel to campus by ride hail than public bus and train. As consumers switched towards ride hail, the demand for taxi services dropped sharply, and Comfort Delgro shrunk its fleet of taxis by one quarter.

When exiting the Singapore market, Uber sold its business to Grab, leaving Grab as the only ride hail operator. This would have reduced competition in the market for personal transport and increased the demand for Grab's services. However, the reduction in competition may have attracted Go-Jek to enter the Singapore market.

Key takeaways

- Owing to diminishing marginal benefit, consumers and businesses are only willing to buy more if the price is lower.
- Consumer demand for normal products increases with income, while consumer demand for inferior products decreases with income.
- The demand for a product increases with the price of a substitute, and decreases with the price of a complement.
- Business demand increases with the output of the item being produced.
- Buyer surplus is the difference between the buyers' total benefit from consumption and the buyers' actual expenditure.
- A seller can extract the buyers' surplus and raise profit by selling through package deals and two-part pricing.

Review questions

1. Think of a good or service that you bought recently. Would you have bought less of the item if the price had been lower? Explain why or why not.
2. Give an example of an inferior product, and explain why it is an inferior product.

3. Think of a good or service that you bought recently. Would you have bought more or less of the item if your income had been lower? Explain why or why not.
4. Give an example of two products which are complements, and explain why they are complements.
5. A new birth-control device protects women against pregnancy but not sexually transmitted diseases. Would this new product affect the demand for male condoms or birth-control pills relatively more?
6. How would Pepsi advertising affect the demand for: (a) Pepsi; and (b) Coca-Cola?
7. A key component of mobile phones is the microprocessor. Explain how changes in consumer incomes affect Apple's demand for microprocessors.
8. Why are automated teller machines (ATMs) relatively more common in countries with higher labor costs?
9. Explain the meaning of buyer surplus.
10. Buyer surplus applies to consumer demand but not business demand. True or false?
11. Passengers on a London to Sydney flight compared fares and discovered that they had paid different prices for the same flight. Explain how this illustrates that the market demand curve is downward-sloping.
12. The price of mobile telephone calls is 10 cents a minute. Antonella buys 200 minutes a month. Illustrate her demand curve and identify her buyer surplus.
13. "Summer sale: the more you buy, the more you save." Comment.
14. What is a package deal? How can a ride hail operator use package deals to increase profit?
15. What is two-part pricing? How can a mobile telecommunications provider use two-part pricing to increase profit?

Discussion questions

1. An important issue in economic development is the relationship between fertility and female literacy. With data from 110 countries, the following linear relationship between the female literacy rate and the number of births per woman (fertility rate) was estimated: if the literacy rate is 0%, the fertility rate is 7.63 per woman; and if the literacy rate is 100%, the fertility rate is 2.42 per woman.
 - (a) On a figure with female literacy on the vertical axis and fertility on the horizontal axis, draw a graph of the linear relationship. Referring to the linear relationship, if the literacy rate is 60%, what would be the fertility rate (approximately)?

- (b) A large cost of having a baby is the time that the mother must invest in bearing and rearing the child. For a more educated woman, is the value of this time higher or lower?
 - (c) In the chart, mark “cost of child” on the vertical axis. Does the trend line have any relation to a demand curve? Explain.
 - (d) Give an alternative explanation of the figure: use the fertility rate to explain female literacy.
2. Deliveroo delivers food and groceries in the United Kingdom and Ireland. In May 2021, Deliveroo offered a voucher for a 20% discount on a purchase of at least £15 at specific Subway restaurants.
- (a) Construct a straight-line individual demand curve as follows. At a price of £5, the consumer would buy three sandwiches, while, at a price of £4, she would buy five sandwiches.
 - (b) Why does the demand curve slope downward?
 - (c) Suppose that the consumer does not use the discount voucher and the Subway price is £5. How many sandwiches would she buy and how much would she spend?
 - (d) Now suppose that the consumer uses the discount voucher. What would be the price of sandwiches? How many sandwiches would she buy and how much would she spend?
 - (e) Referring to (c) and (d), how would the voucher change the consumer’s spending at Deliveroo?
3. Hutchison Telecom provides mobile and broadband telecommunications services in Hong Kong under the brand Three. In 2020, Three served 1.427 million post-paid customers who spent an average of HK\$196 per month, and 1.852 million prepaid customers who spent an average of HK\$171 per month. Post-paid service is subject to a contract that stipulates a monthly subscription charge.
- (a) Explain the meaning of normal and inferior products.
 - (b) Apply the concepts of normal and inferior products to prepaid and post-paid mobile telephone service.
 - (c) Refer to Three’s average revenue from prepaid and post-paid customers. Are the data consistent with your answer to (b)?
 - (d) A major source of Three’s revenue from post-paid customers is international roaming charges. How would Covid-19 travel restrictions have affected Three’s revenues from roaming?
4. The Coca-Cola Company markets the Coke brand and manufactures concentrate for sale to regional bottlers. Coke bottlers mix concentrate with sweetener and water to produce the soft drink for supermarkets, restaurants, and other retail outlets. Possible sweeteners include corn syrup

and sugar. Owing to federal restrictions against imports, sugar is relatively more expensive in the United States than in the rest of the world.

- (a) Why do US soft drink bottlers use relatively more corn syrup than bottlers elsewhere in the world?
 - (b) Draw a US Coke bottler's demand for corn syrup. (*Hint: You are free to assume any data necessary to draw the demand.*)
 - (c) Use your figure to explain how the following changes would affect the Coke bottler's demand for corn syrup: (i) removal of the federal restrictions against sugar imports; (ii) an increase in the sales of Pepsi; and (iii) shift in consumer preferences towards unsweetened beverages.
 - (d) Who benefits and who loses from the federal restrictions against sugar imports?
5. Historically, Bombardier specialized in producing regional jets, which are smaller short-range jets with up to 100 seats. In 2008, it secured a launch customer for the new CSeries, a family of 100- to 149-seat mid-range aircraft, which was scheduled to enter service in late 2015. The CSeries would reduce fuel consumption by 20% through use of advanced materials and a more fuel-efficient engine, the Pratt & Whitney PW1000G.
 - (a) Draw the market demand for jet aircraft. (*Hint: You are free to assume any data necessary to draw the demand.*)
 - (b) Use your figure to explain how the Covid-19 pandemic affected the consumer demand for air travel and the airline demand for jet aircraft.
 - (c) If travelers are less sensitive to fare increases, how would that affect the demand for fuel-efficient aircraft?
 - (d) How does the price of oil affect the demand for advanced materials?
 6. Following the outbreak of Covid-19 in early 2020, the Singapore government imposed a partial lockdown called a "circuit breaker" to control the spread of the disease. Only essential workers were allowed to attend at workplaces. All other workers and students were required to work from home. The government also prohibited eating in restaurants. Restaurants were only allowed to sell food for take away or delivery.
 - (a) Discuss the relations – whether complements or substitutes – among ride hail, food delivery, and restaurant dining.
 - (b) Draw the market demand curves for (i) ride hail and (ii) food delivery. (*Hint: You are free to assume any data necessary to draw the demand.*)
 - (c) Use your figures to explain how the shift to work from home affected the demands for ride hail and food delivery.
 - (d) Use your figures to explain how the prohibition against eating in restaurants affected the demands for ride hail and food delivery.
 7. At the time of writing, almost half of all residential water connections in the United Kingdom were not metered. Unmetered customers paid a flat fee regardless of usage.

- (a) Suppose that the Johnson home water supply is not metered, and the family consumes 10,000 liters a month. Illustrate the family's monthly demand curve for water, assuming that it is a straight line, and, if the price is £50 per 1,000 liters, the family would consume nothing.
 - (b) Calculate the total benefit and marginal benefit from water when the Johnson family consumes 10,000 liters a month. What is the family's buyer surplus?
 - (c) Suppose that the water supplier installs a water meter and charges a price of £5 per 1,000 liters. How much water would the family consume and how much would it spend each month?
 - (d) What is the maximum that the water supplier could charge the Johnson family for the consumption in (c)?
8. Students at the University of California, Los Angeles, enjoy several privileges. One is a good education at a low price. Another is California's unbeatable weather, and a third is access to discounted movie tickets. Suppose that Alan buys 12 tickets a year at \$7 rather than the full price of \$10. By how much does he gain from the discount scheme?
- (a) One answer is that Alan "saves" $\$10 - \$7 = \$3$ on each ticket, which sums to a total of $\$3 \times 12 = \36 . Explain why this overestimates Alan's gain.
 - (b) Using a suitable diagram and the concept of buyer surplus, explain how much Alan gains from the discount scheme.
 - (c) Taking account of the discount movie scheme, by how much could the University raise Alan's tuition fees?
9. Telstra is Australia's largest provider of mobile telecommunications services. In May 2021, it offered two SIM-only contract plans for mobile telecommunications. The small plan provided 40 gigabytes of data usage at a subscription charge of A\$55 per month, while the medium plan provided 80 gigabytes of data at a subscription charge of A\$65 per month.
- (a) Suppose that Julia's demand is a straight line, zero at a price of A\$5 per gigabyte and 40 at a price of zero. Illustrate her demand.
 - (b) Suppose that Scott's demand is a straight line, zero at a price of A\$4 per gigabyte and 80 at a price of zero. On the same figure as in (a), illustrate his demand.
 - (c) Compare Julia's buyer surplus if she buys the small vis-à-vis medium plan. Which plan would she buy?
 - (d) Compare Scott's buyer surplus if he buys the small vis-à-vis medium plan. Which plan would he buy?
 - (e) Suppose that Telstra wants Scott to buy the medium plan. By how much can Telstra raise the price of the medium plan without Scott switching to the small plan?

You are the consultant!

Consider a product that your organization sells. (a) What customer segments buy the product? (b) Describe the current pricing policy. (c) Under the current pricing policy, do any of the customer segments enjoy buyer surplus? (d) Explain how you could use the techniques of package-deal or two-part pricing to extract the buyer surplus and raise profit.

Progress check answers

- 2A. The operator must cut its price by \$3 from \$11 to \$8.
- 2B. (a) It slopes downward because of diminishing marginal benefit.
(b) Assuming that bus travel is an inferior service, the drop in the consumer's income will cause the demand curve to shift to the right.
- 2C. Restaurant meals are a complement with ride hail travel. A fall in the price of restaurant meals will cause the demand curve for rides to shift to the right.
- 2D. If the price of rides is \$8, Angela's buyer surplus would be the area under her demand curve above the horizontal line at the price of \$8.
- 2E. Package deal offers fixed quantity of consumption for fixed payment. Two-part price stipulates fixed payment plus charge based on consumption, and allows consumer to choose the quantity of consumption.
- 2F. Similar to those of individual demand curve.

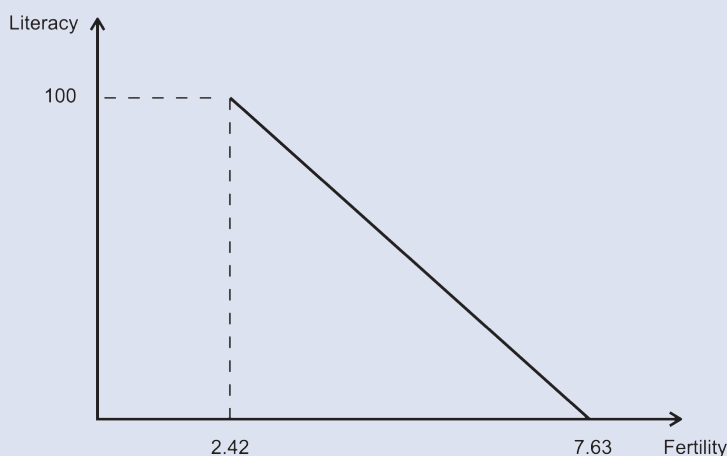
Review answers

- 1. [Omitted.]
- 2. The demand for an inferior product falls with consumer income.
- 3. [Omitted.]
- 4. Two products are complements if an increase in the price of one causes a fall in the demand for the other.
- 5. Male condoms protect women against both pregnancy and sexually transmitted diseases. Birth-control pills protect women only against pregnancy. Hence, the new birth-control device is a closer substitute for birth-control pills and it would reduce the demand for birth-control pills relatively more.
- 6. Pepsi advertising will: (a) increase the demand for Pepsi, and (b) decrease the demand for Coca Cola.

7. Changes in consumer incomes would affect consumer demand for Apple iPhones, and so affect Apple's demand for microprocessors.
8. ATMs are a substitute for bank clerks. The higher labor costs will increase the demand for ATMs.
9. Buyer surplus is the difference between buyer's total benefit from consumption and the buyer's actual expenditure.
10. False.
11. Each person has a different marginal benefit for the flight. The market demand curve shows the marginal benefits of the various consumers, arranged from the consumer with highest marginal benefit to the consumer with lowest marginal benefit.
12. Draw any line which includes the point with 200 minutes and 10 cents. Antonella's buyer surplus is the area between the demand curve and the 10 cents line.
13. Not true. Each additional item provides lower marginal benefit. Actual savings are the difference between total benefit and the price paid.
14. A package deal provides a fixed level of consumption at a lump-sum price. A ride hail operator can design a package deal providing a fixed number of rides, fixed at the economically efficient level, at a price just a little less than the consumer's total benefit.
15. Two-part pricing is a pricing scheme comprising a fixed payment and a charge for usage. A mobile provider can design a two-part price such that the fixed charge extracts the consumer's buyer surplus.

Discussion answers

1. (a)



Fertility rate = 4.5.

- (b) Higher (the opportunity cost is higher).
- (c) The trend line is like a demand curve: the lower is the cost of a child, the higher is the fertility rate.
- (d) Women who bear more children would have less time and resources to attend school. Hence, the higher the fertility rate, the lower would be the female literacy rate.

Appendix 2.A

Market demand curve: construction

Chapter 2 introduces the concept of market demand, which shows the quantity that all buyers will buy at every possible price. One way to construct the market demand is to ask each potential consumer the quantity that they would buy at every possible price. Then, at each price, sum the reported individual quantities to get the quantity that the market as a whole will buy.

Market demand				
Price (\$)(per movie)	Angela	Maggie	Lisa	Market
20	0	0	0	0
19	1	0	0	1
18	2	0	0	2
...	...	0	0	...
10	10	10	0	20
8	12	14	2	28
...	...	...	...	...
0	20	30	10	60

Another way to construct the market demand is by *horizontal summation* of the individual demand curves. Figure 2.A1 draws the individual demand curves of three consumers – Angela, Maggie, and Lisa. Horizontal summation means adding the curves in the horizontal direction.

Each individual demand curve shows the number of rides that the consumer would buy at every possible price. So, at every price, add the quantities that the three consumers would buy to obtain the quantity that the market as a whole will buy. The figure depicts the market demand as the bold line.

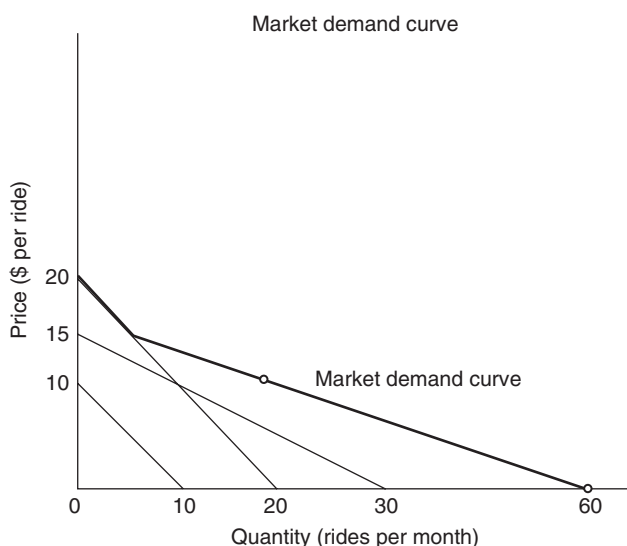


Figure 2.A1 Market demand curve

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CHAPTER 3

Elasticity

LEARNING OBJECTIVES

- Understand the concept of own-price elasticity of demand.
- Distinguish price elastic and price inelastic demand.
- Appreciate that, if demand is inelastic, the seller can increase profit by raising the price.
- Appreciate the behavioral factors underlying the elasticity of demand.
- Understand the concepts of income elasticity, cross-price elasticity, and advertising elasticity of demand.

3.1 Introduction

Amazon.com's Prime service bundles free shipping on consumer purchases, grocery discounts, as well as video, music, games, and books for a fixed annual fee. When Covid-19 broke out, governments across the world confined people at home to limit the spread of the disease. Locked down at home, consumers turned to buying work equipment, office supplies, and even food and other essentials online. Between January 2020 and April 2021, worldwide Amazon Prime subscriptions increased by one-third from 150 million to 200 million.

In March 2014, Amazon raised the price of Prime from US\$79 to US\$99 per year, then, in April 2018, raised the price again to US\$119. Despite the price increases, subscriptions to Prime continued to grow. Consumer Intelligence Research Partners reported that 93% of one-year Prime subscribers renewed their subscriptions, while the rate was 98% among two-year subscribers.

By default, Amazon renews all subscriptions to Prime. To prevent automatic renewal, the customer must browse the Amazon Prime webpage, navigate to the Membership page, and there, choose to end the subscription.

In June 2020, investment bank, RBC Capital Markets, surveyed 2,800 consumers. When asked how they would respond if Amazon raised the price of Prime to US\$139, 46% said that they would cancel their Prime subscription, while 54% said they would not.

How does Amazon’s policy of automatically renewing Prime subscriptions influence the stickiness of subscribers? How would an increase in the price of Prime affect demand, sales, and revenues? If Amazon were to raise the price, by how much should it do so?

To address these questions, we apply the concept of *elasticity*. The elasticity of demand measures the responsiveness of demand to changes in an underlying factor, such as the price of the item, the prices of complementary or substitute products, buyers’ income, and advertising expenditure. There is an elasticity corresponding to every factor that affects demand.

The *own-price elasticity* of demand measures the responsiveness of the quantity demanded to changes in the price of the item. Using the own-price elasticity of the demand for Prime, Amazon can estimate the impact of an increase in price on demand and revenues. A price increase will always reduce the quantity demanded. We show that a price increase will raise sellers’ profit if demand is price inelastic.

Next, we discuss how behavioral biases affect elasticities. Then, we introduce the concepts of income, cross-price, and advertising elasticities of demand. .

3.2 Own-price elasticity

To gauge the impact of changes in price on quantity demanded, we need a measure of buyers’ sensitivity to price changes – the own-price elasticity of demand. The concept of own-price elasticity of demand is so basic that it is often called simply the *price elasticity* or *demand elasticity*.

Own-price elasticity of demand: The percentage by which quantity demanded will change if price of the item rises by 1%.

The **own-price elasticity of demand** is the percentage by which the quantity demanded will change if the price of the item rises by 1%. Equivalently, the own-price elasticity is the ratio

$$\frac{\text{Proportionate change in quantity demanded}}{\text{Proportionate change in price}} \tag{3.1}$$

or

$$\frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in price}}. \tag{3.2}$$

Estimation

To estimate the own-price elasticity of demand, collect records of changes in the price of the item and the corresponding changes in quantity demanded. Then calculate the own-price elasticity as the ratio of the proportionate (percentage) change in quantity demanded to the proportionate (percentage) change in price.

To illustrate, Figure 3.1 represents the demand for subscriptions to audiovisual entertainment at home. Suppose that, the price of entertainment is \$10 per month and

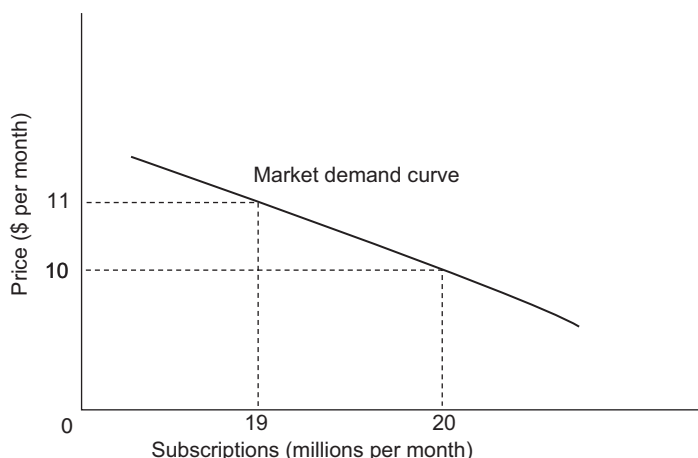


Figure 3.1 Calculating own-price elasticity

quantity demanded is 20 million subscriptions. According to Figure 3.1, if the price rises to \$11 per month, the quantity demanded would drop to 19 million.

The proportionate change in quantity demanded is the change in quantity demanded divided by the initial quantity demanded. The change in quantity demanded is $19 - 20 = 1$ million, and the initial quantity demanded is 20 million. Hence, the proportionate change in quantity demanded is $-1/20 = -0.05$.

Similarly, the proportionate change in price is the change in price divided by the initial price. The change in price is $\$11 - \$10 = \$1$ per month, while the initial price is \$10 per month. Hence, the proportionate change in price is $1/10 = 0.1$.

Thus, by equation (3.1), the own-price elasticity of the demand for entertainment is $-0.05/0.1 = -0.5$. Equivalently, in this example, the percentage change in quantity demanded was -5% , while the percentage change in price was 10% . By equation (3.2), the own-price elasticity is $-5/10 = -0.5$.

Progress check 3A. Referring to Figure 3.1, suppose that, initially, the price of entertainment is \$10 per month and the quantity demanded is 20 million subscriptions per month. Then the price falls to \$9 per month and the quantity demanded rises to 21 million. Calculate the own-price elasticity.

Properties

The home entertainment example illustrates several properties of the own-price elasticity of demand. First, as discussed in Chapter 2, demand curves generally slope downward: if the price of an item rises, the quantity demanded will fall. Hence,

the own-price elasticity is a negative number. For ease of interpretation, some analysts report own-price elasticities as an absolute value; that is, without the negative sign. When applying the concept, note that the own-price elasticity is a negative number.

Second, the own-price elasticity is a pure number, independent of the units of measurement. The quantity demanded of entertainment is measured in millions per month. The proportionate change in quantity demanded, however, is the change in quantity demanded divided by the initial quantity demanded. Hence, it is a pure number that does not depend on any units of measurement: the proportionate change would be the same whether we measure quantity demanded in millions or thousands. Likewise, the proportionate change in price is a pure number.

Since the own-price elasticity is the proportionate change in quantity demanded divided by the proportionate change in price, it is also a pure number. Thus, the own-price elasticity of demand provides a handy way of characterizing price sensitivity that does not depend on units of measurement. Hence, it can be used to compare the price sensitivity of the demand for different goods and services.

Third, recall from equation (3.1) that the own-price elasticity is the ratio of the proportionate change in quantity demanded to the proportionate change in price. If a very large proportionate change in price causes no change in quantity demanded, then the elasticity will be 0. By contrast, if an infinitesimal percentage change in price causes a large change in quantity demanded, then the elasticity will be negative infinity. Accordingly, the own-price elasticity ranges from 0 to negative infinity.

Accuracy

The estimate of the own-price elasticity depends on the calculation of the proportionate changes, and specifically the denominators of the proportionate changes. Equation (3.1) uses the initial prices and quantities as the denominators, but the calculation could also use the average or final prices and quantities. As we consider smaller and ever-smaller price changes, the estimate of the own-price elasticity will converge to a single number, which is called the “point estimate” of the elasticity.

Evidently, from equation (3.1), the formula using the initial price or quantity as the denominator of the proportionate change is not workable if the initial price or quantity is zero. In that case, we should use either the average or final price or quantity as the denominator.

Also, note that the own-price elasticity is a measure that depends on all factors that affect demand – including price, income, prices of complementary and substitute products, and sellers’ advertising. So, changes in any of these may lead to a change in the own-price elasticity.

In particular, the own-price elasticity may vary along the demand curve, and so vary with changes in the price itself. Hence, strictly, the own-price elasticity is accurate only for small changes in the price.

Progress check 3B. What are the properties of the own-price elasticity of demand?

Elastic/inelastic demand

The demand for an item is described as **price elastic** or elastic with respect to price if a 1% increase in price leads to more than a 1% drop in quantity demanded. Equivalently, demand is price elastic if a price increase causes a proportionately *larger* reduction in quantity demanded.

If the demand is elastic, the elasticity is less than -1 . This means that the absolute value (that is, without the negative sign) of the elasticity exceeds 1.

By contrast, the demand is described as **price inelastic** or inelastic with respect to price if a 1% price increase causes less than a 1% drop in quantity demanded. Equivalently, demand is price inelastic if a price increase causes a proportionately *smaller* reduction in quantity demanded.

If the demand is inelastic, the elasticity exceeds -1 . This means that the absolute value (that is, without the negative sign) of the elasticity is less than 1.

Price elastic: A price increase causes a proportionately larger reduction in quantity demanded.

Price inelastic: A price increase causes a proportionately smaller reduction in quantity demanded.

Amazon Prime: own-price elasticity

In April 2021, Amazon charged US\$119 per year for Prime. Investment bank RBC Capital Markets carried out a consumer survey. Asked how they would respond if Amazon raised the price of Prime to US\$139, 46% said that they would cancel their subscription.

An increase in the price from US\$119 to US\$139 would be a proportionate change of $20/139 = 0.168$. According to the survey, the proportionate change in the quantity demanded would be -0.46 . Hence, the own-price elasticity of the demand for Prime is $-0.46/0.168 = -2.74$, which means that the demand is price elastic.

3.3 Forecasting

The own-price elasticity of demand can be applied to forecast the effect of price changes on quantity demanded and buyers' expenditure. Expenditure is related to the quantity demanded, since expenditure equals the quantity demanded multiplied by the price. (In Chapter 8 on pricing, we consider the possibility of price discrimination. With price discrimination, different buyers pay different prices, so expenditure is not simply quantity demanded multiplied by price.)

The concept of own-price elasticity can be applied at the level of individual sellers as well as entire markets. From the standpoint of an individual seller, the quantity

demand is sales, while buyers' expenditure is revenue. Hence, using the own-price elasticity of demand, the seller can forecast the effect of price changes on sales and revenue.

Quantity demanded

Let us first consider how to use the own-price elasticity of demand to forecast the effect of price changes on the quantity demanded. Refer to the demand for entertainment in Figure 3.1. Suppose that the price is \$10 per month and the quantity demanded is 20 million subscriptions. How would a 5% increase in the price affect the quantity of entertainment that buyers demand?

Above, we calculated the own-price elasticity of demand at the \$1 price to be -0.5 . By definition, the own-price elasticity is the percentage by which the quantity demanded will change if the price rises by 1%. Hence, if the price of entertainment increases by 5%, then the quantity demanded will change by $5 \times (-0.5) = -2.5\%$, that is, the quantity demanded will fall by 2.5%.

To forecast the change in quantity demanded in terms of entertainment, multiply the percentage change of -2.5% by the quantity demanded before the price change. Accordingly, the 5% price increase would change the quantity demanded by $-2.5 \times 20 \text{ million} = 0.5 \text{ million}$ per month. (This estimated change in quantity demanded is smaller than that shown by the demand curve. The inaccuracy is due to the own-price elasticity being precise only for small changes in prices.)

As the home entertainment example illustrates, the rule for estimating the impact of price changes on buyers' quantity demanded is:

$$\begin{aligned} &\textit{Proportionate change in quantity demanded} \\ &= \textit{Proportionate change in price} \times \textit{own-price elasticity of demand.} \end{aligned} \quad (3.3)$$

Expenditure

Next, let us see how to use the own-price elasticity of demand to estimate the effect of changes in price on buyers' expenditure. Buyers' expenditure equals the quantity demanded multiplied by the price. Hence, a change in price will affect expenditure through the price itself as well as through the related effect on quantity demanded.

Generally, the rule for estimating the impact of price changes on buyers' expenditure is:

$$\begin{aligned} &\textit{Proportionate change in expenditure} = \textit{Proportionate change in price} \\ &+ \textit{Proportionate change in quantity demanded.} \end{aligned} \quad (3.4)$$

Consider the effect of an increase in price. By itself, the price increase will tend to raise the expenditure. The price increase, however, will reduce the quantity that

buyers demand, which would tend to reduce the expenditure. Hence, the net effect on expenditure depends on which effect is relatively larger.

The concept of own-price elasticity helps to determine whether the price or quantity effect is relatively larger. Recall that demand is elastic with respect to price if an increase in price causes a proportionately larger fall in quantity demanded, while demand is inelastic if a price increase causes a proportionately smaller fall in quantity demanded. The own-price elasticity enables us to compare the relative magnitude of changes in price and quantity demanded.

If the demand is price elastic, then the drop in the quantity demanded will be proportionately larger than the increase in price, and hence, the price increase will reduce expenditure. Generally, if demand is price elastic, a price increase will reduce expenditure while a price reduction will increase expenditure.

By contrast, if the demand is price inelastic, the drop in quantity demanded will be proportionately smaller than the increase in price, and then the price increase will increase expenditure. Generally, if demand is price inelastic, a price increase will increase expenditure while a price reduction will reduce expenditure.

To clarify further, substitute from equation (3.3) for the proportionate change in quantity demanded in (3.4). Then the rule for estimating the impact of prices changes on buyers' expenditure simplifies to:

$$\begin{aligned} & \textit{Proportionate change in expenditure} \\ &= \textit{Proportionate change in price} \times (1 + \textit{own-price elasticity of demand}). \quad (3.5) \end{aligned}$$

Pricing strategy

Whenever managers are asked to raise prices, their most frequent response is: "But sales would drop!" Since demand curves slope downward, it certainly is true that a higher price will reduce sales. The real issue is the *extent* to which the price increase will reduce sales. Managers should focus on the own-price elasticity of demand.

To explain, suppose that, at the current price, the demand is price inelastic. What if the seller raises the price? Since demand is price inelastic, the reduction in quantity demanded would be proportionately smaller than the price increase. Hence, the buyers' expenditure would increase, which means that the seller's revenue would increase.

Meanwhile, owing to the reduction in quantity demanded, the seller would sell less, meaning that costs would be lower. With higher revenues and lower costs, the seller's profit definitely would be higher. Accordingly, if demand is price inelastic, a seller can increase profit by raising price.

Under the appropriate conditions (inelastic demand), a price increase can raise profit even though it may cause sales to drop. Therefore, when setting the price for an item, managers should focus on the own-price elasticity of demand. Generally, the price should be raised until the demand becomes price elastic. Chapter 8 on pricing further develops this principle.

Progress check 3C. Suppose that the own-price elasticity of the demand for mobile phone service is -0.8 . If the service provider raises price by 5%, what would be the proportionate effect on quantity demanded and buyers' expenditure?

Netflix: 2020 price increases

In January 2019, the online entertainment service, Netflix, raised the U.S. price of its Basic plan by US\$1 to US\$8.99 per month, and the prices of its Standard and Premium plans by US\$2 to US\$12.99 and US\$15.99 per month respectively. Meanwhile, Netflix added new TV shows and films, including original productions for international audiences. Despite the price increases, subscribers grew by 20% and revenue by 28% to US\$20.2 billion.

With the outbreak of Covid-19, governments worldwide imposed lockdowns to control the spread of the disease. Confined to home, people turned to online entertainment. In the first half of 2020, Netflix gained nearly 26 million subscribers globally, and, in the third quarter, another 2.2 million.

In October 2020, Netflix increased the prices of the Standard and Premium plans by US\$1 and US\$2 respectively. Market research analyst Ross Benes described Netflix as underpriced and predicted that the price increases "would pay off." However, Wedbush Securities analyst, Michael Pachter, was skeptical, "It looks to me like they risk having domestic subscribers decline this quarter... it is a foolish move."

3.4 Behavioral factors

To estimate the own-price elasticity requires information on changes in prices and the corresponding changes in quantity demanded. However, changing the price to estimate the elasticity may be too costly or not practical. As an alternative, managers can intuitively consider the behavioral factors that influence the own-price elasticity of demand.

Benefits/costs of economizing

Buyers have limited time to spend on searching for better prices, so they focus attention on items that account for relatively larger expenditures. Parents, for instance, spend more time economizing on diapers than on cotton buds. Similarly, office managers focus attention on copying paper rather than on paper clips. Marketing practitioners

have given the name “low involvement” to products that get relatively little attention from buyers.

The balance between the benefit and cost of economizing also depends on a possible split between the person who incurs the cost of economizing and the person who benefits. If you bring a damaged car for repair, the repair manager will surely ask: “Are you covered by insurance?” Car owners who are covered by insurance are less concerned about price. They get the benefit of the repair work, while the insurer pays most or all the costs. A car owner who bargains over the repairs must spend her own time, while the insurer will enjoy most of the saving.

Availability of substitutes

The fewer substitutes that are available, the less price elastic will be the demand. People who are dependent on alcoholic drinks or cigarettes feel that there is no other way to satisfy their needs. Hence, the demand for these items is relatively price inelastic.

There are fewer substitutes for a product category than for specific products within a category. Consider, for instance, the demand for home entertainment compared with the demand for a specific brand. The brand has many more substitutes than the category as a whole. Accordingly, the demand for the brand will tend to be more elastic than the demand for the category. This means that, if home entertainment providers can collectively raise prices by 10%, their sales will fall by a smaller percentage than if a single provider increases its price by 10%.

Buyer's prior commitments

A person who has bought a particular car becomes a captive customer for spare parts. Automobile manufacturers understand this very well. They set relatively higher prices on spare parts than on new cars. The same applies as well in the software business. Once users have invested time and effort to learn one program, they become “locked in” for future upgrades. Whenever there is such a lock-in, demand is less elastic.

Adjustment time

Typically, commitments unwind over time and adjustments take time. Subscribers to post-paid mobile telecommunications services are free to switch at the end of their contract. A car owner will cease to be a captive customer of the manufacturer for spare parts when she sells the car. Accordingly, the effect of buyer commitments on the own-price elasticity of demand will diminish over time. This implies that, in the long run, demand will be more price elastic than in the short run.

Sunk-cost fallacy

Once a person has incurred a sunk cost, she may feel mentally obliged to justify the sunk cost and that mental obligation will affect her subsequent choices. For instance,

having paid the annual subscription fee for unlimited free shipping, a consumer may feel that she must buy more to justify the fee. If the subscription fee is higher, the consumer will feel obliged to spend even more and her demand for shopping will be less price elastic.

Anchoring

Facing uncertainty, individuals need information and may use cues, even irrelevant cues, to guide their choices. Consumers may be uncertain about their benefit from specific goods and services.

Appreciating this uncertainty, retailers set list prices to anchor consumer perceptions of the benefit. To the extent of such anchoring, consumers perceive that prices above the list price exceed their benefit, while prices below the list price yield buyer surplus. Accordingly, the consumer demand is price elastic at prices above the list price and price inelastic at prices below the list price.

Progress check 3D. What behavioral factors influence the own-price elasticity of demand?

Shared costs: frequent flyer programs

Whenever there is a split between the person who pays and the person who chooses the product, the demand will be less elastic. In 1981, American Airlines established its AAdvantage program for frequent flyers. This program gives free flights and other awards according to the member's travel on American Airlines, but not on competing airlines.

Frequent flyer programs are especially attractive to travelers, such as business executives, who fly at the expense of others. They are relatively less price sensitive than those who pay for their own travel. The frequent flyer program rewards them for choosing the airline whose program they belong to, even if the fare is higher.

European low-cost airline Ryanair caters mainly to people traveling for pleasure at their own expense. Ryanair famously does not run a frequent flyer program.

Supermarket pricing: anchoring

Supermarket chains Giant and Sheng Siong cater to the mass market in Singapore. On 21 May 2021, Sheng Siong discounted Golden Pineapple

rice to S\$12.50 for four weeks. On 3 June 2021, Giant discounted Golden Eagle rice to S\$12.90 for one week.

Giant's promotion of Golden Eagle rice highlighted "Was \$15.80," serving to anchor consumers' perception of benefit. Emphasizing the list price might also help to sell Giant's private label rice at S\$7.30 after the Golden Eagle promotion ends.

3.5 Other elasticities

In addition to price, the demand for an item also depends on buyers' incomes, the prices of complementary and substitute items, and sellers' advertising. Changes in any of these factors shift the demand curve.

There is an elasticity to measure the responsiveness of demand to changes in each factor. Managers can use these elasticities to forecast the effect of changes in these factors. In particular, the elasticities can be used to forecast the effect of changes in multiple factors that occur at the same time.

The analysis of elasticities of demand with respect to income, the prices of complementary and substitute items, and sellers' advertising is quite similar to that for the own-price elasticity. Accordingly, we will focus on the differences for the other elasticities.

Income elasticity

The income elasticity of demand measures the sensitivity of demand to changes in buyers' incomes. By definition, the **income elasticity** of demand is the percentage by which the demand will change if the buyers' incomes rise by 1%. Equivalently, the income elasticity is the ratio

$$\frac{\text{Percentage change in demand}}{\text{Percentage change in buyers' incomes}}. \quad (3.6)$$

Income elasticity:

The percentage by which demand will change if buyers' incomes rise by 1%.

For a normal product, if buyers' incomes rise, the demand will rise, so the income elasticity will be positive. By contrast, for an inferior product, if incomes rise, demand will fall, so the income elasticity will be negative. Thus the sign of the income elasticity will depend on whether the product is normal or inferior. Hence, it is important to note the sign of the income elasticity. The income elasticity can range in value from negative infinity to positive infinity.

Demand is described as *income elastic* or elastic with respect to income if a 1% increase in income causes more than a 1% change in demand. Demand is described as *income inelastic* or inelastic with respect to income if a 1% increase in income causes less than a 1% change in demand.

The demand for necessities tends to be relatively less income elastic than the demand for discretionary items. Consider, for instance, the demand for home entertainment

as compared with food. Entertainment is more of a discretionary item as compared to food. Accordingly, the demand for food is relatively less income elastic than the demand for entertainment.

Progress check 3E. Refer to Section 3.2 of this chapter for the properties of own-price elasticity. What are the corresponding properties of the income elasticity?

Cross-price elasticity

Just as the income elasticity of demand measures the sensitivity of demand to changes in income, the cross-price elasticity measures the sensitivity of demand to changes in the prices of related products. By definition, the **cross-price elasticity** of demand with respect to another item is the percentage by which the demand will change if the price of the related item rises by 1%. Equivalently, the cross-price elasticity is the ratio

$$\frac{\text{Percentage change in demand}}{\text{Percentage change in price of related item}}. \quad (3.7)$$

If two products are substitutes, an increase in the price of one will increase the demand for the other, so the cross-price elasticity will be positive. The more substitutable are two items, the higher their cross-price elasticity will be. By contrast, if two products are complements, an increase in the price of one will reduce demand for the other, and so the cross-price elasticity will be negative. The cross-price elasticity can range from negative infinity to positive infinity.

Advertising elasticity

The advertising elasticity measures the sensitivity of demand to changes in the sellers' advertising expenditure. By definition, the **advertising elasticity** of demand is the percentage by which the demand will change if the sellers' advertising expenditure rises by 1%. Equivalently, the advertising elasticity is the ratio

$$\frac{\text{Percentage change in demand}}{\text{Percentage change in sellers' advertising expenditure}}. \quad (3.8)$$

Generally, an increase in advertising will raise the demand, and so the elasticity will be positive. Most advertising is undertaken by individual sellers to promote their own business. By drawing buyers away from competitors, advertising has a much stronger effect on the sales of an individual seller than on the market demand. Accordingly, the advertising elasticity of the demand faced by an individual seller tends to be larger than the advertising elasticity of the market demand.

Cross-price elasticity: The percentage by which demand will change if the price of a related item rises by 1%.

Advertising elasticity: The percentage by which demand will change if sellers' advertising expenditure rises by 1%.

Forecasting multiple factors

The business environment will often change in conflicting ways. For instance, incomes may rise, while the prices of substitutes and complements rise as well. For a normal product, the higher income would raise demand, the higher price of substitutes would also raise demand, but the higher price of complements would reduce demand.

What is the net effect on demand? This question can be addressed using the elasticities with respect to each of the factors affecting demand. Generally, the percentage change in demand due to changes in multiple factors is the sum of the percentage changes due to each separate factor.

To illustrate, suppose that the price of home audiovisual entertainment is \$10 per month and the quantity demanded is 20 million subscriptions per month. Then the price increases by 5%, while buyers' incomes rise by 3%. What would be the net impact on demand?

Suppose that the own-price elasticity of the demand for entertainment is -0.5 and the income elasticity of demand is 2.0 . Then the 5% increase in price would change the quantity demanded by $5 \times -0.5 = -2.5\%$. Further, the 3% increase in incomes would change demand by $3 \times 2 = 6\%$. Hence, the net effect of the increases in price and incomes is to change demand by $-2.5\% + 6\% = 3.5\%$.

Originally, the quantity demanded of home entertainment services was 20 million. After the increases in price and incomes, the quantity demanded would be $1.035 \times 20 \text{ million} = 20.7 \text{ million}$. A similar approach can be used to forecast the effects of changes in other factors, including the prices of related products and sellers' advertising expenditures.

Progress check 3F. Suppose that, in the preceding example, the price fell by 5%, while buyers' incomes increased by 5%. What would be the net impact on demand?

Energy prices and car choice

Transport economists Lasse Fridstrøm and Vegard Østli studied the demand for cars in Norway between 2002 and 2016. Regarding gasoline-powered cars, the own-price elasticity was -1.094 , and the cross-price elasticities with respect to the prices of gasoline, electricity, and electric cars were -0.71 , 0.06 , and 0.19 respectively. As for electric cars, the own-price elasticity was -0.99 , and the cross-price elasticities with respect to the prices of electricity, gasoline, and gasoline-powered cars were -0.18 , 0.38 , and 0.35 respectively.

Apparently, the demand for gasoline-powered cars was more sensitive to the price of gasoline than the demand for electric cars was to the price of electricity. By contrast, the demand for gasoline-powered cars was less sensitive to the price of electric cars than the demand for electric cars was to the price of gasoline-powered cars.

Key takeaways

- The own-price elasticity of demand for an item is the percentage by which the quantity demanded will change if the price of the item rises by 1%.
- The demand for an item is price elastic if a 1% increase in price leads to more than a 1% drop in quantity demanded, and price inelastic if a 1% increase in price leads to less than a 1% drop in quantity demanded.
- If demand is inelastic, the seller can increase profit by raising the price.
- The demand for an item will be more price elastic to the extent that: (i) the benefits of economizing exceed the costs; (ii) it has more substitutes; (iii) the buyer has fewer prior commitments; and (iv) the time for adjustment is longer.
- The own-price elasticity of demand depends on the extent that the buyer is subject to: (i) sunk-cost fallacy; (ii) status quo bias; and (iii) anchoring.
- The income elasticity of demand is the percentage by which the demand will change if buyers' incomes rise by 1%.
- The cross-price elasticity of demand is the percentage by which the demand will change if the price of a related item rises by 1%.
- The advertising elasticity of demand is the percentage by which the demand will change if sellers increase advertising expenditure by 1%.

Review questions

1. Consider a service that you buy frequently. (a) Suppose that the price is 5% lower. How much more would you buy each year? (b) Calculate the own-price elasticity of your demand.
2. Explain why the own-price elasticity is a pure number with no units and is negative.

3. Referring to the own-price elasticity, under what conditions is demand price elastic or price inelastic?
4. Consider the demands for Netflix and HBO Max. If we want to compare how sensitive are the demands to price changes, why should we use the own-price elasticity?
5. The own-price elasticity of the demand for one brand of toilet paper is -1.5 . Suppose that the manufacturer reduces price by 5%. In percentage terms, how would that affect the volume of sales?
6. Suppose that the own-price elasticity of the market demand for gasoline is -0.7 . Owing to a pipeline failure, the price of gasoline rose by 10%. In percentage terms, how would that affect the quantity of gasoline purchased and expenditure?
7. If the demand for your product is price elastic, should you raise the price?
8. "I won't raise price because that would reduce sales." What's wrong with this statement?
9. The demand for low involvement products is price inelastic. True or false?
10. Explain why the demand for a category of products is more price elastic than the demand for one brand in the category.
11. Compare the own-price elasticity of the demand for a particular brand of inkjet cartridges: (a) before the user has bought an inkjet printer; and (b) after the user has bought the printer.
12. Consider a good that you buy frequently. (a) Suppose that your income is 10% higher. How much more would you buy each year? (b) Calculate the income elasticity of your demand.
13. Under what conditions would the income elasticity of demand for a product be (a) negative, or (b) positive?
14. Battery manufacturers use lithium and cobalt to produce batteries. Are the two metals substitutes or complements? Would the cross-price elasticity of demand for lithium with respect to the price of cobalt be positive or negative?
15. Explain why the advertising elasticity of the market demand for beer may be less than the advertising elasticity of the demand for one particular brand.

Discussion questions

1. Economists Fabian Berges, Daniel Hassan, and Sylvette Monier-Dilhan analyzed demand at a major French food retailer. The own-price elasticities of the demand for pasta were: -1.36 for national brands, -2.16 for private labels, and -1.85 for low-price brands. The own-price elasticities of the demand for biscuits were: -1.00 for national brands, -1.14 for private labels, and -0.50 for low-price brands.

- (a) Compare the elasticities of the demand for national brands and private labels of pasta. Does the difference make sense?
 - (b) Do national brands or private labels or low-price brands command more brand loyalty? (*Hint:* Interpret brand loyalty by the own-price elasticity.)
 - (c) Which is more price elastic? The demand for pasta or biscuits?
 - (d) Based on the own-price elasticities, can you make any recommendations on pricing?
2. Referring to Figure 3.1, at the current price of entertainment of \$10 per month, the quantity demanded is 20 million subscriptions. If the price of entertainment were \$11 or \$12 per month, the quantity demanded would be 19 or 18 million subscriptions respectively.
 - (a) Calculate the own-price elasticity of demand if the price increases (i) from \$10 to \$11 per month; (ii) from \$11 to \$12 per month; and (iii) from \$10 to \$12 per month.
 - (b) How would your calculations in (a) change if you measured prices in cents rather than dollars?
 - (c) Use your estimates in (a) to comment on the argument that the own-price elasticity of demand is a constant.
 - (d) As the price increases, marginal consumers who value entertainment less would drop out, and only consumers with stronger preference would subscribe. Do you expect the demand to become less or more price elastic at a higher price?
 - (e) Based on your analysis in (d), comment on the realism of a straight line demand curve.
3. In January 2019, the online entertainment service, Netflix, raised the U.S. price of its Basic plan by US\$1 to US\$8.99 per month, and the prices of its Standard and Premium plans by US\$2 to US\$12.99 and US\$15.99 per month respectively. Meanwhile, Netflix added new TV shows and films, including original productions for international audiences. Despite the price increases, subscribers grew by 20% and revenue by 28% to US\$20.2 billion.
 - (a) If Netflix had not added content, how would the 2019 price increases have affected subscriptions?
 - (b) How did Covid-19 lockdowns affect the demand for Netflix subscriptions?
 - (c) In October 2020, Netflix increased the U.S. prices of the Standard and Premium plans by US\$1 and US\$2 respectively. Market analysts disagreed on whether earnings would fall or increase. How would the effect depend on the own-price elasticity of demand?
 - (d) How would mass vaccinations against Covid-19 affect the demand for Netflix subscriptions?

4. Both airlines and supermarkets offer customer loyalty programs. However, airline frequent flyer programs seem to be much more profitable. In 2020, the American Airlines AAdvantage program in the United States was appraised to be worth over US\$19.5 billion.
 - (a) Business executives often fly at the expense of their employer or clients. By contrast, leisure travelers typically pay for their own travel. Compare the price elasticity of the demands for air travel of business vis-à-vis leisure travelers.
 - (b) Explain how frequent flyer programs exploit the price inelastic demand of business travelers.
 - (c) European low-cost airline Ryanair caters mainly to people traveling for pleasure at their own expense. Can this explain why Ryanair does not run a frequent flyer program?
 - (d) Discuss whether there is a substantial segment of supermarket customers who shop at the expense of others.
 - (e) Drawing on your answers above, explain why airline frequent flyer programs yield more profit than supermarket loyalty programs.
5. In April 2021, Amazon charged US\$119 per year for Prime. Investment bank RBC Capital Markets carried out a consumer survey. Asked how they would respond if Amazon raised the price of Prime to US\$139, 46% said that they would cancel their subscription.
 - (a) Based on the survey, calculate the own-price elasticity of demand for Prime. Is the demand price elastic or inelastic?
 - (b) How does Amazon's policy of automatically renewing Prime subscriptions influence the stickiness of subscribers? How does it affect the own-price elasticity of demand for Prime?
 - (c) Which behavioral bias of consumers does the automatic renewal policy exploit?
 - (d) How does the sunk-cost fallacy affect the price elasticity of demand for products sold on Amazon?
6. Supermarket chains Giant and Sheng Siong cater to the mass market in Singapore. On 21 May 2021, Sheng Siong discounted Golden Pineapple rice to S\$12.50 for four weeks. Sheng Siong's advertisement did not state the regular price. On 3 June 2021, Giant discounted Golden Eagle rice to S\$12.90 for one week, highlighting "Was \$15.80."
 - (a) Some consumers are busy, while others have time to shop. Some consumers buy only small quantities, while others buy large amounts. Explain the differences in their benefit vis-à-vis cost of economizing.
 - (b) How do random discounts exploit the differences in (a)?
 - (c) Explain why Giant highlighted the list price.
 - (d) How would the list price of Golden Eagle price affect the demand for Giant's private label rice at S\$7.30 after the Golden Eagle promotion ends.

7. Tourism economists Aon Waqas-Awan, Jaume Rosselló-Nadal, and Maria Santana-Gallego studied the demand for outbound international travel in 192 countries, between 1995 and 2016. The income elasticity of demand in low, low-middle, and high-middle income countries was 0.45, 0.76, and 0.68 respectively. Income did not significantly affect outbound travel from high income countries.
 - (a) If incomes rise by 10%, how would the demand for outbound travel change in low, low-middle, and high-middle income countries?
 - (b) If incomes fall by 10%, how would the demand for outbound travel change in low, low-middle, and high-middle income countries?
 - (c) During a boom, which markets (low, low-middle, or high-middle income countries) should an airline target?
 - (d) During a recession, which markets should an airline target?
8. Transport economists Lasse Fridstrøm and Vegard Østli studied the demand for cars in Norway between 2002 and 2016. Regarding gasoline-powered cars, the own-price elasticity was -1.094 , and the cross-price elasticities with respect to the prices of gasoline, electricity, and electric cars were -0.71 , 0.06 , and 0.19 respectively. As for electric cars, the own-price elasticity was -0.99 , and the cross-price elasticities with respect to the prices of electricity, gasoline, and gasoline-powered cars were -0.18 , 0.38 , and 0.35 respectively.
 - (a) Referring to the above data, discuss whether gasoline cars and electricity are substitutes or complements.
 - (b) Electric cars are more expensive than gasoline cars. Compare the incomes of people who buy electric cars vis-à-vis those who buy gasoline cars.
 - (c) Considering the buyers' incomes, explain why the demand for electric cars is less price elastic than the demand for gasoline cars.
 - (d) Why would the short-run demand for gasoline cars be less elastic with respect to the price of gasoline than the long run demand?
9. Health economists Dhaval Dave and Henry Saffer researched the U.S. market for four prescription medicines (analgesic/musculoskeletal, antilipidemics, gastrointestinal acid reducers, and insomnia remedies). The elasticity of demand with respect to consumer advertising ranged between 0.13 and 0.19 , while the elasticity of demand with respect to physician advertising was 0.51 . The own-price elasticity was -0.67 for drugs advertised to consumers and -0.73 for drugs not advertised to consumers.
 - (a) How would a 5% increase in expenditure on advertising to consumers affect the demand for the four prescription medicines?
 - (b) What about a 5% increase in expenditure on advertising to physicians?

- (c) Do you expect the same difference between advertising to consumers vis-à-vis physicians in the demand for over-the-counter (non-prescription) medicines?
- (d) Suppose that a drug manufacturer were to increase advertising. Explain why it should also raise the price of its drugs.

You are the consultant!

Identify a product that your organization sells for which the demand is price inelastic. Write a memorandum to the chief financial officer of your organization to recommend an increase in price.

Progress check answers

- 3A. The proportionate change in quantity demanded is $(21 - 20)/20 = 1/20 = 0.05$. The proportionate change in price is $(9 - 10)/10 = -1/10 = -0.1$. The own-price elasticity is $0.05/-0.1 = -0.5$.
- 3B. The own-price elasticity is a pure number, negative, and ranges from 0 to negative infinity.
- 3C. The proportionate change in quantity demanded would be $5 \times -0.8 = -4\%$. The proportionate change in expenditure would be $5\% - 4\% = 1\%$.
- 3D. The behavioral factors that influence the own-price elasticity of demand are: (a) benefits/costs of economizing; (b) availability of substitutes; (c) buyer's prior commitments; (d) adjustment time; (e) sunk cost fallacy; (f) status quo bias; and (g) anchoring.
- 3E. The own-price elasticity is always a negative number. But the income elasticity could be negative or positive, depending on whether it is an inferior or normal good.
- 3F. The net effect would be $(-5 \times -0.5) + (5 \times 2) = 2.5 + 10 = 12.5$, an increase of 12.5%.

Review answers

- 1. [Omitted.]
- 2. The demand curve is sloping downward. Hence, the own-price elasticity is negative. The proportionate changes in quantity demanded and

price of an item are pure numbers. Hence, the own-price elasticity is a pure number with no units.

3. If a 1% price increase causes less than a 1% drop in quantity demanded, then the demand is price inelastic. If a 1% price increase causes more than a 1% drop in quantity demanded, then the demand is price elastic.
4. Netflix and HBO Max are two different services. Using the own-price elasticity, we can compare price sensitivity of the demands for different products.
5. The volume of sales would change by $-5\% \times -1.5 = 7.5\%$.
6. The quantity purchased would change by $10\% \times -0.7 = -7\%$. The expenditure would change by $10\% - 7\% = 3\%$.
7. It depends. The price increase would reduce quantity demanded by proportionately more than the price increase. Hence, buyer expenditure (and our sales revenue) would be lower. But cost would be lower as well.
8. Raising price would reduce quantity demanded and sales. However, if sales are lower, costs would be lower as well. Hence, the effect on profit depends on which effect is larger – the increased profit on each item or the reduction in sales.
9. Consumers tend to pay little attention to buying of low involvement products.
10. A brand in a category has more substitutes than the category as a whole.
11. (a) More elastic. (b) Less elastic.
12. [Omitted.]
13. (a) Inferior product; (b) Normal product.
14. Complements; negative.
15. Advertising by one brand will draw customers from customers of other brands as well as increase the demand for beer in general. Advertising of beer in general can only increase the market demand.

Discussion answers

1. (a) The demand for national brands is more inelastic than private label pasta.
(b) National brands command more loyalty.
(c) The demand for pasta is more price elastic.
(d) Supermarkets should raise the prices of low-price brands of biscuits.

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CHAPTER 4

Supply

LEARNING OBJECTIVES

- Appreciate why producers supply more at higher prices.
- In the short run, appreciate how to decide whether to continue in production, and if so, how much to produce.
- Distinguish fixed and variable costs.
- Understand the concepts of marginal cost and marginal revenue.
- In the long run, appreciate how to decide whether to continue in production, and if so, how much to produce.
- Appreciate that, in the long run, producers can adjust by entering or exiting the industry.
- Apply the concept of price elasticity of supply.
- Appreciate the concept of seller surplus.

4.1 Introduction

The Covid-19 pandemic and government restrictions on eating out devastated the food and beverage industry in Hong Kong. Between 2019 and 2020, overall revenue fell by 25% from HK\$26 billion to HK\$19.4 billion, with bars suffering the sharpest drop, 47%, followed by Chinese restaurants, 36%, as compared with just 15% at fast food shops.

Edwin Kam, general manager of a group of Shanghainese restaurants, explained that their customers often ate in large groups, “If only a table of two is allowed, it’s difficult for us to prepare food in such a small amount.” He said that he might lay off 10% of their 200 workers if business did not improve by the Lunar New Year.

By December 2020, the Hong Kong Federation of Restaurants and Related Trades reported that 2,300 of the city's 16,000 restaurants had closed. Yet, taking advantage of lower rents, 300 new ones opened.

Earlier in the year, Deliveroo opened its third facility in Hong Kong to host cloud kitchens which prepare meals for delivery. Lorraine Kwan Suk-kan, owner of Shanghai Lane, with branches in Central, Tin Hau, and Happy Valley, set up a cloud kitchen in Deliveroo.

How do changes in rents and wages affect the restaurant industry? Should restaurants lay off workers or shut down? Why would new restaurants open while others were shutting down?

To address these questions, we analyze two key decisions of a business: first, whether to continue in production; and, second, how much to produce. The first is a decision on participation and depends on the total revenue and total cost. The second is a decision on extent and depends on the marginal revenue and marginal cost.

We can apply the analyses to explain how restaurants should respond to changes in rents and wages, whether a restaurant should lay off workers or shut down, and why entrepreneurs would set up new restaurants while others were shutting down.

The analyses provide the foundation for the concepts of the supply curve. The supply curve is the seller-side counterpart to the demand curve. This chapter also presents the concepts of price elasticity of supply and seller surplus, which are the seller-side counterparts to price elasticity of demand and buyer surplus.

4.2 Short-run costs

Every business must make two key decisions: the participation decision of whether to continue in production and the extent decision of how much to produce. These decisions depend on the time horizon.

Short run: A time horizon in which a seller cannot adjust at least one input.

The **short run** is a time horizon in which a seller cannot adjust at least one input. In the short run, the business is constrained by past commitments such as employment contracts or investment in facilities. Over time, however, these commitments expire. The **long run** is a time horizon long enough for the seller to adjust all inputs, including possibly entering or exiting the industry.

Long run: A time horizon long enough for the seller to adjust all inputs, including possibly entering or exiting the industry.

The difference between the short run and long run depends on the circumstances. A restaurant that just engaged ten workers on 12-month contracts has committed to a longer horizon than one that hires workers on a daily basis. Similarly, a restaurant that has purchased kitchen equipment has committed to a longer horizon than one that leases equipment on a yearly contract.

Fixed and variable costs

To determine its rate of production, a business needs to know the cost of producing an additional unit. To decide whether to continue in production, a business needs to know how shutting down will affect its total costs.

An important factor in both decisions is the distinction between fixed and variable costs. The **fixed cost** is the cost of inputs that do not change with the production rate. By contrast, the **variable cost** is the cost of inputs that do change with the production rate.

Let us consider the distinction between fixed and variable costs in the context of Luna, a restaurant. Like those of most businesses, Luna's accounting records do not classify expenses into fixed and variable. Rather, the records organize expenses according to the type of input: rent, equipment lease, salaries, wages, and payments for supplies. By interviewing Luna's management, we can learn the costs required for alternative short-run production rates. Table 4.1 presents this information.

To distinguish between fixed and variable costs, a business must analyze how each category of expense varies with changes in production. Referring to Table 4.1, Luna cannot adjust the size of its facility, equipment, or managers' salaries. The rent is \$2,000 and equipment leases cost \$500 whether Luna produces nothing or 900 meals per week; hence, they are a fixed cost.

At low levels of production, salaries and wages do not change with the rate of production. However, at higher levels, the restaurant pays bonuses to managers and must hire more workers and pay overtime. Accordingly, salaries and wages are partly fixed and partly variable. The cost of supplies is completely variable.

Table 4.2 assigns Luna's expenses – rent, equipment lease, salaries, wages, and cost of supplies – into the two categories of fixed costs and variable costs. As the production rate increases from zero to 900 meals per week, the fixed cost is always \$10,100. By contrast, the variable cost increases from zero for no production to \$31,450 at 900 meals per week. **Total cost** is the sum of fixed cost and variable cost. Writing as an equation,

$$\text{Total cost} = \text{Fixed cost} + \text{Variable cost}. \quad (4.1)$$

Fixed cost: The cost of inputs that do not change with the production rate.

Variable cost: The cost of inputs that do change with the production rate.

Total cost: The sum of fixed cost and variable cost.

Table 4.1 Short-run weekly expenses

Meals per week	Rent (\$)	Equipment leasing (\$)	Salaries (\$)	Wages (\$)	Cost of supplies (\$)	Total (\$)
0	2,000	500	4,000	3,600	0	10,100
100	2,000	500	4,000	3,600	1,000	11,100
200	2,000	500	4,000	3,600	2,000	12,100
300	2,000	500	5,500	3,600	3,000	14,600
400	2,000	500	7,000	3,600	4,000	17,100
500	2,000	500	8,500	4,950	5,000	20,950
600	2,000	500	10,000	6,750	6,000	25,250
700	2,000	500	11,550	9,200	7,000	30,250
800	2,000	500	13,050	11,900	8,000	35,450
900	2,000	500	14,550	15,500	9,000	41,550

Table 4.2 Analysis of short-run costs

Meals per week	Fixed cost (\$)	Variable cost (\$)	Total cost (\$)	Marginal cost (\$)	Average fixed cost (\$)	Average variable cost (\$)	Average cost (\$)
0	10,100	0	10,100				
100	10,100	1,000	11,100	10.00	101.00	10.00	111.00
200	10,100	2,000	12,100	10.00	50.50	10.00	60.50
300	10,100	4,500	14,600	25.00	33.67	15.00	48.67
400	10,100	7,000	17,100	25.00	25.25	17.50	42.75
500	10,100	10,850	20,950	38.50	20.20	21.70	41.90
600	10,100	15,150	25,250	43.00	16.83	25.25	42.08
700	10,100	20,150	30,250	50.00	14.43	28.79	43.21
800	10,100	25,350	35,450	52.00	12.63	31.69	44.31
900	10,100	31,450	41,550	61.00	11.22	34.94	46.17

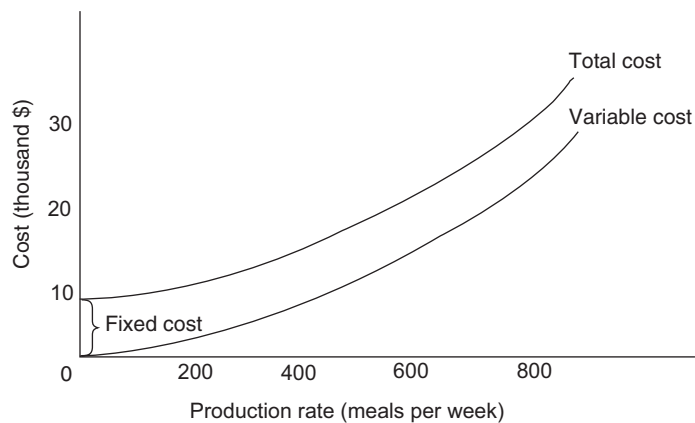


Figure 4.1 Short-run total cost

Provided that there are some variable costs, the total cost will increase with production. In Luna’s case, referring to Table 4.2, the total cost is \$10,100 for no production, and rises to \$41,550 at 900 meals per week.

It is helpful to illustrate the concepts of total, fixed, and variable costs graphically. In Figure 4.1, the vertical axis represents cost, while the horizontal axis represents the rate of production. The variable cost curve graphs how variable cost changes with production. The total cost curve is the variable cost curve, shifted up everywhere by the amount of the fixed cost. In particular, at zero production, the height of the total cost curve is the fixed cost.

By analyzing its costs as fixed and variable, the management of a business can understand how changes in production would affect its costs. For instance, suppose that management is planning to reduce costs by downsizing. Downsizing would have no effect on fixed costs and would only reduce the variable costs. Hence, in a business whose costs are mostly fixed, downsizing would not reduce costs by much.

Progress check 4A. In Figure 4.1, if the fixed cost were higher, how would that affect the total and variable cost curves?

Marginal cost

To determine how much it should produce, a business needs to know the cost of producing an additional unit. The change in total cost due to the production of an additional unit is the **marginal cost**. The marginal cost can be derived from the analysis of fixed and variable costs.

Let us derive the marginal cost in the case of Luna. Referring to Table 4.2, as the production rate increases from zero to 100 meals per week, the total cost increases from \$10,100 to \$11,100. The increment of $\$11,100 - \$10,100 = \$1,000$ is the additional cost of producing the 100 meals. Hence, the marginal cost is $\$1,000/100 = \10 per meal.

Recall that only the variable cost changes with the production rate. So, we can also calculate the marginal cost from the increase in variable cost. Using this approach, as production increases from zero to 100 meals per week, the variable cost increases from \$0 to \$1,000. Therefore, the marginal cost is $\$1,000/100 = \10 per meal.

Similarly, we can calculate the marginal cost as the change in the variable cost as the production rate increases from 100 to 200 meals per week, 200 to 300 meals per week, and so on. Table 4.2 displays this information.

Marginal cost:

The change in total cost due to the production of an additional unit.

Bank of the West: marginal cost of funds

Bank of the West is chartered in the State of California. At the time of writing, it operated over 560 branches across the United States. With over US\$96 billion in assets, the bank is one of the five largest California-chartered banks.

In 2020, the bank held US\$46.1 billion, US\$4.4 billion, and US\$6.0 billion in demand, savings, and time deposits, on which it paid interest of 0.41%, 0.04%, and 1.81% respectively. Arranging the deposits in order of interest rate, the bank's marginal cost of funds was 0.04% up to US\$4.4 billion, 0.41% up to US\$50.5 billion, and 1.81% thereafter.

Average cost

Average cost (unit cost): The total cost divided by the production rate.

The marginal cost is the cost of producing an additional unit. A related concept is the **average cost**, also called the *unit cost*, which is the total cost divided by the production rate. Given the rate of production, the average cost reflects the cost of producing a typical unit.

Recall from equation (4.1) that total cost is the sum of the fixed cost and variable cost. Then dividing throughout by the production rate, the average cost is

$$\frac{\text{Total cost}}{\text{production}} = \frac{\text{Fixed cost}}{\text{production}} + \frac{\text{Variable cost}}{\text{production}}. \quad (4.2)$$

In words, the average cost is the average fixed cost plus the average variable cost.

The average fixed cost is the fixed cost divided by the production rate. So, if the production rate is higher, the fixed cost will be spread over more units; hence, the average fixed cost will be lower. This factor causes the average cost to fall with increases in the production rate. Referring to Table 4.2, as the production rate increases from 100 to 900 meals per week, the average fixed cost falls from \$101 to \$11.22 per meal.

The other element in average cost is the average variable cost, which is the variable cost divided by the production rate. In the short run, at least one input is fixed; hence, to raise the production rate, the business must combine increasing quantities of the variable inputs with the fixed input.

Marginal product: The increase in output arising from an additional unit of an input.

The increase in output arising from an additional unit of an input is called the **marginal product** from that input. As more of the variable inputs are added, they will mismatch the fixed input. (In Luna's case, imagine cooks getting in the way of each other as they produce more meals.) Eventually, there will be a *diminishing marginal product*. This means that the marginal product becomes smaller with each increase in the variable inputs.

With a diminishing marginal product, the average variable cost will increase with the production rate. Referring to Table 4.2, as the production increases from 100 to 900 meals per week, the average variable cost increases from \$10 to \$34.94 per meal.

Recall that the average cost is the average fixed cost plus the average variable cost. While the average fixed cost falls with the production rate, the average variable cost increases. Referring to Table 4.2, at 100 meals per week, the average cost is \$101 + \$10 = \$111 per meal, while at 200 meals per week, the average cost is \$60.50 per meal. The average cost continues to fall with increases in the production rate until it reaches a minimum of \$41.90 at 500 meals per week. Thereafter, it increases with the production rate. At 900 meals per week, the average cost is \$46.17 per meal.

Figure 4.2 graphs the marginal, average, and average variable costs against the production rate. The vertical axis represents cost per meal, while the horizontal axis represents the production rate. The average fixed cost slopes downward, the average variable cost slopes upward, and the average cost is U-shaped (it first slopes downward, then upward).

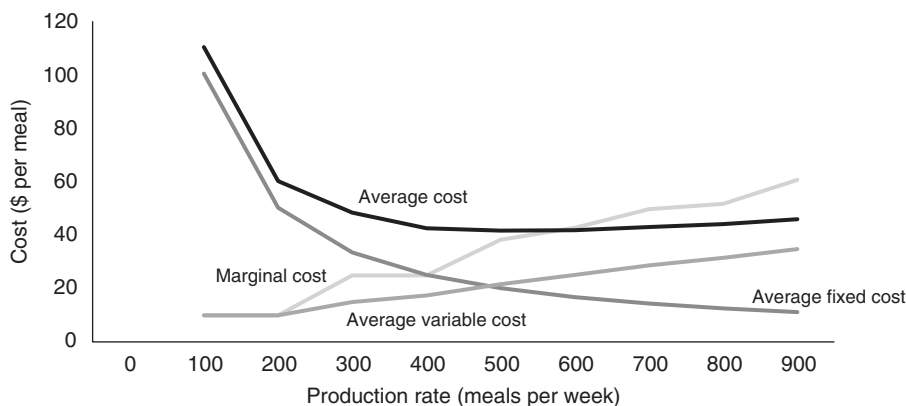


Figure 4.2 Short-run marginal, average variable, and average costs

Progress check 4B. In Figure 4.2, if wages were higher, how would that affect the average cost, average variable cost, and marginal cost curves?

Production technology

We derived the information about costs by asking the seller for the expenses at each rate of production. Accordingly, the costs depend on the seller's production technology.

This means that the curves will change with the seller's technology. A producer that uses a method with lower fixed cost would have lower average fixed and average cost curves. A producer that uses a technology with higher variable cost would have higher average variable, average, and marginal cost curves.

In addition, producers may use different technologies, and hence have different cost curves. They may differ in the structure of fixed and variable costs.

Hybrid vs gasoline cars

A key decision for a taxi or limousine service is what car to buy. For the 2021 model year, the fuel consumption of a gasoline-powered Hyundai Elantra (1.6 liter, four cylinder, automatic) was 31 miles per gallon, while that of the hybrid gasoline-electric Toyota Prius (1.8 liter, four cylinder, automatic) was 54 miles per gallon.

Obviously, the Prius would be cheaper to operate. However, the Prius is more expensive. In the United States, the cheapest Elantra cost US\$19,650, as compared with the cheapest Prius at US\$24,525.

The Prius offered lower variable cost but higher fixed cost, while the Elantra offered lower fixed cost but higher variable cost. Which car to buy would depend on how much the cars would be driven (and the cost of gasoline).

4.3 Short-run individual supply

Costs are one aspect of the short-run decisions whether to continue in production and how much to produce. The other aspect to these decisions is revenue. We now consider the revenues of a business.

In analyzing revenues, we shall assume that the business aims to maximize profit and that the business is so small relative to the market that it can sell as much as it would like at the market price. We need the assumption of smallness to construct individual and market supply, which are the counterparts to individual and market demand.

Production rate

Supposing that the price of restaurant meals is \$50, how much should Luna produce? Generally, the profit of a business is its total revenue less its total cost, and in turn, total revenue is the price multiplied by production. (Here, we assume that the seller sells each unit at the same price. Chapter 8 considers the possibility of charging different prices for each unit.)

Table 4.3 presents Luna’s cost and revenue at various production rates, based on the price being \$50. For instance, if production is 100 meals per week, then Luna’s total

Table 4.3 Short-run profit								
Meals per week	Variable cost (\$)	Total cost (\$)	Price (\$)	Total revenue (\$)	Accounting profit (\$)	Economic profit (\$)	Marginal cost (\$)	Marginal revenue (\$)
0	0	10,100	50	0	(10,100)	0		
100	1,000	11,100	50	5,000	(6,100)	4,000	10	50
200	2,000	12,100	50	10,000	(2,100)	8,000	10	50
300	4,500	14,600	50	15,000	400	10,500	25	50
400	7,000	17,100	50	20,000	2,900	13,000	25	50
500	10,850	20,950	50	25,000	4,050	14,150	39	50
600	15,150	25,250	50	30,000	4,750	14,850	43	50
700	20,150	30,250	50	35,000	4,750	14,850	50	50
800	25,350	35,450	50	40,000	4,550	14,650	52	50
900	31,450	41,550	50	45,000	3,450	13,550	61	50

revenue would be $\$50 \times 100 = \$5,000$. If production is 200 meals per week, then Luna's total revenue would be $\$50 \times 200 = \$10,000$. Similarly, we can calculate the total revenue at other production rates.

In addition, Table 4.3 presents Luna's accounting profit, which is total revenue minus total cost. Reviewing the accounting profit at the various production rates, we deduce that Luna's maximum profit is \$4,750, achieved by producing 700 meals per week. (Strictly, the profit would be even higher at some rate between 600 and 700 meals per week. For simplicity, we focus on 700 meals per week as the profit maximizing production.)

Table 4.3 also presents the economic profit, which is total revenue minus variable cost. The rate of production which maximizes economic profit is exactly the same as that which maximizes accounting profit. The maximum economic profit is \$14,850.

We can derive a general rule for the profit-maximizing production rate by studying cost and revenue on a diagram. Figure 4.3 reproduces the cost curves from Figure 4.1, and adds a line to represent Luna's total revenue. The line rises at a rate of \$5,000 for every increase of 100 meals in production. Equivalently, the slope of the line is \$50.

Figure 4.3 represents the profit at every production rate by the vertical difference between the total revenue line and total cost curve. For instance, at a production rate of 100 meals per week, the height of the total revenue line is \$5,000, while the height of the total cost curve is \$11,100. Hence, the vertical difference is $-\$6,100$, which is the accounting profit.

At a production rate of 100 meals per week, the total revenue line climbs faster than the total cost curve. So, increasing production would raise the profit. To understand this in another way, we apply the concept of marginal revenue. The **marginal revenue** is the change in total revenue arising from selling an additional unit. The seller should increase production if marginal revenue exceeds the marginal cost.

By contrast, at 900 meals per week, the total revenue climbs more slowly than the total cost curve, which means that the marginal revenue is less than the marginal cost.

Marginal revenue:

The change in total revenue arising from selling an additional unit.

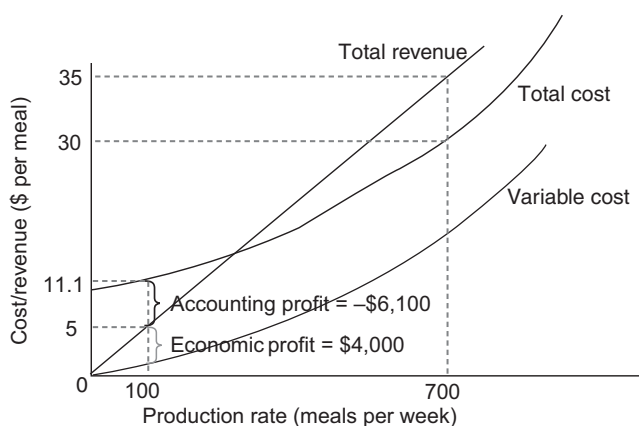


Figure 4.3 Short-run profit

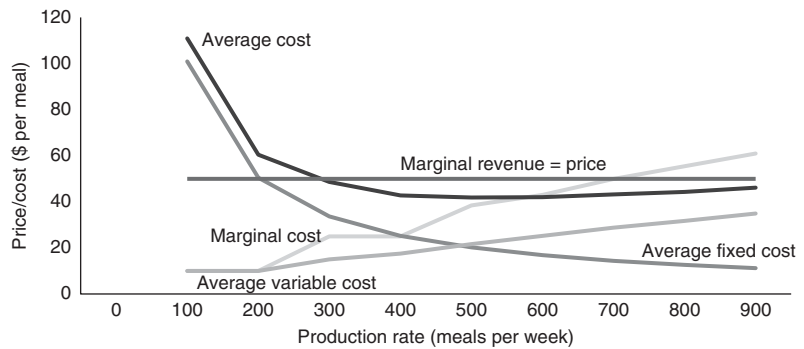


Figure 4.4 Short-run production rate

Then cutting production would increase profit. The seller should reduce production if marginal revenue is less than the marginal cost.

The seller would *maximize profit at the production rate where its marginal revenue equals marginal cost*. At that point, the total revenue line and the total cost curve increase at exactly the same rate. Hence, any change in production would affect both total revenue and total cost to the same extent. Accordingly, it would not be possible to increase profit any further. Referring to Table 4.3, at 700 meals per week, the marginal revenue and marginal cost are both \$50.

Profit-maximizing scale of production:

The scale where marginal revenue equals marginal cost.

For a small seller, which can sell as much as it would like at the market price, the rule for **profit-maximizing production** can be expressed in another way. By definition, the marginal revenue is the change in total revenue arising from selling an additional unit. For a small seller, the change in total revenue arising from selling an additional unit is exactly the price of the product. Hence, the seller would maximize profit by producing at the rate where the price of the product equals marginal cost.

To illustrate this rule, Figure 4.4 reproduces the marginal and average cost curves from Figure 4.2 and adds a line representing the marginal revenue and price. Where the price exceeds the marginal cost, the seller can increase profit by raising production. By contrast, where the price is less than the marginal cost, the seller can increase profit by cutting production. Therefore, the seller would maximize profit by producing 700 meals per week, the rate at which the price just balances the marginal cost.

Break-even analysis

Should a business continue in production? To make this decision, the business should compare the profit from continuing in production with the profit from shutting down.

If Luna were to shut down, how much would it earn? Clearly, total revenue would be zero. What about its costs? We assume that the entire fixed cost of \$10,100 is also sunk. Chapter 1 introduced the concept of sunk cost in an informal way. Here we define it formally: a **sunk cost** is one that has been committed and cannot be avoided. Costs which are not sunk are *avoidable*.

Sunk cost: A cost that has been committed and cannot be avoided.

Since the fixed cost of \$10,100 is sunk, if Luna were to shut down, its accounting profit would be $-\$10,100$. Thus, the business should continue in production so long as its accounting profit is at least $-\$10,100$. Apparently, the business should produce even though it incurs a “loss.” The reason is that if it shut down, it would incur an even larger loss.

A more intuitive rule applies the concept of economic profit. Augmenting the concept as introduced in Chapter 1, define economic profit as the difference between the seller’s total revenue and the *avoidable* cost of production. Since the fixed cost is sunk, the avoidable cost is the variable cost.

Referring to Table 4.3, if Luna were to shut down, its economic profit would be zero. Hence, a business should continue in production so long as the economic profit is at least zero. (This is more intuitive than the rule based on accounting profit because it ignores the fixed cost.) Equivalently, the **short-run break-even** condition is to continue in production so long as the total revenue covers the variable cost.

Another way to express the short-run break-even condition refers to the price of the product. Recall that total revenue is the price multiplied by production, and so, total revenue divided by production is price. Further, variable cost divided by production is average variable cost. Hence, the seller should continue in production so long as the price covers the average variable cost.

Short-run break-even: Total revenue covers variable cost, or price covers average variable cost.

Individual supply curve

To summarize, in the short run, a business (which can sell as much as it would like at the market price) should produce at the rate that balances the price with the marginal cost, provided that the price covers the average variable cost. This rule determines the production at every possible price of the product.

By varying the price, we can construct the individual supply curve. The **individual supply curve** is a graph showing the quantity that a seller will supply at every possible price.

Referring to Figure 4.4, the lowest level of the average variable cost is \$10 per meal. This is the lowest price at which Luna would produce. If the price were lower, say \$8, it would be less than the average variable cost, and Luna should not produce at all.

At prices of \$10 and higher, Luna would produce at the rate where the price equals the marginal cost. Hence, the individual supply curve is that portion of the seller’s marginal cost curve which lies above the average variable cost curve.

The individual supply curve slopes upward because to expand production, the seller must incur a higher marginal cost. So, the seller will expand production only if the price is higher. The effects of changes in the price of the product are represented by moving along the supply curve.

Individual supply curve: A graph showing the quantity that a seller will supply at every possible price.

Progress check 4C. Using Figure 4.4, show the quantity that Luna would produce at a price of \$30 per meal.

Managing a restaurant in a pandemic: short run

To control the spread of Covid-19, the Hong Kong government severely restricted dining in restaurants by limiting opening hours, the number of persons at each table, and the distance between tables. Edwin Kam is general manager of a chain of Shanghainese restaurants. In December 2020, he remarked that, if conditions did not improve by the Lunar New Year, they might lay off 10% of their 200 workers.

One of the largest costs of operating a restaurant in Hong Kong is rent. This is a fixed cost for the duration of the tenancy. The restaurant cannot avoid paying rent by shutting down. In the short run, in deciding whether to continue in business, the restaurant should consider only variable costs. Hence, rent would not matter.

Depending on their employment contracts, workers may be a variable cost. Which explains why Kam was considering layoffs but not shutting down. So long as revenue exceeded variable cost, it made sense to continue operating.

4.4 Long-run individual supply

In the short run, a business must work within the constraints of past commitments. Yet, with sufficient time, all inputs become avoidable. The *long-run* time horizon is long enough for the seller to adjust all inputs, including possibly entering or exiting the industry.

How should a business make the two key decisions – the participation decision of whether to continue in production and the extent decision of how much to produce – in the long run? To analyze these decisions, we consider long-run costs and long-run revenue.

Long-run costs

To calculate the long-run costs of the business, we proceed in the same way as for short-run costs. Interview management on the expenses at the various production rates, assuming that all inputs are avoidable. Then extract the information to compile Table 4.4, which displays the long-run total, marginal, and average costs.

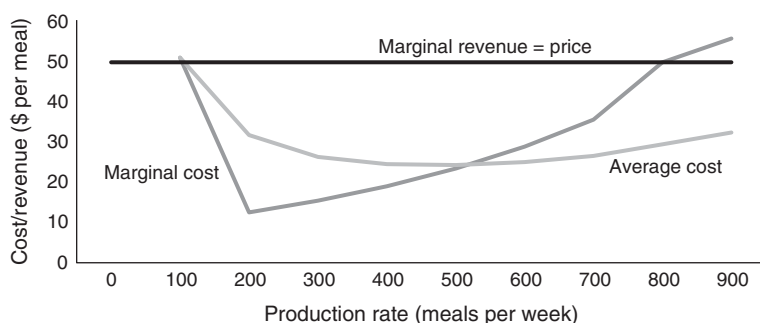
In the long run, all costs are avoidable. Hence, the accounting profit and economic profit would be the same. Below, we focus on the economic profit.

Production rate

How much should the business produce in the long run? The rule for maximizing profit is similar to that for short-run production. To maximize profit, a business should

Table 4.4 Long-run profit

Meals per week	Total cost (\$)	Marginal cost (\$)	Average cost (\$)	Price (\$)	Total revenue (\$)	Economic profit (\$)
0	4,100			50	0	(4,100)
100	5,118	10.18	51.18	50	5,000	(118)
200	6,374	12.56	31.87	50	10,000	3,626
300	7,923	15.49	26.41	50	15,000	7,077
400	9,833	19.10	24.58	50	20,000	10,167
500	12,186	23.53	24.37	50	25,000	12,814
600	15,084	28.98	25.41	50	30,000	14,916
700	18,651	35.68	26.64	50	35,000	16,349
800	23,651	50.00	29.56	50	40,000	16,349
900	29,244	55.93	32.49	50	45,000	15,756

**Figure 4.5** Long-run production rate

produce at that rate where its long-run marginal revenue equals the long-run marginal cost.

For a business that can sell as much as it would like at the market price, the long-run marginal revenue equals the long-run price of its product. Hence, the rule for maximizing profit is to produce at that rate where the long-run price equals the long-run marginal cost.

Suppose that the long-run price is \$50 per meal. Table 4.4 presents the long-run cost, revenue, and economic profit. The economic profit reaches a maximum of \$16,349 at production rates of 700 and 800 meals per week. Strictly, its profit would be even higher at some rate between 700 and 800 meals per week. For simplicity, we focus on 800 meals per week as the profit maximizing production.

Figure 4.5 depicts the long-run marginal and average cost curves as well as the line representing marginal revenue and price. At the production rate of 800 meals per

week, the marginal cost is \$50 per meal, which is equal to the marginal revenue and price. This confirms that production of 800 meals maximizes profit.

Break-even analysis

Should the business continue in production? To make this decision, the business should compare the profit from continuing in production with the profit from shutting down.

In the long run, all costs are avoidable, hence, if Luna were to shut down, it would incur no costs and so its economic profit would be zero. Hence, a business should continue in production so long as the economic profit is at least zero. Equivalently, the **long-run break-even** condition is to continue in production so long as the total revenue covers the total cost.

Long-run break-even: Total revenue covers total cost, or price covers average cost.

Another way to express the long-run break-even condition refers to the price of the product. Total revenue divided by production is average revenue. Since every unit is sold at the same price, average revenue equals the price. Further, total cost divided by production is average cost. Hence, the seller should continue in production so long as the average revenue (equal to price) covers the average cost.

Referring to Table 4.4, Luna's lowest average cost is \$24.37. It attains this cost at a production rate of 500 meals per week. Hence, if the long-run price of restaurant meals falls below \$24.37, then Luna should go out of business.

Individual supply curve

In the long run, a seller maximizes profit by producing at the rate where its long-run marginal cost equals the long-run price of the output. By varying the price, we can determine the quantity that the seller would supply at every possible price of the output.

Further, the seller should remain in business only if the long-run price covers the long-run average cost. Thus, the seller's long-run individual supply curve is that part of its long-run marginal cost curve which lies above its long-run average cost curve.

Progress check 4D. Referring to Figure 4.5, if the long-run price of restaurant meals is \$19, how much would Luna produce?

Managing a restaurant in a pandemic: long run

Between 2019 and 2020, the average retail rent in Hong Kong Island fell from HK\$1,533 to HK\$1,207 per square foot per month. Still, by December 2020, the Hong Kong Federation of Restaurants and Related

Trades reported that 2,300 of the city's 16,000 restaurants had closed. Yet, 300 new outlets opened.

In the long run, all inputs are avoidable, and businesses can freely enter and exit. Restaurants whose total revenue does not cover their total cost would shut down. Entrepreneurs who expect that their total revenue would cover their total cost would set up new restaurants. The lower rents attracted some to set up new restaurants.

A new segment in the industry is cloud kitchens, which produce meals for delivery. These require less physical space and can be set up in industrial areas where rents are lower, and therefore fixed costs are much lower. In April 2020, Shanghai Lane, with restaurants in Central, Tin Hau, and Happy Valley, set up a cloud kitchen in Deliveroo, Quarry Bay.

4.5 Market supply

To address questions such as the effect of changes in rent and wages on the restaurant industry, we need to understand the *market supply*. The **market supply curve** of an item is a graph of the quantity that all sellers will supply at every possible price. The market supply is the seller-side counterpart to the market demand, introduced in Chapter 2. Together, the supply and demand constitute a market.

We construct the market supply curve in a similar way as the individual supply curve. Ask each potential seller for the quantity that it would supply at every possible price. Then, at each price, add the individual quantities to get the quantity that the market as a whole will supply (see Appendix 4.A).

Let Figure 4.6 depict the long-run market supply curve for restaurant meals. In the long run, at a price of \$50 per meal, the restaurant industry would supply 800,000 meals.

Market supply curve: A graph of the quantity that all sellers will supply at every possible price.

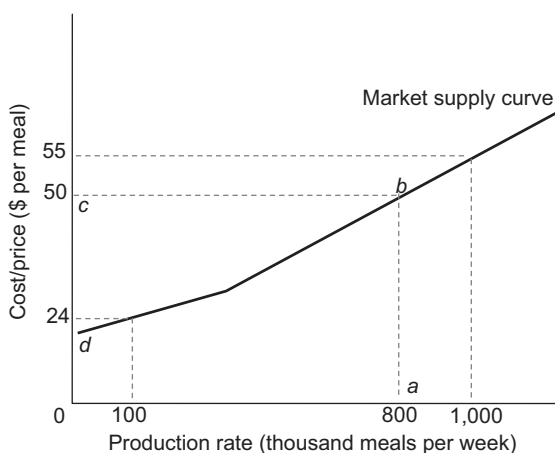


Figure 4.6 Market supply curve

Short and long run

The long-run market supply differs from the short-run market supply in one essential way. In the long run, every business will have complete flexibility in deciding on inputs and production. This flexibility implies that existing sellers can leave the industry, and new sellers can enter. The freedom of entry and exit is the essential difference between the short and long run.

In the long run, for a seller to break even, its total revenue must cover its total cost. If a seller's total revenue does not cover the total cost, then the seller should leave the industry. This exit would reduce the market supply, hence raise the market price and the profits of the other sellers. Sellers that cannot cover their total costs would leave the industry until all the remaining sellers at least break even.

By contrast, an industry where businesses can make (economic) profits, in the sense that total revenue exceeds total cost, will attract new entrants. Each of the new entrants would contribute its individual supply, and so add to the market supply. The increase in the market supply would push down the market price and hence reduce the profits of all the existing sellers.

Accordingly, in the long run, when there is a change in the market price, the quantity supplied would adjust in two ways: first, existing sellers would adjust their quantities supplied along their individual supply curves; and second, some sellers may enter or leave the market.

Properties

The market supply curve slopes upward. At a higher price of the product, the market as a whole would supply a larger quantity. Referring to Figure 4.6, at a price of \$55 per meal, the restaurant industry would supply 1 million meals.

The market supply curve shifts according to the prices of inputs. So, for instance, the market supply of restaurant meals depends on rents and wages. If wages increase, the marginal costs of production would be higher, and so sellers would produce less. This implies that the market supply curve would shift to the left.

We represent the effect of a change in the price of the product by a movement along the market supply curve. By contrast, we represent changes in the prices of inputs by shifts in the entire market supply curve.

Progress check 4E. In Figure 4.6, if rents were higher, how would that affect the market supply curve?

4.6 Elasticity of supply

Consider a typical issue for a market analyst. If the price of restaurant meals and wages were to increase by 5% and 10% respectively, what would be the effect on industry

sales? The analyst could answer this question with the supply curve. In practice, however, analysts seldom have sufficient information to construct the entire supply curve.

Another response to the question applies the elasticities of supply, which measure the responsiveness of supply to changes in underlying factors such as the prices of the item and inputs. The elasticities of supply are the supply-side counterparts to the elasticities of demand, introduced in Chapter 3.

The price elasticity is a handy way of comparing the sensitivity of the sellers of different items to changes in price. For instance, a food manufacturer may want to know how sensitive suppliers of fruits and vegetables are to changes in prices. The manufacturer can address this question by comparing the price elasticities of the supplies.

Price elasticity

The price elasticity of supply measures the responsiveness of the quantity supplied to changes in the price of the item. By definition, the **price elasticity of supply** is the percentage by which the quantity supplied will change if the price of the item rises by 1%. Equivalently, the price elasticity is the ratio

$$\frac{\text{Percentage change in quantity supplied}}{\text{Percentage change in price}}. \quad (4.3)$$

Price elasticity of supply: The percentage by which the quantity supplied will change if the price of the item rises by 1%.

Let us calculate the price elasticity of the long-run supply of restaurant meals. Referring to Figure 4.6, at a price of \$50, the industry would produce 800,000 meals per week, while at a price of \$55, it would produce 1 million meals. The percentage change in quantity supplied is the change in quantity supplied divided by the initial quantity supplied. The change in quantity supplied is $1,000,000 - 800,000 = 200,000$ meals, hence the percentage change in quantity supplied is $200,000/800,000 = 25\%$.

Similarly, the percentage change in price is the change in price divided by the initial price. The change in price is $\$55 - \$50 = \$5$, hence, the percentage change in price is $5/50 = 10\%$. Accordingly, the price elasticity of the long-run supply is $25/10 = 2.5$.

Intuitive factors

To estimate the price elasticity requires information on a change in price and the corresponding change in quantity supplied. However, changing the price to estimate the elasticity may be too costly or not practical. As an alternative, managers can consider two intuitive factors to gauge the price elasticity of supply.

Available production capacity

One factor is the available production capacity. A seller with considerable excess capacity will step up production in response to even a small increase in price. So supply would be relatively elastic. On the other hand, if capacity is tight, the seller may not

increase production by much for even a substantial price increase. Then supply would be relatively inelastic.

Adjustment time

In the short run, some inputs may be costly or impossible to change. Consequently, the marginal cost of increasing production would be high. For instance, a restaurant wishing to produce more meals quickly may have to pay overtime rates to workers. Since overtime rates are higher than regular wage rates, the marginal cost of expanding production would be relatively high.

With sufficient time, however, the restaurant could hire more workers at the regular wage. Accordingly, in the long run, the marginal cost would increase more gently. So, generally, the long-run supply would be more elastic than the short-run supply.

Progress check 4F. Under what intuitive conditions would supply be inelastic?

Farming: short and long run

For almost a decade, increasing demand from China encouraged farmers in Australia to grow more barley for export. Then, in May 2020, following a series of disputes, the government of China levied an 80% tariff on Australian exports of barley.

The tariff was announced when many Australian farmers had already sowed their crops for the November harvest. In the short run, the supply of grains is quite inelastic. The price of barley fell by over A\$50 per tonne. Some farmers, however, had time to adjust. At Croppa Creek in New South Wales, Tim Mooney switched 350 hectares from barley to wheat.

For later plantings, all farmers would have time to switch to other crops. Hence, in the long term, the supply would be more elastic.

4.7 Seller surplus

In Chapter 2 on demand, we learnt that the price that buyers pay is less than what they would be willing to pay, and so buyers enjoy buyer surplus. Similarly, on the supply side, the price that sellers receive is more than what they would be willing to accept, and so sellers enjoy seller surplus.

We derived the individual supply curve by asking a seller how much it would supply at every possible price. Another way to interpret the supply curve is that it shows the minimum price that the seller would accept for each unit of production. Generally, the

seller surplus is the difference between a seller's total revenue from some quantity of production and the seller's avoidable cost of producing that quantity.

Similarly, the market seller surplus is the difference between the sellers' total revenue and the sellers' avoidable cost. Referring to Figure 4.6, the minimum price that the industry would accept for 100,000 meals per week is \$24. But if the market price is \$50, the industry would enjoy seller surplus of \$26 on each of those meals.

Indeed, the industry would enjoy seller surplus on every meal up to the marginal unit produced. In Figure 4.6, the total revenue is represented by the area of the rectangle $0abc$ under the price line up to the production of 800,000 meals per week. The variable cost is the area $0abd$ under the supply curve up to 800,000 meals. Graphically, the seller surplus is the area dbc between the price line and the supply curve.

Seller surplus: The difference between a seller's total revenue from some quantity of production and the seller's avoidable cost of producing that quantity.

Progress check 4G. In Figure 4.6, show how an increase in the price of restaurant meals to \$55 would affect the market seller surplus.

Key takeaways

- To the extent that marginal costs increase with production, sellers will only increase production if the price of the product is higher.
- In the short run, a business (which can sell as much as it would like at the market price) maximizes profit by: if the total revenue covers the variable cost, producing at the rate where the price equals the marginal cost; if the total revenue does not cover the variable cost, shutting down.
- Fixed cost is the cost of inputs that do not change with the production rate, while variable cost is the cost of inputs that do change with the production rate.
- Marginal cost is the change in total cost due to the production of an additional unit, while marginal revenue is the change in total revenue arising from producing an additional unit.
- In the long run, a business (which can sell as much as it would like at the market price) maximizes profit by: if the total revenue covers the total cost, producing at the rate where the price equals the marginal cost; if the total revenue does not cover the total cost, shutting down.
- In the long run, businesses can adjust by entering or exiting the industry.
- The price elasticity of supply is the percentage by which quantity supplied will change if price of the item rises by 1%.
- Seller surplus is the difference between the seller's total revenue from some quantity of production and the seller's avoidable cost of producing that quantity.

Review questions

1. Explain the distinction between the short run and long run. How is this related to the distinction between fixed and variable costs?
2. Comment on the following statement: "It costs our factory an average of \$5 to produce a shirt. I cannot accept any order for less than \$5 per shirt."
3. Farmer Axel's fixed cost of growing corn is higher than that of Farmer Julia. What, if anything, does this imply for the difference in their marginal costs of growing corn?
4. Explain the principle of diminishing marginal product.
5. Under what conditions would a seller's marginal revenue equal the market price of its product?
6. Jupiter Oil produces 2,000 barrels of crude oil a day, at marginal cost of \$20 per barrel. The market price is \$15 per barrel. Explain how the company can increase its profit.
7. Does the following analysis under- or overestimate the change in profit? The price of eggs is 60 cents per dozen and a farmer produces 10,000 dozen eggs a month. If the price rises to 70 cents, profit would increase by \$1,000.
8. Explain why the following two conditions for short-run break-even are equivalent: (a) revenue covers variable cost; and (b) price covers average variable cost.
9. Some companies continue in business even though they are losing money. Are they making a mistake?
10. Explain why the following two conditions for long-run break-even are equivalent: (a) revenue covers total cost; and (b) price covers average cost.
11. Explain the differences between the short-run and long-run decisions to continue in business.
12. How would (a) a higher price of lumber, and (b) lower wages affect the supply of furniture?
13. If the supply curve slopes upward, the price elasticity of supply will be positive. True or false?
14. Consider the price elasticity of the market supply of crude oil. Do you expect supply to be relatively more price elastic in the short run or long run?
15. For a given increase in price of the product, will the increase in seller surplus be smaller or larger if the supply is more elastic? (*Hint*: Draw two supply curves, one more elastic than the other.)

Discussion questions

1. In 2020, Bank of the West held US\$46.1 billion, US\$4.4 billion, and US\$6.0 billion of funds in demand, savings, and time deposits. On these deposits, the bank paid interest of 0.41%, 0.04%, and 1.81% respectively.

- (a) In a table, list the three sources of funds and amounts in order of interest rate from lowest to highest.
 - (b) On a diagram with funds in billions of dollars on the horizontal axis and interest rate on the vertical axis, illustrate the (i) marginal cost of funds, and (ii) average variable cost of funds.
 - (c) If the bank had to downsize, which type of deposits should it reduce?
2. Table 4.1 reports Luna's weekly expenses. Suppose that wages are 5% higher.
 - (a) By recalculating Table 4.1, explain how the increase in wages would affect the (i) average variable cost, and (ii) average cost.
 - (b) Luna's management says that the wage increase has raised its break-even price by 5%. Do you agree?
 - (c) Supposing that the market price remains at \$50, how should Luna adjust production?
 - (d) How would an increase in rent affect your answers to (b) and (c)?
3. Throughout the world, the Covid-19 pandemic and government restrictions drastically cut the number of customers at retail shops. The Crown Estate, owner of London's Regent Street, decided to help its retail tenants by revising the rent. Tenants could choose between paying 9% of sales revenue or getting a discount on the contractual fixed rent.
 - (a) How would the shift from the fixed rent to the percentage rent affect the (i) fixed and (ii) variable cost of retail stores?
 - (b) Suppose that retailer A pays the percentage rent, while retailer B pays a fixed rent. (In expected value, the percentage rent equals the fixed rent.) During the next pandemic, explain which retailer would be more likely to shut down in the: (i) short run and (ii) long run.
4. In 2012, Barrick Gold's two most productive mines were Cortez and Goldstrike in Nevada, USA. Table 4.5 reports their financial performance. The "average cash cost" includes operating cost, royalties, and taxes, while the "average cost" includes the cash cost as well as amortization.
 - (a) Suppose that each mine produces at the rate where the (upward-sloping) marginal cost equals the price of gold. Illustrate the shifts in Goldstrike's marginal cost curve, selling price, and production between 2010 and 2012. (*Hints:* The marginal cost curve changes over time. You have only one data point on each curve. Assume any other data necessary to draw the figures.)
 - (b) Use the 2012 data to compare the (i) short-run break-even conditions for Cortez and Goldstrike; and (ii) the long-run break-even conditions for the two mines.
 - (c) If the price of gold falls to \$600 per ounce, how should Barrick adjust production at the two mines?

Table 4.5 Barrick Gold

2-34-7	Cortez			Goldstrike		
	2010	2011	2012	2010	2011	2012
Production (thousand ounces)	1,141	1,421	1,370	1,239	1,088	1,174
Selling price (\$ per ounce)	1,288	1,578	1,669	1,228	1,578	1,669
Average cash cost (\$ per ounce)	244	245	282	475	511	541
Average cost (\$ per ounce)	452	426	503	569	593	629

5. A ride-hail service must choose cars. In the 2021 model year, gasoline-powered Hyundai Elantra yielded 31 miles per gallon, while the hybrid gasoline-electric Toyota Prius yielded 54 miles per gallon. In the United States, the cheapest Elantra cost US\$19,650 as compared with the cheapest Prius at US\$24,525. Suppose a business has bought both cars. (*Hint: The following questions do not require any calculation.*)
 - (a) Compare the fixed and variable costs of operating the two cars.
 - (b) Compare the short-run break even prices of operating the two cars.
 - (c) How does the break-even price depend on the price of gasoline?
 - (d) In the short run, if demand falls, which car should be withdrawn from operation?
 - (e) In the long run, demand is uncertain. Justify the following plan: buy Priuses to meet the lowest expected demand, and then buy Elantras for the additional demand.
6. The Covid-19 pandemic and government restrictions on dining in restaurants devastated the food and beverage industry. By December 2020, the Hong Kong Federation of Restaurants and Related Trades reported that 2,300 of the city's 16,000 restaurants had closed. Yet, 300 new outlets opened.
 - (a) Classify the following as fixed or variable costs in the short run: (i) rent; (ii) salaries and wages; and (iii) ingredients and supplies.
 - (b) In the short run, if demand falls, discuss whether a restaurant should shut down.
 - (c) Classify the following as fixed or variable costs in the long run: (i) rent; (ii) salaries and wages; and (iii) ingredients and supplies.
 - (d) Explain the effect of a drop in rents on the opening of new restaurants.
7. In July 2012, Johnson Service Group decided to close 100 of its 460 dry cleaning shops in Britain. Sales at those outlets had declined by 2.7% in the first half of the year. However, Johnson did not know whether the fall in demand was due to weakness in the macroeconomy or consumers switching to machine-washable suits.

- (a) What is the long-run break-even condition for a dry cleaner?
 - (b) Which of the following affects the long-run price of dry cleaning relatively more: (i) macroeconomic weakness; or (ii) a shift in consumer preference toward machine-washable suits?
 - (c) Using a suitable figure, illustrate how the Johnson Service Group's decision affected the market supply of dry cleaning services. (*Hint: Assume any data necessary to draw the figures.*)
 - (d) For a competing dry cleaner, was the Johnson Service Group's decision good or bad news?
8. Domestic, Canadian, and Asian manufacturers supply furniture in the United States. They produce furniture in two formats – fully assembled, and ready-to-assemble in kits which the consumer must assemble at home. Manufacturing of furniture is relatively labor-intensive.
- (a) How do wages affect the relative cost of manufacturing fully assembled compared to ready-to-assemble furniture?
 - (b) Asian manufacturers benefit from lower wages. Using suitable diagrams, illustrate how the entry of Asian manufacturers would affect the US supply of: (i) fully assembled; and (ii) ready-to-assemble furniture.
 - (c) Using either of your diagrams for (b), show how a reduction in the cost of shipping would affect the supply of furniture.
 - (d) Which do lower shipping costs affect relatively more: Asian exports of fully assembled or ready-to-assemble furniture?
9. A controversial issue in managing climate change is the effect of taxes on gasoline. Higher taxes would reduce the after-tax price received by gasoline producers. The price elasticity of the supply of gasoline has been estimated to be 2.0.
- (a) Explain why the price elasticity of supply is positive.
 - (b) Suppose that a tax on gasoline reduces the after-tax price of gasoline by 5%. By how much would suppliers reduce gasoline production?
 - (c) Compare the effect of the tax on gasoline in the short vis-à-vis long run.

You are the consultant!

Consider any business that your organization is planning to downsize. How would the plan affect avoidable costs in the (a) short run, and (b) long run?

Progress check answers

- 4A. If the fixed cost were higher, the variable cost curve would not be affected, while the total cost curve would be shifted up by the extent of the increase in the fixed cost.

- 4B. If wages were higher, the average cost, average variable cost, and marginal cost curves would be shifted up.
- 4C. Luna would produce at the rate where marginal cost is \$30 per meal.
- 4D. \$19 is below Luna's lowest average cost. Hence, Luna would shut down and not produce at all.
- 4E. Higher rents would shift the market supply curve upward and to the left.
- 4F. Supply would be inelastic if production capacity is fully used and the adjustment time is short.
- 4G. The new seller surplus would be the area between the new price line of \$55 per meal and the market supply curve. The market seller surplus would increase by the area between the \$50 and \$55 price lines.

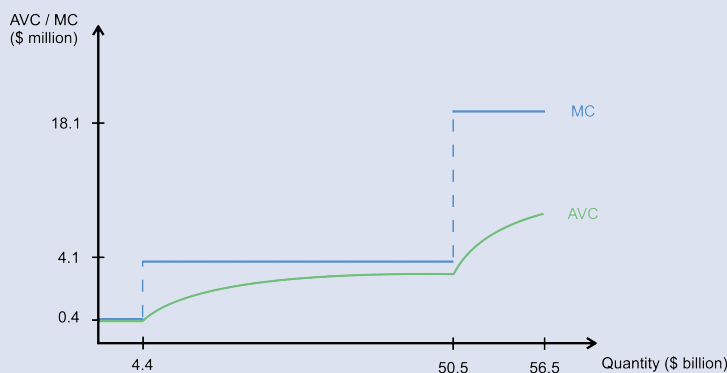
Review answers

1. The short run is a time horizon within which a seller cannot adjust at least one input. By contrast, the long run is a time horizon long enough that the seller can adjust all inputs. It is assumed that, in the short run, all fixed costs are also sunk, while all variable costs are avoidable.
2. This statement fails to consider that the fixed cost is unavoidable in the short run. The average cost is \$5. The factory should accept orders in the short run so long as the price of a shirt covers the average *variable* cost.
3. Nothing. Marginal costs are not necessarily related to fixed costs.
4. The marginal product of an input is the increase in production arising from an additional unit of input. With each increase in the input, the increase in production would be smaller.
5. If the seller is so small that it can sell as much as it would like at the market price.
6. Since the price is less than the marginal cost, the producer can raise profit by reducing production.
7. The analysis underestimates the increase in profit: It considers only the increase in profit on the existing production, and ignores the increase in profit resulting from an increase in production.
8. Price is revenue divided by sales (or production), while average variable cost is variable cost divided by sales (or production).
9. Not necessarily. In the short run, break-even depends on whether or not the revenue covers the variable cost. In the long run, break-even depends on whether or not the revenue covers average cost.
10. Price is revenue divided by sales (or production), while average cost is total cost divided by sales (or production).

11. In the short run, the business should continue in production so long as its revenue covers the variable cost. In the long run, the business should continue in production so long as its revenue covers the total cost.
12. (a) The supply of furniture will be lower (shift to the left); (b) The supply of furniture will be higher (shift to the right).
13. True.
14. The supply will be relatively more elastic in the long run.
15. For a given increase in price, if the supply curve is more elastic, the increase in seller surplus will be larger.

Discussion answers

1. (a) Savings deposits, US\$4.4 billion; Demand deposits, US\$46.1 billion; Time deposits, US\$6.0 billion.
(b) See diagram.



- (c) If the bank had to downsize, it should reduce time deposits, as they incur the highest marginal cost of funds.

Appendix 4.A

Market supply curve: construction

Chapter 4 introduces the concept of market supply, which shows the quantity that all sellers will supply at every possible price. Here, we discuss in detail the method by which to construct the market supply curve from the individual supply curves of the various sellers.

Generally, the market supply curve is the horizontal sum of the individual supply curves. At any particular price, each seller's individual supply curve shows the quantity

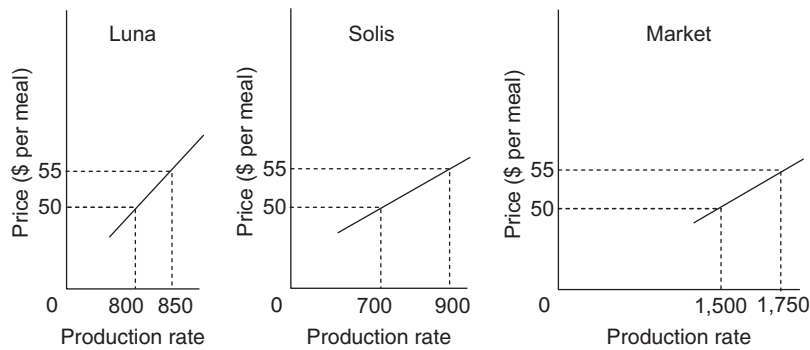


Figure 4.A1 Market supply curve

that the seller will supply. The sum of these quantities is the quantity supplied by the market as a whole. By varying the price, we can get the information needed to construct the market supply curve.

Short run

The short-run supply curve of an individual seller is the portion of its marginal cost curve that lies above its average variable cost curve. Hence, the market supply curve begins with the seller that has the lowest average variable cost. The market supply curve then gradually blends in sellers with higher average variable cost.

Long run

The long-run supply curve of an individual seller is the portion of its marginal cost curve that lies above its average cost curve. Hence, the market supply curve begins with the seller that has the lowest average cost. The market supply curve then gradually blends in sellers with higher average cost.

To illustrate, assume that there are just two restaurants: Luna and Solis. We draw the individual supply curves of the two producers and sum these horizontally to obtain the market supply curve. For instance, at a price of \$50, the market as a whole will supply $800 + 700 = 1,500$ meals per week. At a price of \$55, the market will supply $850 + 900 = 1,750$ meals.

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CHAPTER 5

Market equilibrium

LEARNING OBJECTIVES

- Understand the market equilibrium of demand and supply.
- Appreciate the impact of excess supply on the market price and quantity.
- Appreciate the impact of excess demand on the market price and quantity.
- Apply the price elasticities of demand and supply to predict the impact of shifts in demand on market price and quantity.
- Apply the price elasticities of demand and supply to predict the impact of shifts in supply on market price and quantity.
- Appreciate the effect of intermediation on buyers and sellers.
- Understand economic efficiency.
- Appreciate that perfect competition achieves economic efficiency.

5.1 Introduction

The UK exit from the European Union (so-called Brexit) and outbreak of Covid-19 reduced the demand for apartment rentals in London. Average monthly rents fell from £1,673 in March 2020 to a low of £1,583 in June, recovered to £1,653 in August, and then fell further to £1,556 in December.

Mariana Santos and a friend secured a two-bedroom apartment near Hyde Park for £1,680 per month, which was less than 70% of the pre-Covid rent. She was pleasantly surprised: “When we first started looking, in September, we thought we could only afford places further out, but by December, prices had come down even further so we could live really centrally.”

Landlords of London apartments – big and small – all faced the same perplexing question. How would Brexit and the Covid-19 pandemic affect rents?

To answer this question, landlords must understand demand, supply, and how they interact in a market. At first glance, the need to understand both demand and supply may seem surprising. Brexit and Covid-19 would affect the demand for apartment rentals. They would not affect the supply. Yet, as we shall see, landlords must consider both sides of the market.

This chapter combines the analyses of demand and supply to understand market equilibrium, and particularly, the effects of changes in demand and supply. We then show how intermediation affects buyers and sellers, and finally, how the market system achieves economic efficiency.

Using demand–supply analysis, we can explain the effects of Brexit and Covid-19 on the market for London apartment rentals. When demand falls, the market would be in excess supply and rents would fall until the market reaches equilibrium.

Demand–supply analysis is the core of managerial economics. It can help managerial decision-making in a wide range of markets, including goods and services, consumer as well as industrial products, labor markets, and domestic and international markets.

5.2 Perfect competition

Generally, demand–supply analysis applies to markets in which competition is very keen in the particular sense of *perfect competition*. The following conditions define perfect competition:

- The product is homogeneous.
- There are many buyers, each of whom purchases a quantity that is small relative to the market supply.
- There are many sellers, each of whom supplies a quantity that is small relative to the market demand.
- New buyers and sellers can enter freely, and existing buyers and sellers can exit freely.
- All buyers and all sellers have symmetric information about market conditions.

To appreciate the conditions for perfect competition, compare the markets for home cleaning and apartment rentals. The market for home cleaning services is close to perfectly competitive. The product is not completely homogeneous, but it is fairly easy for the buyer to observe quality. There are many buyers and many sellers, and buyers and sellers can freely enter and exit. Information about available suppliers, prices, and other market conditions is quite good, and more importantly, equally available to buyers and sellers.

By contrast, the market for apartment rentals is competitive but not to the extent of perfect competition. Apartments are heterogeneous: they differ in location, layout, defects, nuisances, and other ways. There are many tenants, and they can freely enter

and exit (at end of contract). There are many landlords, many small, but some large. Building new apartments is subject to government regulation. But, given the housing stock, landlords can freely enter and exit. Information is asymmetric: landlords know more about defects and nuisances than potential tenants.

In practice, very few markets exactly satisfy the conditions for perfect competition. Nevertheless, demand–supply analysis is still useful: many of the managerial implications are similar even if a market is not perfectly competitive. Chapters 6–12 discuss the particular features of markets which are not perfectly competitive.

Progress check 5A. What are the conditions for a market to be perfectly competitive?

5.3 Market equilibrium

For markets that meet the conditions for perfect competition, we can apply the *demand–supply framework*. In this framework, the concept of *market equilibrium* unifies demand and supply. **Market equilibrium** is the price at which the quantity demanded equals the quantity supplied. Market equilibrium is the basis for all analyses of how changes in demand or supply affect market outcomes.

Market equilibrium:

The price at which the quantity demanded equals the quantity supplied.

Demand and supply

To introduce the concept of market equilibrium, consider the market for apartment rentals. Tenants generate the demand, and landlords provide the supply. On a graph with the rent in dollars per month on the vertical axis and the quantity of apartments on the horizontal axis, we draw the demand and supply of apartment rentals.

Suppose that the equilibrium in the apartment market is at a rent of \$2,000 per month and quantity of 10,000. Referring to Figure 5.1, the demand curve shows that,

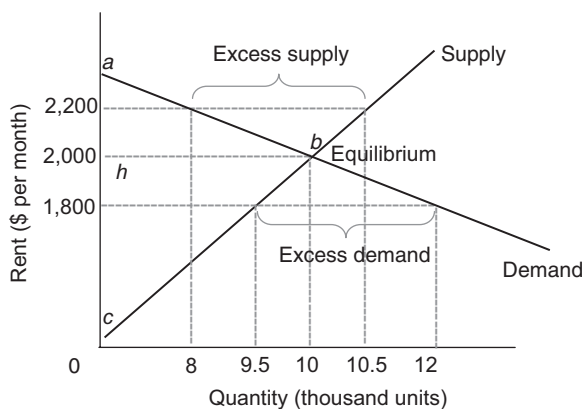


Figure 5.1 Market equilibrium

at the rent of \$2,000, tenants want to rent 10,000 units. The supply curve shows that, at the rent of \$2,000, landlords want to supply 10,000 units. The quantity that tenants want to purchase exactly balances the quantity that landlords want to supply.

At the market equilibrium, there is no tendency for price, purchases, or sales to change. In the apartment market with rent of \$2,000 per month, the rent will not change because the quantity demanded of 10,000 just balances the quantity supplied of 10,000. Purchases will not change because, at the rent of \$2,000, tenants maximize benefits less expenditure by renting 10,000 units. Further, sales will not change because, at the rent of \$2,000, landlords maximize profits by supplying 10,000 units.

For a market to be in equilibrium, both the quantity demanded and the quantity supplied must be the result of voluntary choices by buyers and sellers. Neither buyers nor sellers should face rationing or other restrictions.

What happens when the market is not in equilibrium? Then, generally, the market price will tend to change in such a way as to restore equilibrium. The price signals information about the disequilibrium and provides an incentive for buyers and sellers to converge to equilibrium.

Excess supply

One way in which the market can be out of equilibrium is if the price exceeds the equilibrium level. In the apartment market, suppose that the rent is \$2,200 per month. Then, referring to the demand curve in Figure 5.1, tenants would cut back rentals to 8,000 units. Referring to the supply curve, landlords would increase quantity supplied to 10,500 units.

Hence, at a rent of \$2,200 per month, the quantity supplied would exceed the quantity demanded by $10,500 - 8,000 = 2,500$ units. In more colorful terms, there would be too many apartments chasing too few tenants. The amount by which the quantity supplied exceeds the quantity demanded is the **excess supply**. So, at a rent of \$2,200, there would be an excess supply of 2,500 units.

In a situation of excess supply, the market price will tend to fall. Landlords would compete to clear their empty units and the market rent would drop back toward the equilibrium level of \$2,000.

From Figure 5.1 it is clear that, if the rent were even higher, at \$2,500 per month, the excess supply would be even larger than at a rent of \$2,200. Generally, the higher is the price above the equilibrium level, the larger will be the excess supply.

Excess demand

Another way in which the market can be out of equilibrium is if the price falls below the equilibrium level. Then the market price would tend to rise. In the apartment market, suppose that the rent is \$1,800 per month, and, referring to Figure 5.1, tenants demand 12,000 units, while landlords supply 9,500 units. Then the quantity demanded would exceed the quantity supplied by $12,000 - 9,500 = 2,500$ units.

Excess supply: The amount by which the quantity supplied exceeds the quantity demanded.

The amount by which the quantity demanded exceeds the quantity supplied is the **excess demand**. At a rent of \$1,800 per month, there would be excess demand of 2,500 units. Faced with this excess demand, tenants would compete for the limited units and the rent would rise toward the equilibrium level of \$2,000. Generally, the lower is the price below the equilibrium level, the greater will be the excess demand.

Excess demand: The amount by which the quantity demanded exceeds the quantity supplied.

Progress check 5B. In Figure 5.1, illustrate the excess demand if the rent is \$1,600 per month. Mark the quantities demanded and supplied.

Migrant workers: excess supply

High wages in Singapore attract workers from South Asia. In December 2020, the Singapore construction, shipyard, and marine process industries employed 311,000 foreign workers on work permits (the visa for relatively low-skilled workers).

Would-be migrant workers from Bangladesh and India present a huge excess supply of foreign labor to Singapore. With so many workers chasing a limited number of jobs, how does the market equilibrate? Migrant workers pay recruitment fees of ten times their monthly wage or more to secure jobs in Singapore.

Rent control: excess demand

In New York City, 1 million apartments are subject to rent stabilization. The Rent Guidelines Board regulates changes in rents, usually limiting increases to 2.5% or less per year. Columbia Business School professor Stijn Van Nieuwerburgh estimated that, on average, a person lucky enough to secure a rent-stabilized apartment would pay 7% less than market, and after 20 years, 45% less.

The result: excess demand for rent-stabilized apartments. Sitting tenants seldom move, and as CNBC reporter Annie Nova observed, such units are “close to impossible to find.” Nova set a personal goal to get her own apartment by the age of 37.

However, the Covid-19 outbreak accelerated her move. Work from home massively reduced the demand for apartments in New York City. In February 2021, she signed the lease for a one-bedroom rent-stabilized apartment in Manhattan.

5.4 Demand shift

Changes in market conditions or government policies will shift the demand curve, supply curve, or both. However, even if the change directly affects only one side of the market, it is essential to analyze the effects on the other side as well. Any analysis that ignores the other side of the market could be seriously incomplete.

Here, we consider the effect of a change that shifts the demand curve. Brexit and the Covid-19 pandemic reduced the demand for apartments in central London. How would that affect the rent and quantity of apartments rented?

Equilibrium change

Let us answer this question using the demand–supply framework. Figure 5.2 shows the original equilibrium at point *b*, with rent of \$2,000 and quantity of 10,000 units.

Suppose that the demand falls by 1,000 units. In Figure 5.2, the entire demand curve shifts to the left by 1,000. Equivalently, the demand curve shifts down by \$200 per month. The fall in demand, however, does not directly affect the supply of apartments. So the supply curve does not change.

Referring to Figure 5.2, the new demand curve crosses the unchanged supply curve at a new market equilibrium at point *d*. The new equilibrium has a lower rent and a smaller quantity of apartments. By how much would the rent and quantity of apartments fall? The answers depend on the price elasticities of both demand and supply.

Price elasticity of supply

Intuitively, on the supply side, if landlords are very insensitive to rents, then the reduction in demand would not induce them to supply less; hence, the shift in demand

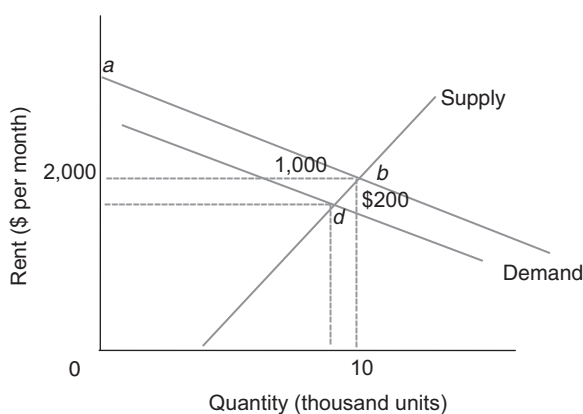


Figure 5.2 Demand shift

would reduce the rent by the entire shift of the demand curve. If, however, landlords are very sensitive to rents, then the reduction in demand would not change the rent.

To illustrate, consider Figure 5.3(a), which depicts an *extremely inelastic supply*. This means that landlords are completely insensitive to the rent: they supply the same quantity regardless of the rent. In particular, if the demand changes, they will not change the quantity supplied.

Then the equilibrium rent would change by exactly the shift of the demand curve. Hence, the market equilibrium rent would be \$1,800 per month and the equilibrium quantity would still be 10,000 units.

Figure 5.3(b) depicts the other extreme, which is an *extremely elastic supply*. This means that, essentially, the marginal cost of production is constant. When the demand curve shifts down by \$200 per month, the equilibrium rent does not change. The quantity supplied falls by 1,000 to 9,000.

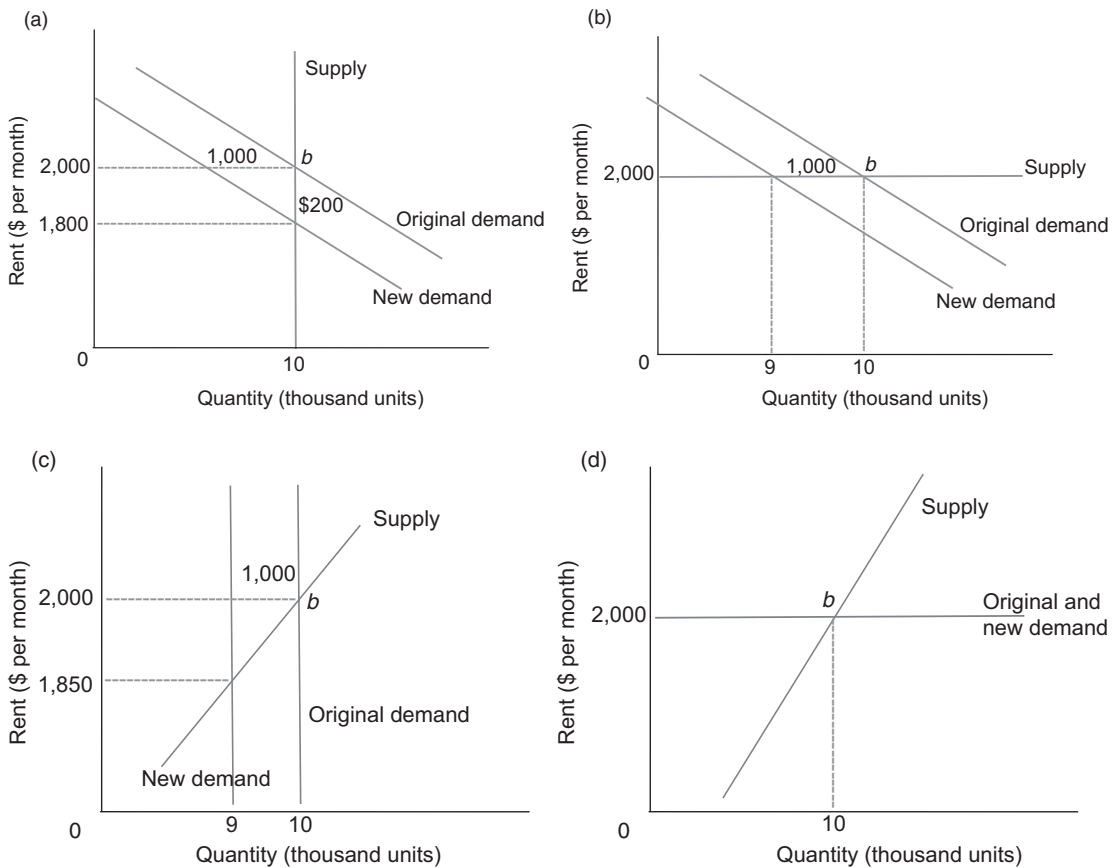


Figure 5.3 Price elasticities of demand and supply

Comparing Figures 5.3(a) and (b), we see the relationship between the price elasticity of supply and the outcome of a shift in demand. Generally, if the supply is more elastic, then a shift in demand would result in a smaller change in the equilibrium price and a larger change in the equilibrium quantity.

Price elasticity of demand

Intuitively, on the demand side, if tenants are extremely insensitive to rent, then the reduction in demand would cause a fall in the quantity by the entire reduction in demand. If, however, they are very sensitive to rent, then the shift in demand would result in no change to the equilibrium rent.

To illustrate, consider Figure 5.3(c), which depicts an *extremely inelastic demand*. This means that tenants are completely insensitive to the rent: they demand the same quantity regardless of the rent. Accordingly, when the demand curve shifts, the tenants reduce their purchases by exactly the same quantity. In Figure 5.3(c), when the demand curve shifts to the left by 1,000 units, the equilibrium quantity drops by exactly 1,000 units and the price falls to \$1,850 per month.

Figure 5.3(d) depicts the other extreme, which is an *extremely elastic demand*. This means that tenants are extremely sensitive to rent. Practically, the reduction in demand has no effect. The original and new demand curves are the same. Consequently, the market equilibrium does not change. In Figure 5.3(d), when the demand curve shifts to the left by 1,000 units, the equilibrium remains the same at a rent of \$2,000 per month and quantity of 10,000 units.

Comparing Figures 5.3(c) and (d), we see the relationship between the price elasticity of demand and the outcome of a shift in demand. Generally, if the demand is more elastic, then a shift in demand would result in smaller changes in the equilibrium price and quantity.

Progress check 5C. Which of (a) and (b), if either, is true? If the market demand curve shifts to the left, the drop in the equilibrium price will be larger if: (a) the demand is more price elastic; or (b) the supply is more price elastic.

Brexit, Covid-19, and London apartments

In the short run, the supply of apartments is fairly inelastic. If they do not rent out their unit, the landlord would still incur all the costs of finance, tax, and repair and maintenance.

The UK exit from the European Union (so-called Brexit) and outbreak of Covid-19 reduced the demand for apartment rentals in London. The supply

was especially inelastic as Covid-19 restrictions on travel cut off the alternative of renting for short periods to tourists.

Rents fell substantially. Between March and December 2020, average monthly rents fell by 7% from £1,673 to £1,556. The fall was more pronounced in central London. In December, Mariana Santos and a friend secured a two-bedroom apartment near Hyde Park for £1,680 per month, which was 30% less than the pre-Covid rent.

Face masks: short and long run

On 25 February 2020, Nancy Messonnier, an official of the US Centers for Disease Control and Prevention (CDC), warned that the coronavirus outbreak could cause “severe disruption.” At that time, the virus had afflicted over 81,000 persons and caused 2,762 deaths worldwide.

In early January, a package of 100 basic sanitary masks was priced at US\$4.21. By the day of the CDC announcement, the price more than tripled to US\$14.99, and a day later, jumped another US\$3. Evidently, in the short run, supply was very inelastic.

By contrast, in the long run, supply was quite elastic. The surge in prices drew multiple entrepreneurs to start producing face masks. By mid-2021, with the growth of domestic production and imports from China, the price of surgical masks had dropped by up to 90%.

The 25 members of the American Mask Manufacturers Association had installed capacity to produce 3.7 billion surgical masks a year. Moreover, they had 260 million unsold masks in stock. Blaming cut-price Chinese imports, the Association called for U.S. government assistance.

5.5 Supply shift

To understand the impact of a shift in demand, it is crucial to consider the interaction between supply and demand. The same is true for a shift in supply. For a complete understanding of the outcome, it is necessary to consider the demand side as well.

Suppose that the costs of providing apartment rentals falls. (Major costs include finance, taxes, and repair and maintenance.) How would that affect the rent and quantity of apartments rented?

The supply curve of rental apartments does not explicitly show the landlords’ costs. Accordingly, any change in costs would shift the entire supply curve. Suppose that the reduction in costs shifts the entire supply curve downward by \$200 per month.

Referring to Figure 5.4, the entire supply curve shifts down because the reduction in costs affects landlords’ marginal costs at every quantity that they supply. Another

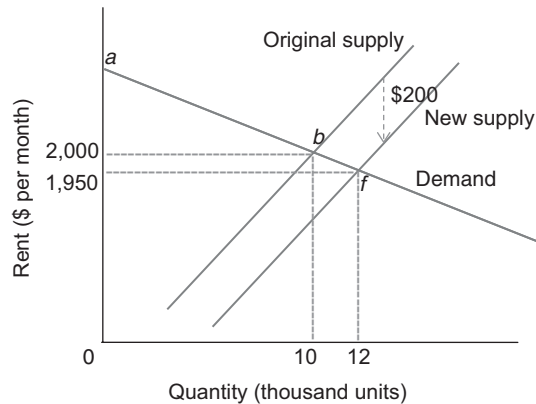


Figure 5.4 Supply shift

way of looking at the impact of the change in costs is that it shifts the supply curve to the right: at every possible rent, landlords want to supply more.

The change in costs, however, does not affect the demand for apartments. Referring to Figure 5.4, the new supply curve crosses the unchanged demand curve at a new equilibrium point, *f*, where the rent is \$1,950 per month. The fall in rent from \$2,000 to \$1,950 increases the quantity demanded from 10,000 to 12,000 units. On the new supply curve, at the rent of \$1,950, the quantity supplied is 12,000. The rent of \$1,950 is the new market equilibrium.

When the supply curve shifts down by \$200, the equilibrium rent falls by only \$50. Generally, a shift in the supply curve will change the equilibrium price by no more than the amount of the supply shift. What determines the change in price? It depends on the price elasticities of demand and supply.

Progress check 5D. In Figure 5.4, show how a \$200 increase in costs would affect the market equilibrium.

World prices of French products: foie gras vis-à-vis butter

France exports foie gras and butter. The supplies of French products to world markets depend on the exchange rate between the euro and other world currencies. If the euro rises against other currencies, the supply curves would shift up. If, however, the euro falls against other currencies, then the supply curves would shift down.

Suppose that the euro rises by 10%, shifting the supply curves of French foie gras and butter up by 10%. How would these shifts affect the prices of foie gras and butter on world markets?

There are few substitutes for French foie gras; hence, the demand is relatively inelastic. The upward shift of the supply curve will result in a relatively large increase in the world price. By contrast, there are many close substitutes for French butter, so that the demand is relatively elastic. Accordingly, the upward supply shift curve will result in a relatively small increase in the world price.

5.6 Intermediation

A very useful application of the demand–supply framework is to understand the impact of intermediation on the market for goods and services. For instance, historically, landlords seeking tenants hired real estate agents. Nowadays, landlords directly advertise to prospective tenants through the Internet. How would the disintermediation of real estate agents affect the rent and quantity of apartments?

Buyer’s price and seller’s price

To analyze disintermediation, it is necessary to make one change to the usual demand–supply analysis. We must distinguish the price that the buyer pays (buyer’s price) from the price that the seller receives (seller’s price). The seller’s price is the buyer’s price minus the cost of the intermediation.

Applying this approach to the market for apartments, suppose that, originally, landlords paid real estate agents an 8% commission. Figure 5.5(a) presents the demand

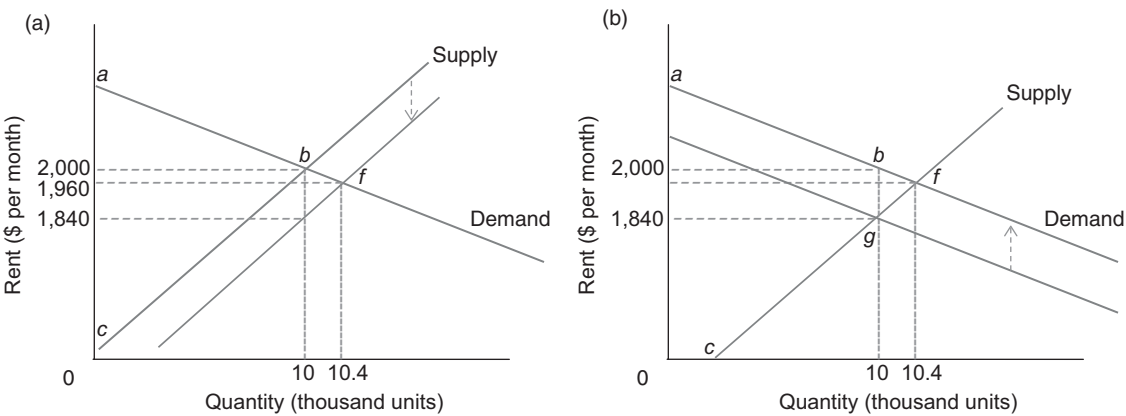


Figure 5.5 Disintermediation

and supply curves. The market equilibrium is at point *b*, with a rent of \$2,000 per month and quantity of 10,000 units.

The 8% commission amounts to \$160 per month. Hence the tenant paid \$2,000 (buyer's price), while the landlord received $\$2,000 - \$160 = \$1,840$ per month (seller's price).

Now suppose that landlords switch from hiring real estate agents to directly marketing on the Internet, and so, avoid paying any commission. In Figure 5.5(a), we represent this by shifting the supply curve vertically down by \$160 (just like the change in costs that we analyzed above).

In the new equilibrium, at point *f*, the rent is \$1,960 per month, and the quantity is 10,400 units. As a result of the disintermediation, the rent is lower and the quantity of apartments is larger. Tenants pay lower rent (buyer price reduced to \$1,960) and landlords receive more (seller price increased to \$1,960).

Incidence

Above, we assumed that the landlord had paid the real estate agent commission. What if tenants had paid the commission? Figure 5.5(b) presents the demand and supply curves.

The market equilibrium is at point *g*, where the tenant would have paid \$1,840 to the landlord and \$160 to the agent, and so, the buyer's price would have been $\$1,840 + \$160 = \$2,000$. The landlord would have received \$1,840 per month. Hence, the buyer's price and seller's price would have been the same as if landlord paid the commission.

Next, suppose that the tenant searches for apartments on the Internet and avoids the real estate agent commission. In Figure 5.5(b), we shift the demand curve up by \$160 (instead of shifting the supply curve down by \$160). Then, the equilibrium will again be point *f*. The buyer's price and seller's price would be the same as if landlord had saved the commission.

When there is a shift in demand or supply, the change in the price for a buyer or seller is called the **incidence** on that party. Generally, the incidence depends only on the price elasticities of demand and supply.

In the case of changes in intermediation, the incidence does not vary with who originally paid the cost of intermediation. The incidence depends only on the price elasticities of demand and supply.

Incidence: The change in price for a buyer or seller resulting from a shift in demand or supply.

Progress check 5E. In Figure 5.5(a), suppose that landlords and tenants each pay half of the real estate commission and show how avoiding the commission would affect the market equilibrium.

Alibaba

Alibaba manages business-to-consumer marketplaces with the avowed mission to “make it easy to do business anywhere.” In March 2020, Alibaba’s Tmall hosted over 250,000 brands and merchants. Merchants pay Alibaba for marketing services as well as commissions of 0.3% to 5.0% of the transaction value, depending on the product category.

Especially for consumers who live outside major cities, Alibaba has effectively disintermediated the conventional chain of wholesalers and retailers. Who benefits relatively more – consumer or merchant – depends on the price elasticities of demand and supply.

For products with elastic demand, the buyer’s price falls relatively little and consumers benefit less. By contrast, for products with inelastic demand, the buyer’s price falls relatively more and consumers benefit more.

5.7 Invisible hand

Two and a half centuries ago, the economist Adam Smith conceived a brilliant insight: In a competitive market, buyers and sellers, each acting independently and selfishly, would channel scarce resources into economically efficient uses. The **invisible hand** which guides the multitude of buyers and sellers is the market price. It is a simple and practical way of achieving economic efficiency.

Invisible hand:

Market price guides buyers and sellers, acting independently and selfishly, to channel scarce resources into economically efficient uses.

Economic efficiency

Let us apply Smith’s proposition to the market for apartment rentals. To start, we define **economic efficiency**. An allocation of resources is economically efficient if:

- all users achieve the same marginal benefit,
- all suppliers operate at the same marginal cost, and
- marginal benefit equals marginal cost.

An economically efficient allocation of resources will maximize the sum of buyer and seller surpluses. If the allocation of resources is economically efficient, there is no way to reallocate the resources to make one person better off without making someone else worse off.

Referring to Figure 5.1, the market is in equilibrium with a rent of \$2,000 per month and quantity of 10,000 units. On the demand side, as Chapter 2 explained, each tenant would rent the quantity such that their marginal benefit equals the market rent, \$2,000, and this is true for every tenant. In a perfectly competitive market, all tenants

face the same \$2,000 rent; hence, their respective marginal benefits will be equal. This is the first condition for economic efficiency.

What about the landlords? On the supply side, as Chapter 4 explained, each landlord will produce at the rate where the marginal cost equals the rent, \$2,000. This production rate maximizes profit. Again, in a perfectly competitive market, all landlords face the same \$2,000 rent. Thus, with each landlord selfishly maximizing profits, every landlord would produce at the same marginal cost. This is the second condition for economic efficiency.

So all tenants balance marginal benefit with the rent and all landlords balance marginal cost with the rent. But, in market equilibrium, all tenants and all landlords face the same rent. Therefore, marginal benefit and marginal cost must be equal. This is the third condition for economic efficiency. Thus, a perfectly competitive market satisfies the three requirements for economic efficiency.

Referring to Figure 5.1, the buyer surplus is area *abh* and the seller surplus is area *hbc*. The sum of buyer and seller surpluses is area *abc*.

Two roles of prices

The apartment example illustrates the power of Adam Smith's invisible hand. The market price guides multiple buyers and sellers, each acting independently and selfishly, to achieve economic efficiency.

The market price performs two roles in achieving economic efficiency. One role is to communicate the necessary information. It tells buyers how much to purchase and tells sellers how much to supply.

The other role is to provide a concrete incentive for each buyer to purchase the quantity that balances marginal benefit with the market price: by purchasing this quantity, the buyer achieves the maximum net benefit. Similarly, the price provides a concrete incentive for every seller to supply the quantity that balances marginal cost with the market price: by supplying this quantity, the seller maximizes its profit.

The term **market system** or **price system** describes an economic system in which freely moving prices guide the allocation of resources. The role of the invisible hand in achieving economic efficiency is the intellectual foundation of the market system.

Market (price) system: An economic system in which freely moving prices guide the allocation of resources.

Progress check 5F. Explain the two functions of price in a market system.

Distortion

A corollary of the invisible hand proposition is that, under conditions of perfect competition, any distortion of the market price would reduce economic efficiency. The distortion could be a price ceiling or price floor, or tax or subsidy. Any such distortion would be economically inefficient.

To illustrate, suppose that, in the market for apartment rentals, the government limits the rent to a maximum of \$1,800 per month. Referring to Figure 5.6, potential

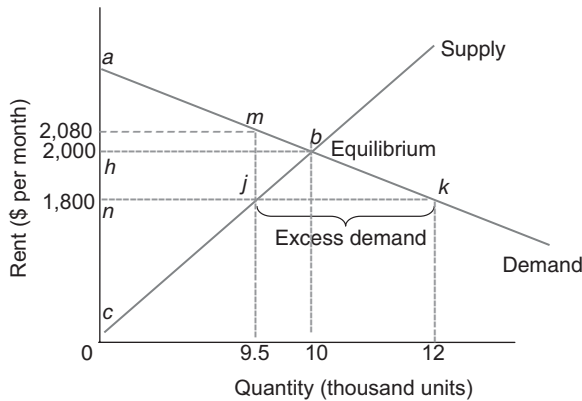


Figure 5.6 Price control

tenants demand 12,000 units but landlords supply only 9,500 units. The market equilibrium is at point j , at which there is an excess demand of 2,500 units.

Rent control does reduce the rent, but only for those lucky enough to get apartments. In equilibrium, the marginal cost of providing the 9,500th apartment equals the rent, \$1,800 per month. However, the marginal benefit of the 9,500th apartment is much higher, \$2,080 per month. Hence, the marginal benefit is not equal to the marginal cost, which violates a condition for economic efficiency.

Applying the concepts of buyer and seller surplus, we can quantify the loss of efficiency. The buyer surplus is the trapezium $amjn$ under the demand curve and above the price line up to the quantity supplied. The seller surplus is the triangle njc below the price line and above the supply curve. The sum of the buyer and seller surpluses is the trapezium $amjc$.

By contrast, if there were no rent control, the market equilibrium would be at point b , with a rent of \$2,000 per month and quantity of 10,000 units. The sum of the buyer and seller surpluses would be the triangle abc .

Comparing the market equilibria with and without rent control, we see that rent control reduces the sum of the buyer and seller surpluses by the triangle mbj . This represents the loss of economic efficiency due to the distortion of the market price.

Distortion of the market price reduces economic efficiency only if the market is perfectly competitive. If the market is imperfect in some way, then deviation from the market price may be efficient. Chapters 6–12 discuss markets which are not perfectly competitive.

Progress check 5G. In Figure 5.6, illustrate the loss of economic efficiency if the controlled rent is \$1,900 per month.

Hong Kong: public rental apartments as storage facilities

The Hong Kong Housing Authority accommodates almost 45% of the population in highly subsidized public rental housing. Rents of HK\$2,500 per month for new units in the Kwun Tong, Sham Shui Po, and Sha Tin districts are much lower than HK\$5,000 for 80 square feet “coffin homes” in the private sector. In January 2019, there were 268,500 applicants on the waiting list for public rental housing.

However, the low rents have attracted substantial abuse, including failing to live at the apartment, subletting to others, and using the apartment for storage or business activities. For tenants using their apartments as storage, their marginal benefit is low but exceeds the subsidized rent and falls short of the marginal cost to the Authority. The result is economically inefficient use of resources.

Key takeaways

- At the equilibrium price, the quantity demanded equals the quantity supplied, and the price will not change.
- If the market price exceeds equilibrium, there will be excess supply and the price will tend to fall.
- If the market price falls below equilibrium, there will be excess demand and the price will tend to rise.
- A shift in demand will affect the market price and quantity to an extent that depends on the elasticities of both demand and supply.
- A shift in supply will affect the market price and quantity to an extent that depends on the elasticities of both demand and supply.
- The incidence of a change in market conditions on buyers vis-à-vis sellers depends on elasticities of both demand and supply.
- The price system ensures that the allocation of resources is economically efficient.

Review questions

1. To what extent does the market for fresh vegetables meet the conditions for perfect competition?
2. To what extent does the market for used cars meet the conditions for perfect competition?

3. How would a requirement that sellers be licensed by the government affect the competitiveness of an industry?
4. If the market is in excess supply, what will happen to the price?
5. If the market is in excess demand, what will happen to the price?
6. Suppose consumers are queuing to buy tickets for a World Cup soccer match. Does this indicate excess demand or excess supply?
7. Suppose that there is excess supply of apartments. How would a fall in consumer incomes affect the excess supply?
8. Explain why the effect of colder weather on the market price of heating oil depends on the price elasticity of supply.
9. Explain why the effect of an increase in consumer incomes on the production of cars depends on the price elasticity of demand.
10. Explain why the effect of an increase in wages of waiters and kitchen staff on the market price of restaurant meals depends on the price elasticity of demand.
11. Consider a market for used cars in which sellers pay a commission to the marketplace. Explain the difference between the buyer's price and seller's price.
12. Luna Catering pays a 20% fee to a contractor for delivering meals to customers. Explain the difference between the buyer's price and seller's price.
13. A new shipping line has reduced the cost of transporting cars from Germany to Australia. Who would benefit? German car manufacturers or Australian consumers?
14. Explain how the invisible hand allocates resources in an economically efficient way.
15. Any distortion of market prices would reduce economic efficiency. True or false?

Discussion questions

1. In New York City, 1 million apartments are subject to rent stabilization. The Rent Guidelines Board regulates changes in rents, usually limiting increases to 2.5% or less per year. Columbia Business School professor Stijn Van Nieuwerburgh estimated that, on average, a person lucky enough to secure a rent-stabilized apartment would pay 7% less than market, and after 20 years, 45% less.
 - (a) Discuss whether the rent stabilization would cause excess demand or excess supply.
 - (b) Using suitable demand and supply curves, illustrate the equilibrium in the market for apartment rentals.
 - (c) How does the rent stabilization policy affect incentives to pay bribes to secure rent-stabilized apartments?
 - (d) How would the shift to work from home affect the equilibrium in (b)?

2. On 25 February 2020, Nancy Messonnier, an official of the US Centers for Disease Control and Prevention, warned that the coronavirus outbreak could cause “severe disruption.” At that time, the virus had afflicted over 81,000 persons and caused 2,762 deaths worldwide. Meanwhile, the price of 100 basic sanitary masks had more than trebled from US\$4.21 to US\$14.99.
 - (a) Discuss the price elasticity of the short-run supply of face masks in the United States.
 - (b) Using suitable demand and supply curves, explain the effect of the Covid-19 outbreak on the short-run equilibrium in the market for face masks.
 - (c) Discuss the price elasticity of the long-run supply of face masks in the United States.
 - (d) On your figure in (b), draw the long-run supply curve and discuss the differences between the short- and long-run equilibria.
3. Apple outsources the production of iPhones to contract manufacturers in China and elsewhere. As of May 2021, the exchange rate of the Chinese yuan to the US dollar was 16 US cents to 1 yuan.
 - (a) Explain how the appreciation of the Chinese yuan from 16 to 18 US cents would affect the cost of supplying iPhones to the United States.
 - (b) Suppose that the Chinese yuan rises by 10% against the US dollar. Which of the following are plausible explanations of why the US retail price of iPhones will rise by less than 10%: (i) the wholesale cost accounts for only part of retailers’ costs; (ii) American retail demand for iPhones is inelastic; (iii) American retail supply of iPhones is inelastic?
4. Following the Covid-19 outbreak, the UK government urged employers to allow their staff to work from home and severely restricted international travel. Between March and December 2020, average monthly rents fell by 7% from £1,673 to £1,556. The drop in rents was more pronounced in central London.
 - (a) How would working from home affect the demand for apartments in central London as compared with outer suburbs?
 - (b) How would travel restrictions affect the demand for short rentals of less than a week? Compare the effects on owners of apartments in central London vis-à-vis outer suburbs.
 - (c) Using your answers to (a) and (b) and suitable demand and supply curves, explain why the drop in rents was more pronounced in central London.
5. The Kurdistan region of Iraq, estimated to have 45 billion barrels of oil reserves, has been exporting crude oil by truck through Turkey. In late 2013, the regional government completed a 20-inch diameter connection

to the main Iraq–Turkey pipeline. The connection can convey 125,000 barrels of oil per day to the port of Ceyhan in Turkey.

- (a) Compare the fixed and marginal costs of transporting oil by (i) truck and (ii) pipeline.
 - (b) Which involves more sunk cost: supply by truck or pipeline?
 - (c) Draw the short-run supply curve of crude oil from Kurdistan through Turkey. On the supply curve, mark the supplies by truck and pipeline. (*Hint: Consider whether the pipeline or trucks supply oil more inelastically.*)
 - (d) The demand for Kurdistan oil fluctuates with global market conditions. Would the price of Kurdistan oil be more volatile if supplied by truck or pipeline?
6. The UK Tenant Fees Act of 2019 prohibits agents from charging fees to rental tenants. The government explained that the law requires the party which contracts the service, the landlord, to pay for the service, and so, increase the incentive of real estate agents to deliver value.
- (a) Consider the situation prior to 2019. Suppose that tenants pay a commission of £100 per month while landlords pay nothing. Suppose that the market equilibrium is a rent of £1,000 per month with 20,000 units rented. (i) Using suitable demand and supply curves, illustrate the equilibrium; (ii) What are the buyer's price and seller's price?
 - (b) Now suppose that the new law has taken effect. Landlords pay a commission of £100 per month while tenants pay nothing. How would that affect the equilibrium, buyer's price, and seller's price?
 - (c) The law can be justified if the market for apartments is not perfectly competitive. Which assumption of perfect competition might be violated?
7. Alibaba manages business-to-consumer marketplaces with the avowed mission to “make it easy to do business anywhere.” In March 2020, Alibaba's TMall hosted over 250,000 brands and merchants. Merchants pay Alibaba for marketing services as well as commissions of up to 5.0% of the transaction value, depending on the product category.
- (a) Consider the situation prior to Alibaba. Suppose that the cost of retailing is 10% of the retail price, and the retail price of an item is 100 yuan with 50,000 units sold per month. (i) Using suitable demand and supply curves, illustrate the equilibrium; (ii) What are the buyer's price and seller's price?
 - (b) Now suppose that Alibaba reduces the cost of retailing to 5%. How would that affect the equilibrium, buyer's price, and seller's price?
 - (c) Compare low involvement products with other products. Which have the more elastic demand?
 - (d) Which consumers would benefit relatively more from Alibaba? Those buying low involvement products or other products?

8. The Hong Kong Housing Authority accommodates almost 45% of the population in highly subsidized public rental housing. Rents of HK\$2,500 per month for new units in the Kwun Tong, Sham Shui Po, and Sha Tin districts are cheap compared with HK\$5,000 for 80 square feet “coffin homes” in the private sector. In January 2019, there were 268,500 applicants on the waiting list for public rental housing.
 - (a) Using suitable demand and supply curves, illustrate the equilibrium for public rental housing.
 - (b) Consider a family that has moved out of a rental unit but needs a storage facility. (i) Explain why they would use the rental unit as a storage facility. (ii) Compare the marginal benefit of the unit as storage facility with the marginal cost to the Housing Authority.
 - (c) If the Housing Authority charged market rents, would people use rental units as storage facilities?
9. To support local farmers, the Indian government buys rice at a minimum price for a national stockpile. As of April 2021, the government had accumulated 50 million tonnes of rice, or over three and a half times the target stock. The minimum support price for common rice was 18.68 rupees per kilogram.
 - (a) Suppose that, without any government support, the free market price of rice would be 15 rupees per kilogram. Using suitable demand and supply curves, illustrate the equilibrium.
 - (b) In your figure, illustrate the effect of the government price support.
 - (c) How does the excess supply depend on the price elasticities of demand and supply?
 - (d) Assume that, with government support, the market price of rice is the minimum support price. Compare the total surplus (sum of buyer and seller surpluses) in (i) the free market equilibrium, and (ii) with government price support.

You are the consultant!

Consider some good or service that your organization supplies in a competitive market. You have experienced a surge in demand, which is expected to be permanent. Prices have risen sharply and senior management is proposing new investment to capitalize on the higher prices. Write a memorandum analyzing the business case for the new investment, focusing on the short- and long-run increase in prices.

Progress check answers

- 5A. (a) The product is homogeneous; (b) There are many buyers, none of whom has market power; (c) There are many sellers, none of whom has market power; (d) New buyers and sellers can enter freely, and existing buyers and sellers can exit freely; (e) All buyers and all sellers have symmetric information about market conditions.
- 5B. See Figure 5.1. If rent drops to \$1,600 per month, the quantity demanded will exceed the quantity supplied.
- 5C. (a) False. (b) False.
- 5D. In Figure 5.4, the entire supply curve would shift up by \$200. The equilibrium price would rise and the quantity would fall.
- 5E. The equilibrium price (buyer's price equal seller's price) would be lower and the quantity would be higher.
- 5F. To communicate information about price and give incentive to buyers to demand and sellers to supply the equilibrium quantity.
- 5G. In Figure 5.6, at the higher controlled rent of \$1,900 per month, the quantity demanded would be smaller, and the triangle representing the loss of economic efficiency would be smaller.

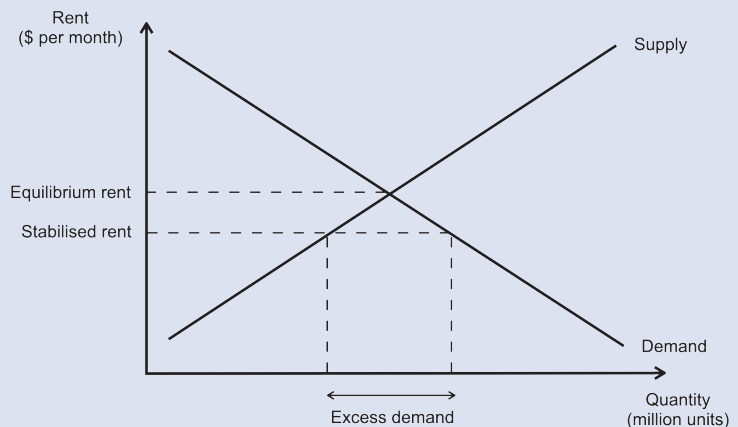
Review answers

- (a) Vegetables vary in quality but buyers can fairly easily observe quality. (b) There are many small consumers. (c) There are many small sellers. (d) Entry and exit are relatively free. (e) Sellers have better information than buyers about product quality.
- (a) Used cars vary in quality. (b) There are many small buyers. (c) There are many small sellers. (d) Entry and exit are relatively free. (e) Sellers have better information than buyers about product quality.
- This regulation presents a barrier to entry, and hence reduces the degree of competition.
- The price will tend to fall.
- The price will tend to rise.
- Excess demand.
- A fall in consumer incomes would reduce demand but not affect supply. It would increase the excess supply.
- Colder weather would increase the demand for heating oil. The effect of any change in demand depends, in part, on the price elasticity of supply. The impact on price would be greater if supply is more inelastic.

9. An increase in consumer incomes would increase the demand for cars. The effect of any change in demand depends, in part, on the price elasticity of demand. The impact on price would be greater if demand is more inelastic.
10. The increase in wages would reduce the supply of restaurant meals. The effect of any change in supply depends, in part, on the price elasticity of demand. The impact on price would be greater if demand is more inelastic.
11. Buyer's price = seller's price + commission.
12. Buyer's price = seller's price + fee.
13. Both manufacturers and consumers would benefit: seller's price would increase and buyer's price would fall.
14. The market price communicates information about demand and supply. It gives incentive to buyers to demand and sellers to supply the equilibrium quantity.
15. True if the market is perfectly competitive; false if the market is imperfect.

Discussion answers

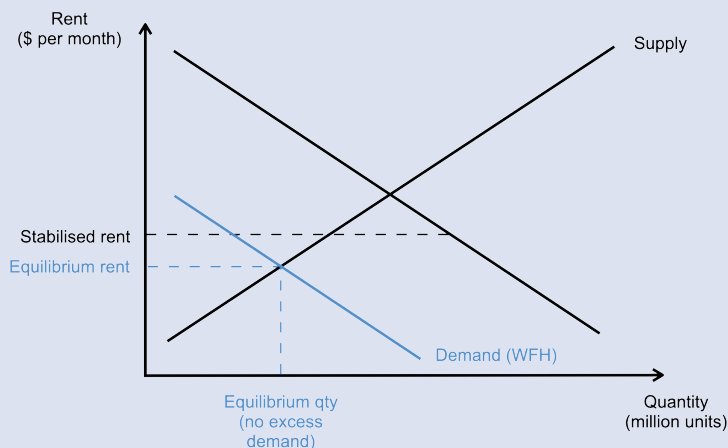
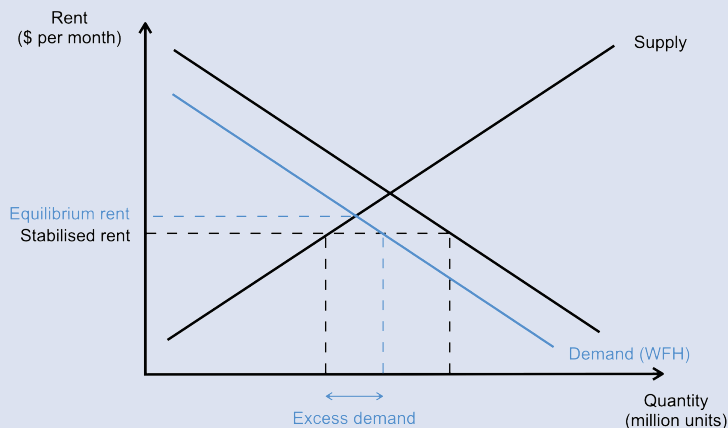
1. (a) Rent stabilization would result in excess demand, as the market price is lower than the equilibrium price. There would be too many tenants chasing too few rent-stabilized apartments.
- (b) See diagram.



- (c) The rent stabilization policy strengthens the incentives for prospective renters to pay bribes to secure rent-stabilized apartments. In particular, prospective renters will be willing to offer bribes equal

to the difference between the stabilized rent and their willingness-to-pay. In this manner, the price ceiling resulting from the rent stabilization policy may promote corruption.

- (d) The answer depends on how the shift to working from home affects the demand for apartments. (i) It could shift people further away, so, reducing the demand for city apartments. (ii) Or it could increase the demand as people need more space at home. The supply curve is unchanged. In case (i), either demand falls by a relatively small amount, so the stabilized rent remains binding but excess demand is reduced, or demand falls by a relatively large amount, so the stabilized rent is no longer binding. Excess demand is eliminated and a lower equilibrium rent is attained. See diagrams. The analysis of case (ii) is similar but in the opposite direction.



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PART II

Market power



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CHAPTER 6

Costs

LEARNING OBJECTIVES

- Appreciate opportunity costs.
- Appreciate sunk costs.
- Understand economies of scale.
- Understand economies of scope.
- Recognize behavioral biases in cost analysis.

6.1 Introduction

In April 2021, Toyota bought Lyft's autonomous car division for US\$550 million. Five months before, Uber sold its autonomous vehicle unit to Aurora Innovation, which specializes in developing technologies for autonomous cars and trucks. Uber invested an additional US\$400 million in Aurora.

Earlier, in mid-2019, Volkswagen merged its European autonomous vehicle unit into Argo AI, which also specializes in developing technologies for autonomous cars and trucks. Volkswagen also invested US\$1 billion in Argo AI, adding to an investment by Ford Motor Company in 2017.

What explains the trend of consolidation in the autonomous vehicle industry? In this industry, do specialists in cars or trucks or one geographical region have any advantage over developers of technology for all vehicles and all regions of the world?

To address these questions, we introduce a framework of cost analysis. We begin by distinguishing accounting from economic costs. Within any planning horizon, costs are either sunk or avoidable. Sunk costs are those that have been committed and cannot be avoided. Accounting costs differ from economic costs by including sunk costs and ignoring opportunity costs.

Within economic costs, it is useful to analyze costs by the rate of production. Fixed costs do not vary with the rate of production, while variable costs do. Fixed costs are an essential reason for economies of scale. The requirement of substantial fixed costs may explain the trend of consolidation in the autonomous vehicle industry.

Another way to analyze costs is whether they vary with the range of products. Joint costs do not vary with the number of products, and are an essential reason for economies of scope. In the autonomous vehicle technology industry, joint costs would explain whether specialists by function (cars or trucks) or geography have any advantage over generalists.

6.2 Economic cost

Practically, the most convenient source of information on costs is accounting records. However, although related, the concept of economic cost differs from accounting cost. Conventional accounting statements may fail to reveal costs which are important to effective business decisions but present costs which are not relevant to effective business decisions.

Economic cost includes *opportunity costs*, which must be forgone to continue with the status quo. By continuing the status quo, the manager is forgoing the profit contribution from the next best course of action. To make correct business decisions, managers must take account of opportunity costs.

By contrast, economic cost excludes *sunk costs*. These are irrelevant to any decision because they have already been incurred and cannot be reversed. Hence, to make correct business decisions, managers must ignore sunk costs.

Accordingly, **economic cost** equals accounting cost plus opportunity cost less sunk cost:

$$\text{Economic cost} = \text{Accounting cost} + \text{Opportunity cost} - \text{Sunk cost}. \quad (6.1)$$

Referring to Figure 6.1, the avoidable costs can be analyzed by how they vary with the rate of production (fixed vis-à-vis variable costs) and how they vary with the range of products (joint vis-à-vis specific costs). Below, we elaborate on the concepts of opportunity, sunk, fixed, variable, joint, and specific costs.

Progress check 6A. Explain the difference between accounting and economic cost.

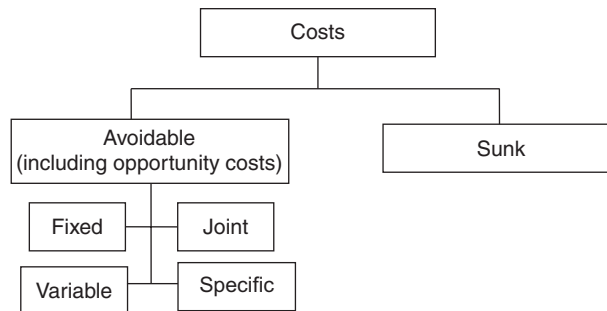


Figure 6.1 Cost taxonomy

Economic cost:
Accounting cost plus
opportunity cost less
sunk cost.

6.3 Opportunity cost

To illustrate the concept of opportunity cost, suppose that Luna Auto has accumulated cash of \$1 billion. It is considering a \$1 billion research and development project to develop technology for autonomous vehicles. The new technology is expected to generate a profit contribution of \$2 billion. (Profit contribution is revenues less variable cost, excluding R&D expenditures.) Luna has not yet commenced R&D.

Meanwhile, a university research group has already developed a similar technology. The university has offered to sell its technology to Luna for \$200 million. The university's technology would be just as good and also yield a profit contribution of \$2 billion. How should Luna choose between commencing its own R&D and buying the university's technology?

Alternative courses of action

Table 6.1 presents a projected income statement for the R&D project. The profit contribution is \$2 billion for an R&D expense of \$1 billion. So, the projected profit is \$1 billion for an investment of \$1 billion. The return on investment, $1/1 = 100\%$, looks very good.

However, the income statement overlooks a significant cost of commencing the R&D project. A proper evaluation should consider the alternative uses of Luna's investment funds. Specifically, the university is willing to sell technology, which would be just as profitable, to Luna for \$200 million.

The income statement, as conventionally presented, does not present the revenues and costs from alternative courses of action. Table 6.2 presents an expanded income statement that explicitly shows the alternatives. This makes it very clear that Luna should cancel its own R&D and buy the university's technology.

Table 6.1 Conventional income statement (\$ million)

Profit contribution	2,000
R&D expense	1,000
Profit	1,000

Table 6.2 Income statement showing alternatives (\$ million)

	<i>Commence R&D</i>	<i>Cancel R&D and buy technology</i>
Profit contribution	2,000	2,000
R&D expense	1,000	0
External purchases	0	200
Profit	1,000	1,800

Table 6.3 Income statement showing opportunity cost (\$ million)

	<i>Commence R&D</i>
Profit contribution	2,000
R&D expense	1,000
Opportunity cost	1,800
Profit	−800

Identifying opportunity cost

Opportunity cost:

What must be forgone from the best alternative course of action.

By commencing its own R&D, Luna forgoes the opportunity to buy the university’s technology, which would yield a profit of \$1.8 billion. The **opportunity cost** of the current course of action is what must be forgone from the best alternative course of action. In Luna’s case, there is only one alternative to its own R&D and the opportunity cost is \$1.8 billion.

We can apply the concept of opportunity cost to present the revenues and costs of continuing the R&D project in another way. Following equation (6.1), this method includes opportunity costs among the costs of the business.

Table 6.3 presents a single income statement, showing both the R&D expense and the opportunity cost. The (economic) profit from commencing R&D is −\$800 million, which is a loss. Clearly, Luna should cancel the R&D project.

Decision-making

So, there are two ways to uncover relevant costs: either explicitly consider the alternative courses of action or use the concept of opportunity cost. When applied correctly, both approaches lead to the same correct decision.

In Luna’s case, there is one alternative to the existing course of action. Where there is more than one alternative, the explicit approach still works well. The opportunity cost approach, however, becomes more complicated: first identify the best of the alternatives, and then charge the profit contribution from that alternative as the opportunity cost of the current course of action.

Conventional methods of cost accounting focus on the costs of the course of action that management has adopted. They do not consider the revenues and costs of alternative courses of action; hence, they ignore costs that are relevant but do not involve cash outlays.

One reason for these omissions is that alternative courses of action and opportunity costs change with the circumstances, and so, are more difficult to measure and verify. Cost accounting focuses on objectively verifiable costs, and so overlooks opportunity costs.

Progress check 6B. If the university demands \$400 million for their technology, what is Luna's opportunity cost of commencing R&D and what is the correct decision?

Harvard MBA: the cost

Harvard Business School estimated the cost of studies for MBA students graduating in the year 2022 to be US\$213,636. The largest expense was the tuition fee of US\$68,440 per year, which for two years totaled US\$136,880. On the plus side, the median graduate received a starting salary of US\$148,750 and signing bonus of US\$30,000.

Surprisingly, the School did not mention the major opportunity cost of the MBA degree. Studying at Harvard would mean foregoing earnings and career advancement for two years. Perhaps students would learn about opportunity cost at Harvard.

Ryanair: carbon allowances

To regulate carbon emissions, the EU and UK require airlines and other carbon-intensive businesses to buy tradable carbon allowances to cover their emissions. Airlines receive free allowances to cover about half of their pre-Covid emissions, but must buy allowances for the remainder.

In 2019, Irish discount airline Ryanair was the seventh largest emitter of carbon in Europe (the top six were coal-fired electric power plants in Poland and Germany). Ryanair bought sufficient allowances at 25 euros per tonne for its operations until March 2023.

Between January and May 2021, the price of allowances rose from 35 to 50 euros per tonne. The price is expected to increase further as EU and UK governments cut the number of allowances. Equity analyst Alexander Paterson remarked that European budget airlines had mistaken the cost of carbon: "They are selling ahead at prices that may not reflect the actual costs they incur if they use the credits they have and need to buy more at 50 euros plus."

6.4 Sunk costs

As introduced in Chapter 4, a **sunk cost** is a cost that has been committed and cannot be avoided. Since sunk costs cannot be avoided, they are not relevant to business decisions and should be ignored.

Sunk cost: Cost that has been committed and cannot be avoided.

To appreciate the concept of sunk costs, let us consider Luna Auto at the midpoint of its R&D program. Suppose that Luna did not buy the university technology and has already spent \$500 million.

Meanwhile, the university sold its technology to another firm, which will soon commence sales. The competition would reduce Luna’s expected profit contribution of its own technology from \$2 billion to \$800 million. Should Luna cancel the R&D project?

Alternative courses of action

Table 6.4 presents an income statement for the R&D project. The profit contribution is \$800 million and R&D expense is \$1 billion. So the expected profit is –\$200 million, that is, a \$200 million loss. Apparently, Luna should cancel the R&D.

However, the income statement overlooks the fact that Luna would still incur at least part of the R&D expense even if it canceled the project. A proper evaluation of the decision to continue the R&D project should also consider the profit from canceling the project.

Table 6.5 lays out the revenues and costs associated with the alternative courses of action. As calculated above, if Luna continues with the R&D, its profit would be –\$200 million.

By contrast, if Luna cancels the R&D, its profit contribution would be zero. But it has already incurred half of R&D expense. Hence, if Luna decided to cancel the R&D, its profit would be –\$500 million. Evidently, Luna should continue with the R&D. Continuation yields a smaller “loss” than cancelation.

Identifying sunk costs

By canceling the R&D, Luna does not avoid the \$500 million of R&D expenditure already incurred. That expenditure is committed and sunk, and so should be ignored.

Table 6.4 Conventional income statement (\$ million)	
Profit contribution	800
R&D expense	1,000
Profit	–200

Table 6.5 Income statement showing alternatives (\$ million)		
	<i>Continue R&D</i>	<i>Cancel R&D</i>
Profit contribution	800	0
R&D expense	1,000	500
Profit	–200	–500

Table 6.6 Income statement omitting sunk costs (\$ million)

	<i>Continue R&D</i>
Profit contribution	800
R&D expense	500
Profit	300

Another way by which Luna can correctly decide whether or not to continue the R&D applies equation (6.1). This motivates a single income statement which includes only avoidable costs and omits sunk costs.

Table 6.6 presents this information, showing only avoidable costs rather than cash outlays. The profit contribution is \$800 million. The avoidable cost of the R&D project is \$500 million. If Luna continues with the R&D, it will earn an (economic) profit of \$300 million. Accordingly, the correct decision is to continue with the R&D.

Decision-making

We have shown two ways of dealing with sunk costs: explicitly consider the alternative courses of action or remove all sunk costs from the income statement. When applied correctly, both approaches lead to the same business decision.

In Luna's case, there is one alternative to the existing course of action. Where there is more than one alternative, the explicit approach still works well. The sunk cost approach, however, becomes more complicated. Which costs are sunk depends on the alternative at hand. Accordingly, it is easier to consider the alternative courses of action explicitly.

Conventional methods of cost accounting focus on the cash outlays associated with the course of action that management has adopted. These methods report all costs that involve cash outlays, even sunk costs. To make cost-effective decisions, managers must look beyond conventional accounting statements and ignore sunk costs.

Strategic implications

What costs are sunk depends on the commitments that have been made and the time horizon. Above, we analyzed Luna's decision when it had incurred 50% of the R&D expenditure. At an earlier point of time, the percentage of cost sunk in R&D would have been smaller. If Luna learnt about the competitor early enough, the correct decision would be to cancel the R&D.

From a prospective viewpoint, managers should be very careful before committing to costs that will become sunk, since such commitments cannot be reversed. Chapter 9 discusses how to exploit investments in sunk costs as a way to strategically influence the behavior of competitors.

Progress check 6C. Suppose that Luna learns about the competing firm when it has completed just 10% of its R&D project. What is Luna's cost of continuing R&D and what is the correct decision?

LG Electronics: off line

In the early and mid-2000s, South Korean LG Electronics placed third among the world's largest mobile phone manufacturers, following Nokia and Samsung. However, like Nokia, LG was late in graduating to smartphones.

In 2020, LG's share of the global smartphone market was just 2%. That year, with sales of 5.2 trillion won and expenses of 6.058 trillion won, LG's mobile phone business incurred an operating loss of 841 billion won. Losses in the previous five years were similar.

LG tried but failed to sell the mobile phone business to Vietnamese conglomerate Vingroup and Russia's sovereign fund. Finally, LG decided to exit. Equity analyst Ko Eui-young predicted that the exit would reduce LG's annual loss by 550 billion won, and increase the market value of the company by 4–5 trillion won.

The difference between the losses in LG's accounts and Ko's estimate of the reduction in losses might be sunk costs. Closing the business would not avoid such costs.

6.5 Economies of scale

For effective decisions, managers must identify all relevant costs and appreciate how those costs vary with the scale of the business. A fundamental issue for any organization is whether to operate on a small or large scale.

Large-scale production means mass marketing and relatively low pricing; by contrast, small-scale production is associated with niche marketing and relatively high pricing. So, how do costs depend on the scale or rate of production? (We treat the meanings of scale and rate as the same.)

Fixed and variable costs

To appreciate how costs vary with the rate of production, recall the distinction between fixed and variable costs introduced in Chapter 4. The *fixed cost* is the cost of inputs that do not change with the production rate. So the fixed cost supports the production of multiple units of output. The *variable cost* is the cost of inputs that change with the production rate.

Table 6.7 Autonomous car production: expenses (\$ million)

<i>Production rate (thousands)</i>	<i>Labor (\$)</i>	<i>Components & parts (\$)</i>	<i>Facilities (\$)</i>	<i>Technology (\$)</i>	<i>Total (\$)</i>
0	50	0	100	300	450
10	100	100	120	300	620
20	150	200	140	300	790
30	200	300	160	300	960
40	250	400	180	300	1,130
50	300	500	200	300	1,300
60	350	600	220	300	1,470
70	400	700	240	300	1,640
80	450	800	260	300	1,810
90	500	900	280	300	1,980

To illustrate, suppose that Luna Auto has developed the autonomous vehicle technology and plans to use it to manufacture self-driving cars. Let Table 6.7 present the expenses for production rates up to 90,000 per month. Production requires some minimum expenditure on labor and facilities. But, increases in production do require more labor and larger facilities.

By contrast, the expense on technology is the same, \$300 million per month, at all rates of production. If Luna wants to produce one more car, it need not use more technology. The same technology supports the production of any number of cars. (The expense on technology is for maintenance and updates, and so, is not a sunk cost.)

Table 6.8 assigns each of the expenses into the categories of fixed and variable costs. Production involves a fixed cost of \$450 million per month. Indeed, a substantial fixed cost is a distinctive feature of all technology businesses. As the rate of production increases from 0 to 90,000 per month, the variable cost rises from nothing to \$1.53 billion.

Marginal and average costs

The analysis of fixed and variable costs reveals how costs depend on the rate of production. As introduced in Chapter 4, the marginal cost is the change in total cost due to the production of an additional unit, and the average (or unit) cost is the total cost divided by the production rate.

In Luna's case, referring to Table 6.8, the marginal cost of the first 10,000 units is \$620 million – \$450 million = \$170 million, or $\$170,000,000/10,000 = \$17,000$ per unit. Indeed, the marginal cost is \$17,000 at all rates of production.

Table 6.8 Analysis of fixed and variable costs

Production rate (thousands)	Fixed cost (\$ million)	Variable cost (\$ million)	Total cost (\$ million)	Marginal cost (\$ thousand)	Average fixed cost (\$ thousand)	Average variable cost (\$ thousand)	Average cost (\$ thousand)
0	450	0	450				
10	450	170	620	17	45.0	17	62.0
20	450	340	790	17	22.5	17	39.5
30	450	510	960	17	15.0	17	32.0
40	450	680	1,130	17	11.3	17	28.3
50	450	850	1,300	17	9.0	17	26.0
60	450	1,020	1,470	17	7.5	17	24.5
70	450	1,190	1,640	17	6.4	17	23.4
80	450	1,360	1,810	17	5.6	17	22.6
90	450	1,530	1,980	17	5.0	17	22.0

Dividing total cost by the scale of production, we can obtain the average cost. The average cost drops from \$62,000 at a rate of 10,000 units per month to \$22,000 at 90,000 units per month.

The average cost decreases with the rate of production. To understand why, recall that the average cost is the average fixed cost plus the average variable cost. The average fixed cost is the fixed cost divided by the production rate. With a larger production rate, the fixed cost will be spread over more units of production and the average fixed cost would be lower.

Meanwhile, the average variable cost is constant at \$17,000 per unit. Therefore, the average cost declines with increases in the production rate. Figure 6.2 graphs the marginal, average variable, and average costs against the scale of production. The marginal and average variable cost curves are identical and flat. The average cost curve slopes downward.

A business for which the average cost decreases with the rate of production is said to exhibit **economies of scale** or **increasing returns to scale**. If production exhibits economies of scale, the marginal cost will be lower than the average cost.

Economies of scale (increasing returns to scale): Average cost decreases with the rate of production.

Diseconomies of scale (decreasing returns to scale): Average cost increases with scale of production.

Progress check 6D. Using the data in Table 6.8, draw the average fixed cost in Figure 6.2.

Diseconomies of scale

A business where the average cost increases with the scale of production is said to exhibit **diseconomies of scale** or **decreasing returns to scale**. A business will have

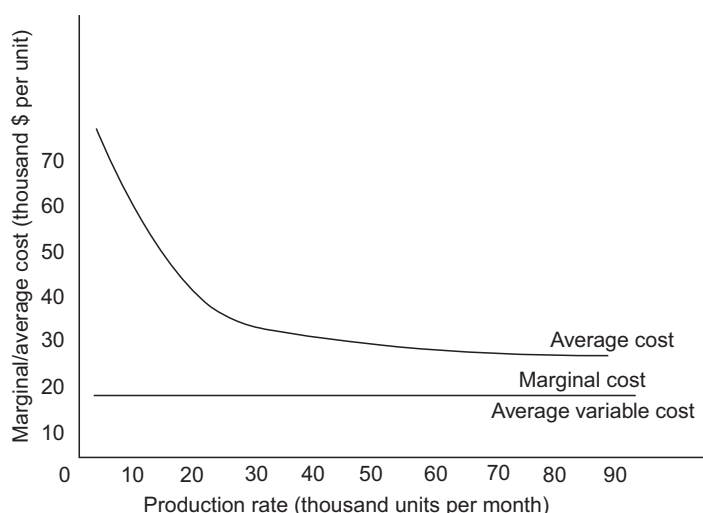


Figure 6.2 Economies of scale

diseconomies of scale if the fixed cost is not substantial and the variable cost rises more than proportionately with the rate of production.

The average cost is the average fixed cost plus the average variable cost. If the variable cost rises more than proportionately with the production rate, the average variable cost would increase. Hence, there is a production rate at which the decreasing average fixed cost is outweighed by the increasing average variable cost. Then the average cost reaches a minimum and rises with further increases in the production rate.

Strategic implications

Economies of scale arise where production requires substantial fixed inputs, that is, inputs that can support any rate of production. If the rate of production is higher, the cost of the fixed inputs would be spread over more units, and so, lower the average fixed cost. If the average variable cost is constant or does not increase very much with the rate of production, then the average cost would fall with scale.

Any business with a strong element of composition or design requires substantial fixed inputs. Manufacturing of autonomous vehicles is one example. The technology can support production of any number of self-driving cars. Movies are another example. The same movie can be shown over and over again to entertain any number of people.

The extent of economies or diseconomies of scale influences the structure of the industry. If production is subject to economies of scale, a business operating on a relatively large scale would achieve a lower average cost than smaller-scale competitors. The industry would tend to be concentrated, with a few producers serving the entire market. The extreme case is monopoly, which we study in Chapter 7.

By contrast, industries where production is subject to diseconomies of scale tend to be fragmented. The extreme case is perfect competition, as in Chapter 5, where there are many producers, none of whom can influence the market demand.

Autonomous vehicle technology: economies of scale

The difficulties of autonomous vehicle technology are much underappreciated. In 2016, Tesla founder, Elon Musk, famously asserted that self-driving vehicles were “probably less than two years away.”

At the time of writing and hundreds of millions of dollars later, self-driving vehicles have yet to arrive. The costs of R&D are large, and moreover, once developed, the technology would be a fixed cost. Any number of car manufacturers and ride-hail services could use the same technology.

The strong economies of scale explain the consolidation of the industry, such as Volkswagen merging its autonomous vehicle unit with Argo AI, Uber selling its Advanced Technologies Group to Aurora, and Lyft selling its Level 5 to Toyota.

Sunk and fixed costs

In popular as well as professional parlance, the term “fixed cost” is often used in two different senses: a cost that cannot be avoided once incurred (properly called *sunk cost*); and the cost of inputs that do not change with the production rate (properly called *fixed cost*).

Referring to Figure 6.1, it is important to distinguish sunk from fixed costs because the two concepts have very different implications for business decisions. Managers should ignore sunk costs that have been incurred, as these cannot be avoided. By contrast, fixed costs give rise to economies of scale, and so management should aim to operate on a large scale. (The confusion between the two concepts arises because economics texts tend to assume that, in the short run, all fixed costs are sunk.)

Some fixed costs become sunk once incurred. Consider, for instance, Luna Auto, which manufactures self-driving cars. Luna must carry out R&D to develop autonomous vehicle technology. The technology can support the production of any number of cars, and so it is a fixed cost. Separately, once Luna has incurred the R&D expenditure, the cost cannot be avoided. Hence, the R&D becomes a sunk cost.

Sunk costs, however, need not be fixed in the sense of supporting any scale of production. Suppose that Luna has developed the technology. To manufacture the cars, it builds a factory. The cost of building the factory is sunk, once incurred. If the demand for the cars is sufficiently high, Luna would need a second production line and must expand the factory. So, the cost of the factory is not a fixed cost. Rather, it depends on the scale of production.

Not all fixed costs become sunk. Continuing the example, Luna may be able to sell the technology produced by its R&D. So, only the part of the R&D expenditure that cannot be recovered from resale is sunk.

Lyft: monetizing sunk costs

Expenditure on R&D is sunk except to the extent that the resulting technology can be sold. Ride-hail operator Lyft increased investment in R&D from US\$300.8 million or 13.9% of revenue in 2018 to US\$909.1 million or 38.4% of revenue in 2020. Part of the R&D was directed at technology for autonomous vehicles.

In April 2021, Toyota bought Lyft's autonomous car division, Level 5, for US\$550 million. Lyft predicted that the sale would reduce its R&D expenditure by US\$100 million per year. Assuming that Lyft had spent US\$300 million on autonomous vehicle R&D, the sale to Toyota more than recovered the R&D expenditure.

Yet, Toyota structured the acquisition carefully. It agreed to pay Lyft US\$150 million initially, and then US\$350 million over five years. Staggering the payments over time postponed Toyota's commitments and the sunk costs incurred.

6.6 Economies of scope

Besides scale, another fundamental strategic issue for any business is whether to produce multiple products or specialize. The answer depends in part on the effect of the scope of production on costs.

There are **economies of scope** across two products if the total cost of production is lower when the products are produced together than when they are produced separately. Conversely, there are **diseconomies of scope** across two products if the total cost of production is lower when the products are produced separately.

Economies of scope: The total cost of production is lower with joint than separate production.

Joint cost

To understand how costs depend on the scope of production, suppose that Luna Autotech is considering whether to develop self-driving technology for cars, trucks, or both. Table 6.9 shows the expenses.

If Luna Autotech carries out R&D into autonomous cars and autonomous trucks as separate projects, the total cost would be \$1.9 billion. If, however, it carries out R&D into autonomous cars and autonomous trucks as a combined project, the cost would be \$1.1 billion.

What explains the difference in cost? The key is that the bulk of autonomous vehicle technology applies to both cars and trucks. The cost of the R&D to produce the

Diseconomies of scope: The total cost of production is lower with separate than joint production.

Table 6.9 Joint/separate production: expenses

Organization	Expense
Separate R&D	
Autonomous cars	1,000
Autonomous trucks	900
Combined R&D	1,100

common technology is a *joint cost* of developing autonomous cars and autonomous trucks.

Joint cost: The cost of inputs that does not change with the scope of production.

The **joint cost** is the cost of inputs that does not change with the scope of production. The joint cost supports the production of multiple products. Economies of scope arise wherever there are significant joint costs.

Specific cost: The cost of inputs that are particular to the production of a product.

The **specific cost** is the cost of inputs that are particular to the production of a product. Referring to Table 6.9, in the Luna example, suppose that the joint cost is \$800 million. Then, the specific cost of developing the technology for autonomous cars is \$200 million and the specific cost of developing the technology for autonomous trucks is \$100 million. When R&D is combined, the cost is \$800 million + \$200 million + \$100 million = \$1.1 billion.

Strategic implications

Economies of scope arise where production of different products requires some substantial common input. The common input could be technology or infrastructure. For instance, mRNA is a technology to trigger an immune response, and can be used in vaccines against many diseases. It is the basis for economies of scope in production of vaccines against many diseases. A wire network can be used to deliver both broadband and cable television. It is the basis for economies of scope across broadband and cable television.

Where two products are underlaid by economies of scope, it would be relatively cheaper to produce the two products together. A business that produces both products would produce at lower cost than businesses that specialize in one of the products. In industries with economies of scope, multiproduct suppliers will dominate.

In an industry with economies of scope, businesses supply multiple products.

Diseconomies of scope

There are diseconomies of scope across two products if the total cost of production is higher when the two items are produced together than when they are produced separately. Diseconomies of scope arise where joint costs are not significant and making one product increases the cost of making the other in the same facility.

Where diseconomies of scope prevail, it will be relatively cheaper to produce the various items separately. Hence, specialized producers can achieve relatively lower

costs than competitors that combine production. In such circumstances, the management should aim for a narrow scope and focus on one product.

Progress check 6E. Referring to Table 6.9, suppose that, with combined R&D, the expenses would be \$1.9 billion. Are there economies or diseconomies of scope?

Autonomous vehicle technologies: economies of scope?

Argo.AI, invested in by Ford Motor Company and Volkswagen, is developing autonomous vehicle technologies for cars and trucks. In May 2021, it disclosed the invention of a lidar sensor capable of seeing 400 meters ahead. Co-founder and CEO Bryan Salesky hailed the invention, “It really unlocks our ability to operate safely on highways and to then expand to entire metropolitan areas.”

The lidar sensor would support both self-driving cars and self-driving trucks. The cost of developing the sensor is joint across the development of self-driving cars and self-driving trucks. To the extent of such joint costs, there would be economies of scope across the development of self-driving cars and self-driving trucks.

Cathay Pacific Airlines

Hong Kong flag carrier, Cathay Pacific Airways, provides passenger and cargo services. The Covid-19 pandemic affected the demands for cargo and passenger services differently. Between 2019 and 2020, revenues from cargo services increased by 17% from HK\$23.8 billion to HK\$27.9 billion. By contrast, revenues from passenger services collapsed by 84% from HK\$74.0 billion to HK\$12.0 billion.

Of Cathay’s fleet of 239 aircraft, all but 12 were passenger jets that also carried freight in their bellies. These aircraft underlie economies of scope across passenger and cargo services. In 2020, the reduction in passenger services reduced Cathay’s belly cargo capacity. Still, the airline grew cargo revenue by 17%.

6.7 Bounded rationality

Being human, managers do not always behave rationally, and indeed, they make systematic errors in decisions. They behave with bounded rationality (less than full rationality) because they have limited cognitive abilities and cannot fully exercise

self-control. The boundedly rational thinking leads to systematic mistakes in analysis of costs.

Status quo bias

Human beings tend to be biased toward the status quo, perhaps because of inertia. To the extent that the status quo involves opportunity costs, the status quo bias reinforces any systematic failure to account for opportunity costs. The result is an even stronger bias toward continuing with the status quo, rather than taking an alternative course of action, which might actually be more profitable.

Consider a family that operates a gasoline station on land that it owns in the business district. Their accounting statements do not reveal that the land could be redeveloped to construct an office building and yield much higher profit. Hence, the family continues in status quo, running a gasoline station.

Sunk-cost fallacy

Accounting statements include sunk costs. One human response to sunk costs is to rationalize the sunk costs by increasing usage or consumption. An (in)famous example is the Anglo-French supersonic airliner Concorde. Having invested heavily, Britain and France continued to pour additional resources into the project long after it was clear that Concorde was not commercially viable. Their actions exemplified the sunk-cost fallacy. This human tendency to rationalize costs that are already sunk by additional expenditures results in *overinvestment*.

Fixed-cost fallacy

Related to the sunk-cost fallacy, but resulting in the opposite outcome, is what might be called the “fixed-cost fallacy.” This is the tendency, which is common, for managers to treat fixed costs as variable.

The tendency possibly arises from the long-run break-even condition which requires that total revenue cover total cost. An equivalent long-run break-even condition is that average revenue cover average cost.

The emphasis on the long-run break-even leads managers to equate average cost with average variable cost. They set a target production rate and allocate the fixed cost to each unit of production. Essentially, this inflates the perceived variable cost and so results in *underproduction* relative to the profit-maximizing level.

Progress check 6F. How might boundedly rational managers misunderstand costs?

Key takeaways

- For effective decision-making, consider alternative courses of action, take account of opportunity costs and ignore sunk costs.
- The opportunity cost is what must be forgone from the best alternative course of action.
- Commit to sunk costs with caution as they cannot be reversed.
- Economies of scale arise from fixed costs, which support the production of multiple units of output.
- With economies of scale, businesses should produce on a large scale and the industry will tend to be concentrated.
- Economies of scope arise from joint costs, which support production of multiple products.
- With economies of scope, businesses should produce multiple products.
- Managers should take care to avoid behavioral biases in decisions with respect to costs.

Review questions

1. Why do accountants not measure opportunity cost?
2. A salesman buys lunch for a potential client. Why is this lunch *not* free for the client?
3. The Kwok family owns a building in the city center and operates a department store on the ground floor. Why should the family charge rent to the department store?
4. “Our costs are very high because of the huge pensions of our retirees.” Please comment.
5. Luna Auto closed its truck manufacturing business. Yet, it continued to incur costs related to truck manufacturing. Please comment.
6. Referring to the taxonomy of costs (Figure 6.1), should it also break down sunk costs into fixed/variable and joint/specific?
7. Which of the following best measures the cost of producing an additional unit of product? (a) Average cost; (b) Average fixed cost; (c) Average variable cost.
8. To treat twice as many patients, a family medicine clinic will probably need twice as many doctors, nurses, and other professional staff. Does this business have economies of scale?
9. Fixed costs and sunk costs are the same. True or false?

10. Explain the difference between joint cost and specific cost.
 11. Passenger aircraft can also carry freight in their bellies. Explain the economies of scope in the airline industry.
 12. Explain the differences between economies of scale and economies of scope.
 13. How does the absence of opportunity costs in accounting statements contribute to status quo bias?
 14. Accounting statements report sunk costs. How does this contribute to the sunk-cost fallacy?
 15. “The average cost of each seat on the flight is \$200. We cannot sell any ticket for less.” Please comment.
-

Discussion questions

1. Harvard Business School estimated the cost of studies for MBA students graduating in the year 2022 to be US\$213,636. The largest expense was the tuition fee of US\$68,440 per year, which for two years totaled US\$136,880. On the plus side, the median graduate received a starting salary of US\$148,750 and signing bonus of US\$30,000.
 - (a) What major opportunity cost of studying for MBA degree did the School not mention?
 - (b) Compare the opportunity cost for two individuals with different earnings. Which one would be more likely to apply for the Harvard MBA program?
 - (c) By reporting the costs of the MBA as the School did, explain which one of the following behavioral biases in decision-making the School exploited: (i) Sunk-cost fallacy; (ii) Status quo bias; (iii) Anchoring.
2. In 2020, LG Electronics accounted for just 2% of the global smartphone market. LG's mobile phone business incurred an operating loss of 841 billion won, and similar losses in the previous five years. LG decided to shut the business. Equity analyst Ko Eui-young predicted that the shutdown would reduce LG's annual loss by 550 billion won. Still, LG committed to continue developing mobility-related technologies to support other business areas.
 - (a) Use the concept of sunk costs to explain the difference between the losses in LG's accounts and Ko's estimate of the reduction in losses from shut down.
 - (b) Use the concept of joint costs to explain the difference between the losses in LG's accounts and Ko's estimate of the reduction in losses from shut down.
 - (c) Suppose that LG Electronics shut down all of its businesses. How would this affect the sunk cost in (a) and joint cost in (b)?

3. Following the subprime financial crisis, the US automobile manufacturer Chrysler LLC filed for bankruptcy in April 2009. It then sold its brands and various other assets to Fiat SpA. Table 6.10 lists the estimated recovery value of Chrysler's property, plant, and equipment in the event of liquidation.
 - (a) Which of the following best describes the difference between book value and estimated recovery value: (i) opportunity cost; (ii) sunk cost; or (iii) joint cost? Explain your answer.
 - (b) Use the low and high estimates of recovery value to calculate the average recovery value.
 - (c) Define *specificity* as the ratio of book value less average estimated recovery value to book value, in percentage terms. Calculate the specificity of each category of assets.
 - (d) Explain the relation between sunk costs and specificity.
 - (e) Stamping equipment is heavy machinery used to produce metal parts such as car bodies. Tooling is equipment designed to produce particular models of cars. Explain why Chrysler's tooling has a higher specificity than the stamping plants.
4. The Great Recession of 2007–2009 severely depressed world trade and the rental rates for tankers. Herbjorn Hansson, CEO of Nordic American Tanker Shipping, remarked: "Those who have a lot of debt are suffering.... If you're collecting \$10,000 a day and you have a cash break-even of \$25,000 a day, that's a \$15,000 a day loss." Hansson expected his company to survive the downturn as it carried no debt.
 - (a) Consider a tanker financed by debt at interest of \$17,000 a day. Suppose that revenues are \$10,000 a day, operating costs are \$8,000 a day, and cost of maintaining a laid-up tanker is \$1,500 a day. Construct an income statement showing the two alternatives – continuing operations and laying up the vessel.
 - (b) What should the owner of the tanker do?

Table 6.10 Chrysler liquidation (\$ million)

Assets	Book value	Recovery value	
		Low estimate	High estimate
Assembly plants	2,205	110	220
Stamping plants	1,129	113	226
Powertrain plants	3,513	352	702
Tooling	1,337	-	67
Furniture, fixtures, etc.	487	5	24

- (c) Prepare an income statement as in (a) but for a tanker financed purely by equity, and so, interest is zero. What should the owner of the tanker do?
 - (d) Comment on Hansson's remark.
 - (e) At what level of revenue should the owner lay up the ship?
- 5. Consider a Lufthansa flight from Frankfurt to New York far enough in advance that the aircraft and crew can be redeployed to another route.
 - (a) Classify the following items as avoidable or sunk. Among the avoidable costs, further classify as fixed or variable with respect to the number of passengers: (i) Aircraft lease charge; (ii) Airport landing charges, (iii) Salaries of pilots and flight attendants, (iv) Fuel, and (v) Catering.
 - (b) Classify the above items as joint or specific to the number of passengers and quantity of cargo carried.
 - (c) How would the classification in (a) change at a time when the flight schedule cannot be changed?
- 6. Generators of electric power produce electricity in large-scale plants with capacities of hundreds of megawatts. However, when electricity is transmitted over cables, resistance causes loss of energy, which increases with distance. (*Hint: Assume any data necessary to draw the below figures.*)
 - (a) Draw a graph to illustrate the average cost of generating electricity at different rates of production (megawatt hours per month).
 - (b) Draw a graph to illustrate the average cost of transmitting electricity over different distances.
 - (c) If a producer of electricity increases the scale of generation to reduce the average cost of generation, how would that affect the average cost of transmission?
- 7. Airbus and Boeing dominate the large commercial jet aircraft industry. Each company manufactures jet aircraft for commercial use as well as military use. In February 2011, Boeing won a US Air Force tender for 179 aerial refueling tankers at an estimated price of \$35 billion. The Boeing tanker is based on the Boeing 767 civil airliner.
 - (a) Which one of the following concepts best explains Boeing's adaptation of the Boeing 767 to produce an aerial tanker: (i) economies of scale; (ii) economies of scope; (iii) sunk-cost fallacy? Explain your answer.
 - (b) Following the initial tender, the US Air Force is expected to buy additional tankers. Apply relevant cost concepts to explain Boeing's advantage in competing for follow-on orders.
 - (c) "The more an aircraft manufacturer spends on R&D, the higher the price that it must charge to recover its investment." Comment.
- 8. Argo.AI, invested by Ford Motor Company and Volkswagen, is developing autonomous vehicle technologies for cars and trucks. In May 2021, it disclosed the invention of a lidar sensor capable of seeing 400 meters

ahead. Co-founder and CEO Bryan Salesky hailed the invention, “It really unlocks our ability to operate safely on highways and to then expand to entire metropolitan areas.”

- (a) Consider the development of self-driving technologies for cars. Compare the cost of R&D if (i) Ford and Volkswagen carry out R&D separately vis-à-vis (ii) Ford and Volkswagen combine to carry out R&D together.
 - (b) Comment on the economies or diseconomies of scale and scope.
 - (c) Consider the development of self-driving technologies for cars and trucks. Compare the cost of R&D if (i) two firms separately carry out R&D on self-driving cars and self-driving trucks vis-à-vis (ii) one firm carries out both R&D projects.
9. Refer to Table 6.8, which analyzes Luna Auto’s monthly costs of manufacturing autonomous cars. Suppose that Luna is producing at a rate of 50,000 units per month.
- (a) A car dealer in a foreign market where Luna has not sold before wants to buy 1,000 cars. What is the minimum that Luna should accept for the new order?
 - (b) If the cost of technology were \$400 million per month rather than \$300 million, how would that affect the minimum price for the new order? Discuss the behavioral fallacy that might confound your answer.
 - (c) Table 6.8 does not consider the \$1 billion cost of developing of the autonomous vehicle technology. Should it? Discuss the behavioral fallacy that might confound your answer.

You are the consultant!

Consider your organization’s various lines of business. For each line of business, consider the revenues and costs from alternative uses of the resources – people, property, and funds. Is every line of business maximizing profit?

Progress check answers

- 6A. Economic cost equals accounting cost plus opportunity cost less sunk cost.
- 6B. The opportunity cost is \$1.6 million. So, if Luna commences R&D, its profit would be the profit contribution minus the R&D expense minus the opportunity cost, $2 - 1 - 1.6 = -\$0.6$ billion. So, the correct decision is not to commence R&D.

- 6C. The avoidable cost of continuing R&D would be $0.9 \times 1,000 = \$900$ million. Hence, if Luna continues R&D, the profit would be $800 - 900 = -\$100$ million, that is, a loss of \$100 million. So, the correct decision is to cancel the R&D.
- 6D. [Omitted.]
- 6E. The sum of the costs of separate R&D is $1,000 + 900 = \$1.9$ billion, which is the same as with combined R&D. Neither economies nor diseconomies of scope.
- 6F. They might succumb to status quo bias, sunk-cost fallacy, or fixed-cost fallacy.

Review answers

1. Conventional methods of cost accounting focus on objectively verifiable costs. Alternative courses of action and opportunity costs change with the circumstances, and so, are more difficult to measure and verify.
2. The client could have used the time spent with the salesman on other activities. In addition, the salesman buys lunch for his client with the objective of increasing sales.
3. The Kwok family could have rented the ground floor to other tenants. The rent is an opportunity cost of operating the department store.
4. The pensions are already committed and unavoidable. They are sunk costs. In forward-looking business decisions, managers should ignore sunk costs.
5. These may be sunk costs, which Luna must still incur even if it shuts the business.
6. No. Sunk costs are irrelevant for business decisions.
7. (c) Average variable cost.
8. No. The costs increase in proportion to the rate of production.
9. False. Fixed costs can be either sunk or avoidable. Fixed costs that are sunk are those fixed costs that are committed can never be recovered. Fixed costs that are avoidable are those fixed costs that can be avoided with change in plans. Sunk costs need not be fixed in the sense of supporting any scale of production.
10. Joint costs are common across the production of different products. Specific costs are particular to the production of a product.
11. Some of the costs of operating the aircraft – lease payment, landing charges, salaries of pilot and other crew – are joint across passenger and freight services. These joint costs underlie economies of scope.
12. Economies of scale pertain to a single product. Economies of scope pertain to multiple products. With economies of scale, increasing the

scale of production would reduce average costs. With economies of scope, increasing the scope of production would reduce average costs.

13. The omission of opportunity costs tends to make the status quo look more profitable than it actually is.
14. The accounting statements draw attention to sunk costs and encourage the sunk-cost fallacy.
15. The average cost includes the average fixed cost, which does not affect the cost of carrying an additional passenger.

Discussion answers

1. (a) The School did not mention that individuals forgo two years of earnings, work experience and career advancement.
- (b) The opportunity cost of attending the MBA program – foregone earnings – is higher for the individual with higher earnings. Therefore, the individual with lower earnings is more likely to apply for the Harvard MBA program.
- (c) The School exploited individuals' tendency to commit anchoring bias. By reporting the annual tuition fee first, followed by the (higher) median starting salary, individuals will be prone to viewing a Harvard MBA as a good investment and therefore be inclined to apply to the program.

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CHAPTER 7

Monopoly

LEARNING OBJECTIVES

- Appreciate how to gain market power.
- For a seller with market power, identify the scale of production/sales that maximizes profit.
- Appreciate how to adjust sales to changes in demand and costs.
- For a seller with market power, identify the levels of advertising and R&D expenditure that maximize profit.
- Appreciate that sellers with market power restrict sales to raise margins and profit.
- For a buyer with market power, identify the scale of purchases that maximizes net benefit.

7.1 Introduction

Enzalutamide, branded as Xtandi, is a non-steroidal antiandrogen pharmaceutical which is used to treat prostate cancer. Biochemists Charles Sawyers and Michael Jung and their team at the University of California, Los Angeles discovered the drug. In May 2006, the University applied for a patent, which was eventually granted as U.S. 2007/0004753 four years later.

San Francisco-based Medivation (later acquired by Pfizer) and Japanese pharmaceutical manufacturer Astellas secured licenses to Xtandi, and commercialized the drug in the United States and rest of the world respectively. By 2020, global sales of Xtandi reached US\$4.19 billion, of which U.S. sales accounted for US\$1 billion.

In 2018, the price of Xtandi in the United States was US\$88,704 per treatment, as compared with US\$36,288 in England, and even lower in Canada. Canadian generic pharmaceutical manufacturer Biolyse estimated that it could produce Xtandi for US\$4,400 per treatment. However, Biolyse could not get a license.

At what scale should Astellas and Pfizer produce Xtandi and how they should they price the drug? Why did Astellas price Xtandi lower in the United Kingdom and Canada than Pfizer in the United States?

A major concern for the two companies is that the basic Xtandi patent will expire in 2027. At that time, generic manufacturers like Biolyse would be free to produce the drug. Then, how should Astellas and Pfizer price Xtandi?

To address these questions, we must understand the behavior of buyers or sellers that have the power to influence market conditions. A buyer or seller that can influence market conditions is said to have **market power**.

Market power: The ability of a buyer or seller to influence market conditions.

A buyer with market power can influence market supply – in particular, the price and quantity supplied. A seller with market power can influence market demand – in particular, the price and quantity demanded.

Here, for simplicity, we focus on markets in which there is either just one seller or one buyer. If there is only one seller in a market, that seller is called a **monopoly**. If there is only one buyer in a market, that buyer is called a **monopsony**.

Monopoly: One seller in a market.

This chapter begins with the sources of market power. Next we analyze how a profit-maximizing monopoly determines its scale of production and price. Applying this analysis, we can answer how much Astellas and Pfizer should produce and how to set prices during the validity of the patent and after expiry. We can also explain why the prices of Xtandi were lower in the United Kingdom and Canada than the United States.

Monopsony: One buyer in a market.

Then, we discuss how much a monopoly should spend on advertising and R&D, and compare production and price under a monopoly with competition. We also analyze how a monopsony that maximizes net benefit would set the scale and price of purchases.

7.2 Sources of market power

Market power has two ingredients – one is barriers to competition, and the other is the elasticity of demand or supply. For a monopoly or monopsony to exist, competitors must be deterred or prevented from entering the market to compete for the business. So, one source of market power is the barriers that keep competitors out.

However, even a monopoly cannot increase profit unless it can influence demand conditions – in particular, by raising price. Likewise, a monopsony cannot increase profit unless it can influence supply conditions. So, the other ingredient to market power is the elasticity of demand or supply.

Here, we focus on the seller's market power, while noting that the ingredients for the buyer's market power are similar. Sellers can create barriers to competition and reduce the price elasticity of demand in four ways.

Product differentiation

Recall from Chapter 3 that a factor in the price elasticity of demand is the availability of substitutes. By *product differentiation*, a seller can reduce buyers' perception of

available substitutes, and so increase the demand and reduce the price elasticity of demand.

Sellers can differentiate their products in several ways. One is function and another is design. Yet another is the distribution channels by which products are made available to buyers. Finally, products can be differentiated through advertising and promotion to influence and sustain buyers' preferences.

Intellectual property

Product differentiation builds, in part, on innovation. To encourage innovation, society may award the innovator a period of exclusive use through *intellectual property*. By securing intellectual property over their innovations, innovators may be able to exclude competitors, and so, build market power.

The three main forms of formal intellectual property are: *patents*, which award exclusive rights to inventions for a specified period of time; *copyright*, which award exclusive rights to expressions for a specified period of time; and *trademarks*, which award exclusive rights to words or symbols associated with a good or service so long as they are used.

Besides, *trade secrecy* provides exclusivity over information that is not generally known and that provides commercial advantage. The scope of secrecy extends to business information such as customer lists as well as technical information that possibly cannot be patented, such as algorithms.

Economies of scale and scope

A third source of market power is *economies of scale and scope*. In an industry characterized by economies of scale or scope, an incumbent producer will have a cost advantage over potential competitors. By establishing a sufficient cost advantage, the incumbent producer may be able to deter entry by competitors, and so gain market power.

Regulation

Finally, for various reasons, including economic or social policy, the government may decide to limit competition, and in the extreme, allow only a single producer. A producer with the government license is shielded from competition by law, and so gains market power.

An important economic reason for such *regulation* is the presence of large fixed costs in production. So, for example, most governments limit competition in the distribution of electricity, natural gas, and water. The policy helps to avoid duplication of the fixed costs of the distribution network.

Progress check 7A. What are the two ingredients of market power?

Apple: product differentiation and innovation

Some smartphone manufacturers produce utilitarian devices and market their products on function and price. Apple famously took a different approach. From the first computer to the latest iPhone, Apple emphasized design as much as function, and priced its products at a premium above competitors.

Apple also pioneered direct distribution to consumers through dedicated retail stores throughout the world. And, of course, Apple reinforces its brand through advertising and creates new products through R&D. In 2015, the last year in which Apple disclosed its advertising expense, it spent \$1.8 billion, or 0.8% of sales revenue. In 2020, Apple spent \$18.7 billion on R&D, amounting to 7% of sales revenue.

7.3 Profit maximum

Consider a seller with market power. How much should it produce and how should it price the product? Suppose that Luna Pharmaceutical has a monopoly over a drug, Gamma-1, to treat prostate cancer. Luna faces the two basic business decisions. One is participation – should it produce the drug? The other is extent – how much should it produce (and how should it price the drug)?

Supposing that Luna decides to produce the drug, we first analyze the profit-maximizing production and price. Then we consider whether Luna should produce the drug at all.

The essence of market power is that the seller faces a demand curve that slopes downward. Luna Pharmaceutical, being a monopoly, faces the market demand curve. Unlike a perfectly competitive seller, a monopoly must consider how its sales would affect the market price. For simplicity, we ignore inventories and hence production equals sales.

Given the market demand curve, a monopoly can either decide how much to produce and let the market determine the price at which it is willing to buy that quantity, or set the price and let the market determine how much it will buy. (If the monopoly tries to set both sales and price, the production and price may be inconsistent in the sense that, at that price, the market wants to buy more or less than the production.)

Let us focus on how much to produce. To analyze the profit-maximizing production, we need to know how Luna's production would affect its revenues and costs.

Revenue

First, consider the relationship among price, sales, and revenue. Table 7.1 shows the annual demand for Gamma-1. The sales and quantity demanded increases by 200,000

Table 7.1 Monopoly revenue, cost, and profit

Price (\$)	Sales (thousands)	Total revenue (\$ million)	Marginal revenue (\$)	Total cost (\$ million)	Marginal cost (\$)	Profit (\$ million)
200	0	0.00		50.00		-50.00
190	200	38.00	190	64.20	71	-26.20
180	400	72.00	170	78.40	71	-6.40
170	600	102.00	150	92.60	71	9.40
160	800	128.00	130	106.80	71	21.20
150	1,000	150.00	110	121.00	71	29.00
140	1,200	168.00	90	135.20	71	32.80
136	1,280	174.08	76	140.88	71	33.20
135	1,300	175.50	71	142.30	71	33.20
134	1,320	176.88	69	143.72	71	33.16
130	1,400	182.00	64	149.40	71	32.60
120	1,600	192.00	50	163.60	71	28.40
110	1,800	198.00	30	177.80	71	20.20
100	2,000	200.00	10	192.00	71	8.00
90	2,200	198.00	-10	206.20	71	-8.20

units per year for every \$10 reduction in price. Using this information, we can then calculate Luna's *total revenue* for every price, which is price multiplied by sales.

From the total revenue, we can then calculate *marginal revenue*, which is the change in total revenue arising from selling an additional unit.

To sell additional units, Luna Pharmaceutical must reduce its price. So, when increasing sales by one unit, Luna will gain revenue from selling the additional (or marginal) unit, but it will lose revenue on the *inframarginal units*. The **inframarginal** units are those units sold other than the marginal unit. Luna would have sold the inframarginal units without reducing the price.

For example, referring to Table 7.1, to increase sales from 200,000 to 400,000 units per year, Luna must reduce the price from \$190 to \$180. Hence, Luna will gain revenue of $\$180 \times 200,000 = \36 million on the additional units, but lose $\$(190 - 180) \times 200,000 = \2 million on the inframarginal 200,000 units that it could have sold at \$190. Thus, Luna's revenue for the additional 200,000 units is $\$36 \text{ million} - \$2 \text{ million} = \$34$ million, which means that marginal revenue is \$170 per unit.

In general, the marginal revenue from selling an additional unit will be less than the price of that unit. The reason is that the marginal revenue is the price of the marginal unit minus the loss of revenue on the inframarginal units.

Inframarginal units:
Units sold other than the marginal unit.

The difference between the price and the marginal revenue depends on the price elasticity of demand. If demand is very elastic, then the seller need not reduce the price very much to increase sales; hence, the marginal revenue will be close to the price. If, however, demand is very inelastic, then the seller must reduce the price substantially to increase sales; so the marginal revenue will be much lower than the price.

The marginal revenue can be negative, if the loss of revenue on the inframarginal units exceeds the gain on the marginal unit. Table 7.1 shows that, if Luna cut the price from \$100 to \$90, sales would increase from 2.0 to 2.2 million units. The change in revenue, however, is $-\$2$ million for the additional 200,000 units, which means that marginal revenue is $-\$10$ per unit.

Progress check 7B. If demand is extremely elastic, what will be the difference between the price and the marginal revenue?

Costs

We have considered the relation among price, sales, and revenue. The other side to profit is cost. Table 7.1 also shows data for Luna Pharmaceutical’s production costs. It reports only avoidable costs. From the total cost at zero production, we can infer that the fixed cost is \$50 million per year.

Total cost increases with the rate of production. Table 7.1 shows Luna’s *marginal cost*, which is the change in total cost due to the production of an additional unit. The change in total cost arises from change in the variable cost. The marginal cost is \$71 per unit at all scales of production.

Profit-maximizing rate

With information on both revenue and cost, we can calculate Luna’s profit at every possible price and quantity. Profit is total revenue less total (fixed and variable) cost. The last column of Table 7.1 reports profit at each quantity of sales. Looking down the column, we see that Luna’s maximum profit is \$33.2 million per year. It achieves this profit with a price of \$135 and sales of 1.3 million units.

Profit-maximizing rate of production:
The rate at which the marginal revenue balances the marginal cost.

Another way to identify the **profit-maximizing rate of production** is that at which the marginal revenue balances the marginal cost. At the price of \$135, Luna’s sales are 1.3 million units per year. The marginal revenue is \$71 per unit (note that, to calculate the marginal revenue more precisely, we drilled down to a smaller increment between prices around the profit-maximizing level). The marginal cost is also \$71 per unit. So, at the profit-maximizing scale, the marginal revenue equals the marginal cost.

This suggests a general rule: to maximize profit, a monopoly should produce at a rate where its marginal revenue balances its marginal cost. This rule applies to any seller and not only a monopoly.

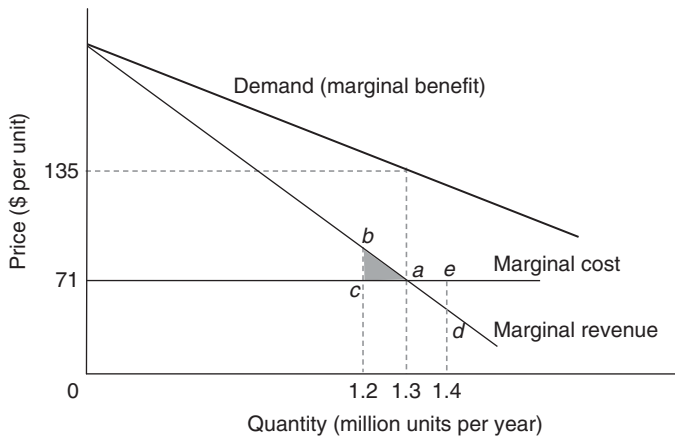


Figure 7.1 Monopoly production and price

Let us illustrate the profit-maximizing production and price with a diagram. Figure 7.1 shows Luna Pharmaceutical's demand, marginal revenue, and marginal cost curves. The demand curve shows, for every price, the quantity that the market will buy. Equivalently, it shows, for every quantity of purchases (on the horizontal axis), the maximum price (on the vertical axis) that the market will pay for that quantity.

The marginal revenue curve shows, for every quantity (on the horizontal axis), the marginal revenue (on the vertical axis). As we have explained, for every quantity, the marginal revenue is less than the price. Accordingly, at all quantities, the marginal revenue curve lies below the demand curve.

The marginal revenue and marginal cost curves cross at the quantity of 1.3 million units per year. From the demand curve, we see that the price at that quantity is \$135. This is the profit-maximizing price.

Let us understand why a seller maximizes profit at the rate of production where marginal revenue balances marginal cost. Suppose that Luna produces at a rate, such as 1.2 million units, where the marginal revenue exceeds the marginal cost. Then, if Luna increases production by 100,000 units, its revenue will increase by more than its cost; indeed, it will increase its profit by the area shaded *bca*.

By contrast, suppose that Luna produces at a rate such as 1.4 million units, where the marginal revenue is less than the marginal cost. Then, if Luna cuts production by 100,000 units, its revenue will fall by less than its cost; hence it will increase its profit by the area *ade*. Generally, a seller will maximize profit by producing at a rate where its marginal revenue balances its marginal cost.

Break-even analysis

What about the participation decision: should Luna produce Gamma-1 at all? Luna should produce the drug if the total revenue covers the total cost, with both revenue and cost calculated at the profit-maximizing scale.

Profit maximum:

Produce if total revenue covers total cost.
Produce at rate where marginal revenue equals marginal cost.

Profit contribution:

Total revenue less variable cost.

Incremental margin:

Price less marginal cost.

Incremental marginal percentage:

The ratio of incremental margin to price.

Referring to Table 7.1, at 1.3 million units per year, total revenue is \$175.5 million, while total cost is \$142.3 million. So, Luna should produce Gamma-1.

Profit measures

Later in this chapter, we discuss how much a seller with market power should spend on advertising and R&D. That discussion applies three measures of profit. One is the **profit contribution**, which is total revenue less variable cost. Another is the **incremental margin**, which is the price less the marginal cost. Further, the **incremental marginal percentage** is the ratio of the incremental margin (price less marginal cost) to the price.

Progress check 7C. Suppose that, at the current production rate, Luna's marginal revenue is less than its marginal cost. How should management adjust its production?

Big pharma vs generics

Branded pharmaceutical manufacturers such as Astellas spend billions of dollars to discover and develop new drugs. R&D expenses are fixed costs with respect to the scale of production. Moreover, once incurred, they may also be sunk. Before incurring R&D expenses, Astellas must expect the profit contribution to be large enough.

In the first half of 2021, Astellas earned revenues of 652 billion yen, with a gross margin of 81%, and spent 119 billion yen or 18.3% of revenues on R&D.

Generic manufacturers such as Biolyse follow a different strategy. They jump in after the patents of branded manufacturers expire and focus on developing generic equivalents. With lower R&D expenses, they incur relatively lower fixed costs, and so can be profitable with smaller margins.

7.4 Demand and cost changes

How should a seller with market power respond to changes in demand and cost? Generally, when there is a change in either demand or cost, the profit-maximizing adjustment to production depends on both the marginal revenue and marginal cost curves. The seller should adjust production until its marginal revenue equals its marginal cost.

Demand change

Suppose, for instance, that Luna Pharmaceutical increases advertising, and so boosts demand for Gamma-1. How should Luna adjust its production? To address this question, Figure 7.2 shows the new demand curve. From the new demand curve, we can calculate the new marginal revenue curve.

The new marginal revenue curve lies further to the right. Since the marginal cost curve does not change, the new marginal revenue curve crosses the marginal cost curve at a larger scale. Specifically, the two curves cross at a scale of 1.4 million units per year, and the new profit-maximizing price is higher, at \$140.

Only the demand changed. However, to identify the new profit-maximizing scale and price, we need both the new marginal revenue and the original marginal cost.

Marginal cost change

We can use a similar approach to understand how a seller with market power should respond to a change in the marginal cost. Suppose, for instance, that, relative to the data reported in Table 7.1, the marginal cost is \$20 lower at all rates of production. Should Luna reduce the price of the drug by \$20 as well?

To address this question, consider Figure 7.3, which shows Luna's marginal revenue and the new marginal cost. The marginal revenue and the new marginal cost cross at a larger rate of 1.62 million units per year. The new profit-maximizing price is lower, at \$121.

Relative to the original maximum (Figure 7.1), Luna now maximizes profits by cutting its price by \$14, which is less than the fall in the marginal cost. Further,

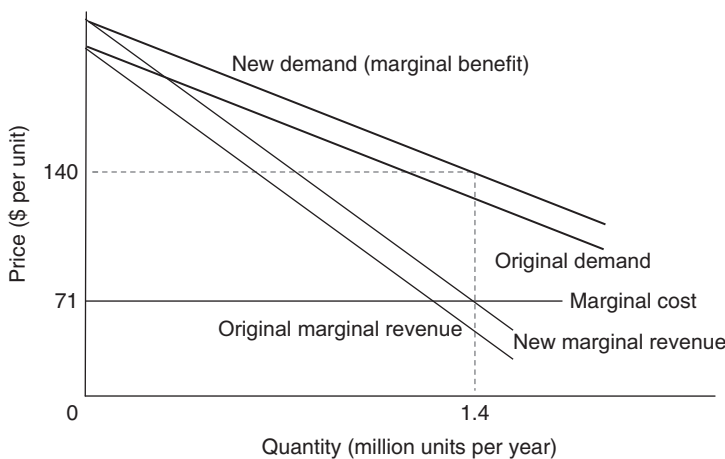


Figure 7.2 Demand increase

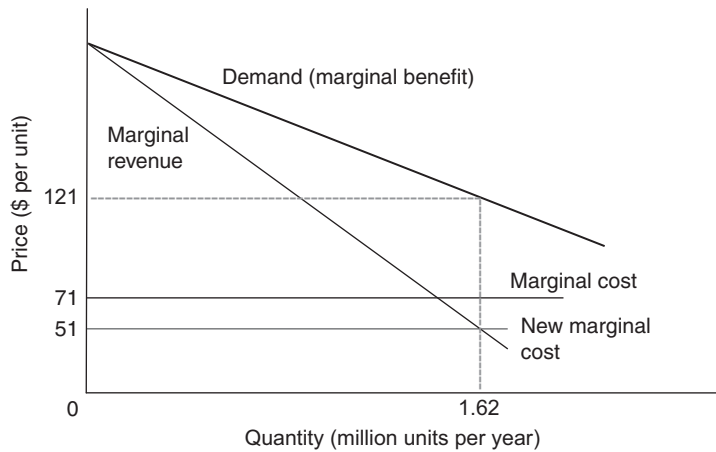


Figure 7.3 Reduction in marginal cost

although the change was only in the marginal cost, Luna must consider the marginal revenue as well as the new marginal cost to obtain the new profit-maximizing production and price.

Fixed-cost change

We should stress that the seller's profit-maximizing production and price do not depend in any way on the fixed cost (so long as it is not too large). Recall that a seller with market power maximizes profit by producing at the rate where its marginal revenue equals its marginal cost. Changes in the fixed cost will not affect the marginal cost curve; hence, they will not affect the profit-maximizing production.

If, however, the fixed cost is so large that the total cost exceeds total revenue, then the business should shut down. In Luna's case, referring to Table 7.1, the profit-maximizing rate of production is 1.3 million units per year. At that rate, total revenue is \$175.5 million, while total variable cost is $(142.3 - 50) = \$92.3$ million.

Hence, total revenue exceeds total variable costs by $(175.5 - 92.3) = \$83.2$ million. Thus, if the fixed cost exceeds \$83.2 million, the company should close.

The principle that the profit-maximizing production and price do not depend on the level of fixed costs is crucial in knowledge-intensive industries such as media, pharmaceuticals, and software. In these industries, production is characterized by relatively high fixed costs and low variable costs.

Progress check 7D. In Figure 7.3, show how Luna should adjust production and price if the marginal cost is \$20 higher.

Astellus: managing competition

In 2027, when the basic Xtandi patent expires, generic manufacturers such as Biolyse can freely produce the drug. They would take some customers from Astellus, but, these would likely be the more price-sensitive customers.

Astellus would face a smaller demand, yet the remaining demand might be more price inelastic. So, Astellus should clearly produce less, but whether it should reduce price would depend on the new marginal revenue and marginal cost.

Samsung: license fees to Ericsson

In May 2021, Swedish telecommunications equipment manufacturer Ericsson and Korean electronics manufacturer Samsung entered into a multiyear cross-licensing agreement. The agreement settled various disputes over patents for mobile network equipment and handsets.

Ericsson expected the agreement to more than double its licensing revenues from 800 million Swedish crowns in the first quarter. The increase included two quarters of license fees from Samsung. For Samsung, looking forward, this cost would be sunk.

The effect of the agreement on Samsung's marginal cost of production depends on the structure of the license fees. To the extent that they depend on unit sales of network equipment and handsets, they would increase marginal cost and Samsung should increase prices.

7.5 Advertising

Any seller with market power can influence the demand for its products through advertising. Advertising can shift out the demand curve as well as cause it to be less price elastic. In the analysis of advertising, for simplicity, we take price as given. However, in practice, it is important to bear in mind that the seller should simultaneously maximize on price, advertising, and other influences on demand.

Profit-maximizing advertising

By shifting out the demand curve and causing it to be less price elastic, advertising can raise sales. The increase in sales will affect total revenue and variable cost. Accordingly, the benefit of advertising is to increase the profit contribution. To maximize profit, Luna should advertise up to the level that the marginal benefit of advertising equals the marginal cost.

Using the concepts of the incremental margin percentage and the *advertising elasticity of demand*, we can derive a simple rule for the profit-maximizing level of advertising. Recall from Chapter 3 that the advertising elasticity of demand is the percentage by which the demand will change if the seller's advertising expenditure rises by 1%.

Advertising-sales ratio

Profit-maximizing advertising-sales ratio: Incremental margin percentage multiplied by advertising elasticity of demand.

When the marginal benefit equals the marginal cost of advertising, the **advertising-sales ratio** (the ratio of the advertising expenditure to sales revenue) equals the incremental margin percentage multiplied by the advertising elasticity of demand. This provides a simple rule for the profit-maximizing level of advertising expenditure.

Strictly, the rule stipulates the ratio of advertising expenditure to sales *revenue*. So the ratio should be called the advertising-revenue ratio. However, in practice, it is usually called the advertising-sales ratio.

We can apply the advertising-sales ratio rule to determine the profit-maximizing level of advertising expenditure for Luna's new drug Gamma-1. Recall that, with the demand and costs in Table 7.1, the profit-maximizing price is \$135 per unit and the marginal cost is \$71. This means that the incremental margin percentage is $(\$135 - \$71)/\$135 = 0.474$. Suppose that, at the price of \$135, the advertising elasticity of the demand is 0.26. Then the profit-maximizing advertising-sales ratio is $0.474 \times 0.26 = 0.123$, or 12.3%.

At the \$135 price, Gamma-1 revenue is $\$135 \times 1.3 \text{ million} = \175.5 million . Hence, the profit-maximizing advertising expenditure is $0.123 \times \$175.5 \text{ million} = \21.6 million .

The rule for advertising expenditures implies that, if the incremental margin percentage is higher, then the seller should spend relatively more on advertising. The reason is that each dollar of advertising produces relatively more benefit. Accordingly, when the incremental margin percentage is higher, the seller should increase advertising. This means that, whenever a seller raises its price or reduces its marginal cost, it should also increase advertising expenditure. By contrast, if a seller reduces its price or raises its marginal cost, it should reduce advertising expenditure.

Further, the rule for advertising expenditures implies that, if either the advertising elasticity of demand or the sales revenue is higher, then the seller should spend relatively more on advertising. Essentially, a higher advertising elasticity of demand or sales revenue means that the influence of advertising on buyer demand is relatively greater. In these circumstances, it makes sense to advertise more.

Progress check 7E. Suppose that the profit-maximizing scale of production for Gamma-1 is 1.3 million units. At that scale, the price is \$135 per unit, the marginal cost is \$71, and the advertising elasticity of demand is 0.14. How much should Luna spend on advertising?

7.6 Research and development

A seller with market power can also influence demand through research and development. Especially in knowledge-intensive industries, R&D drives the pipeline of new products and refreshes existing products.

How much should a business invest in R&D? The principles are the same as for advertising. R&D shifts out the demand curve and causes it to be less price elastic. The benefit of R&D is to increase the profit contribution.

A simple rule for the profit-maximizing level of R&D expenditure applies the concept of the R&D elasticity. The **R&D elasticity** of demand is the percentage by which demand will change if the seller's R&D increases by 1%. The R&D elasticity of demand depends on two factors: one is the effectiveness of R&D in generating new products and enhancing existing products, and the other is the effect of new and enhanced products on demand.

The rule for profit maximization is to spend on R&D up to the level where the **R&D-sales ratio** (the ratio of the R&D expenditure to sales revenue) equals the incremental margin percentage multiplied by the R&D elasticity of demand.

By this rule, when the incremental margin percentage is higher (higher price or lower marginal cost), the seller should increase R&D expenditure relative to sales revenue. Conversely, when the incremental margin percentage is lower (lower price or higher marginal cost), the seller should reduce R&D expenditure relative to sales revenue.

Further, if either the R&D elasticity of demand or the sales revenue is higher, then the seller should increase R&D, and if either the R&D elasticity of demand or the sales revenue is lower, then the seller should reduce R&D.

R&D elasticity: The percentage by which demand will change if the seller's R&D increases by 1%.

Profit-maximizing R&D-sales ratio: Incremental margin percentage multiplied by R&D elasticity of demand.

Progress check 7F. If price is higher while marginal cost is lower, how should R&D expenditure be adjusted?

Big pharma: R&D and advertising

Branded pharmaceutical manufacturers such as Astellas and Pfizer invest heavily to discover and develop new drugs. In 2020, Astellas spent 233 billion yen or 18.6% of its 1253.2 billion yen revenue on R&D, while Pfizer spent US\$9.4 billion or 22.4% of its US\$41.9 billion revenue on R&D.

Interestingly, big pharma also invest in advertising. Astellas does not report its advertising expense, but Pfizer does. Between 2018 and 2020, Pfizer progressively cut expenditure on advertising from 6.6% to 5.8% to 4.3% of revenue.

Why the systematic reduction? In 2019 and 2020, Pfizer divested its consumer and off-patent and generic businesses, and focused itself on

patent-protected pharmaceuticals sold by prescription. The demand for prescription drugs depends on physicians and insurance companies, who are less sensitive to advertising. And so, it made sense to spend less on advertising.

7.7 Market structure

Monopoly, the case of a single seller, is one extreme of a range of market structures. At the other extreme lies perfect competition, where there are numerous sellers, each of whom is too small to affect market conditions. By comparing monopoly with perfect competition, we can understand how production and price depend on the competitive structure of the market.

Consider the market for trucking service between two cities. Assume that, in the long run, the provision of the service involves no fixed cost and the marginal cost is constant at 30 cents per pound of freight. Let us compare production and price when the trucking industry is perfectly competitive and when there is a monopoly.

First, suppose that the industry is perfectly competitive. Since provision requires only a constant marginal cost of 30 cents per pound, all truckers will be willing to supply unlimited service at 30 cents per pound. Hence, the market supply will be perfectly elastic at 30 cents per pound. Given the market demand, the supply will balance demand at a price of 30 cents. Figure 7.4(a) illustrates the market equilibrium. The sales and production will be the quantity demanded at a price of 30 cents, say, 10 million pounds a year. In equilibrium, each trucker earns zero profit.

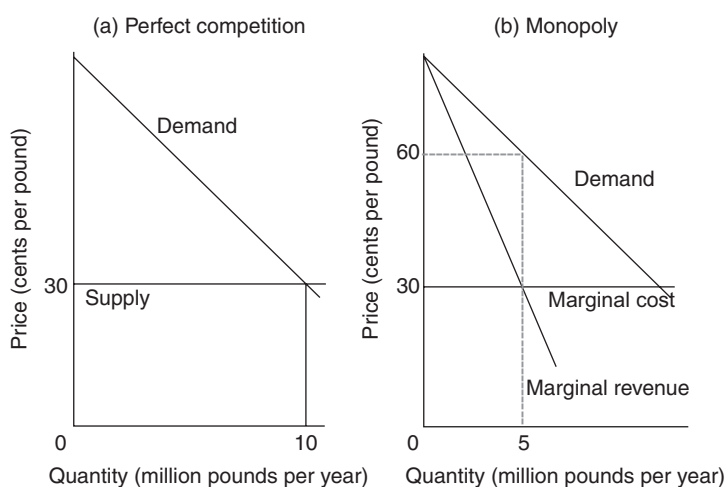


Figure 7.4 Market structure

Next, suppose that the trucking industry is a monopoly. The monopoly will produce at a scale that balances marginal revenue and the marginal cost of 30 cents. Since the marginal revenue curve lies below the demand curve, marginal revenue equals marginal cost at a quantity of less than 10 million pounds a year. Accordingly, the monopoly will set the price above 30 cents. Suppose that the monopoly price is 60 cents and sales are 5 million pounds a year. Figure 7.4(b) depicts the monopoly price and sales. The monopoly will enjoy profits of $\$(0.60 - 0.30) \times 5 = \1.5 million a year.

The trucking example illustrates several general principles. First, a monopoly restricts production below the competitive level and, in so doing, can extract a relatively higher margin and thus larger profit. By contrast, competition drives the market price down toward the long-run average cost and results in more production. Further, the profit of a monopoly exceeds what would be the combined profit of all the sellers if the same market were perfectly competitive.

Progress check 7G. Why does a monopoly restrict production below the competitive level?

Ethiopia: liberalizing telecommunications services

Compared with many other countries, Ethiopia was late in liberalizing the telecommunications market. At the time of writing, state-owned Ethio Telecom monopolized the market.

In June 2019, the Ethiopian government approved legislation to allow competition. Following an international tender, in May 2021, the government awarded one license to a consortium led by Safaricom of Kenya for US\$850 million. Further, the government planned to privatize Ethio Telecom in part by selling 45% of the company.

Ahead of impending competition, in 2018, Ethio Telecom cut prices by up to 50%. It grew subscribers by 5.8% to 46.2 million and revenues by 31.4% to 47.7 billion Ethiopian birrs.

7.8 Monopsony

A seller with market power will restrain sales to raise its price and so increase profit. What about a buyer with market power? How would its business decisions differ from those of a perfectly competitive buyer? For simplicity, we discuss a situation with a single buyer, that is, a *monopsony*. Since there are close parallels between monopoly and monopsony, we will focus on the important differences.

Benefit and expenditure

Suppose that a key input into the production of Gamma-1 is an Indonesian herb. Luna is the only buyer of this herb; hence, it is a monopsony. By contrast, many growers produce the herb. Each grower is too small to affect market conditions, so the supply of the herb is perfectly competitive.

Since the herb is a key input into Luna’s manufacturing process, it provides a benefit that can be measured as the revenue generated less the costs of other associated inputs. The herb, however, must be bought from Indonesian growers.

Luna’s expenditure is the market price of the herb multiplied by the quantity purchased. Accordingly, Luna’s net benefit from the herb is its benefit less expenditure. We suppose that Luna’s objective is to maximize its net benefit.

At what quantity of purchases will Luna maximize its net benefit? Referring to Figure 7.5, Luna’s benefit depends on the quantity of its purchases: we suppose that the marginal benefit of a small quantity is very high and that the marginal benefit falls with the scale of purchases.

Also referring to Figure 7.5, the supply curve shows, for every quantity, the price at which competitive sellers will provide the herb. Equivalently, the supply curve represents the monopsony’s average expenditure for every possible quantity of purchases. Since the price must be higher to induce a greater quantity of supply, the average expenditure curve slopes upward.

The **marginal expenditure** is the change in expenditure resulting from an increase in purchases by one unit. For the average expenditure curve to slope upward, the marginal expenditure curve must lie above the average expenditure curve and slope upward more steeply.

Marginal expenditure: The change in expenditure resulting from an increase in purchases by one unit.

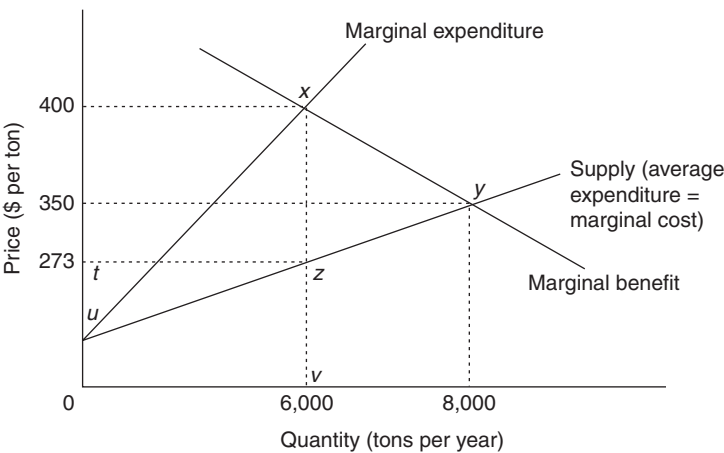


Figure 7.5 Monopsony purchases and price

Maximizing net benefit

We can now state the following rule: a buyer with market power will maximize its **net benefit** by purchasing the quantity at which its marginal benefit equals its marginal expenditure.

To explain this rule, consider a scale of purchases where Luna's marginal benefit exceeds its marginal expenditure. Then, if Luna steps up purchases, its benefit will increase by more than its expenditure; hence it will obtain a larger net benefit.

By contrast, if marginal benefit is less than marginal expenditure, Luna should reduce purchases: its benefit will drop by less than its expenditure. Luna will exactly maximize net benefit when it purchases the quantity where its marginal benefit balances its marginal expenditure.

Referring to Figure 7.5, the quantity that maximizes net benefit is 6,000 tons per year. At that quantity, the price is \$273 per ton. Notice that the price of \$273 per ton is less than the buyer's marginal benefit.

In comparison, if the demand side were competitive and the marginal benefit curve represented the market demand, the equilibrium price would be \$350 per ton and the quantity would be 8,000 tons per year. This illustrates a general point: a monopsony restricts purchases to get a lower price and increase its net benefit above the competitive level.

Net benefit

maximum: Purchase at a scale such that marginal benefit equals marginal expenditure.

Progress check 7H. In Figure 7.5, shade the area that represents Luna's total expenditure on the herb.

National Health Service: buyer market power

In England, the National Health Service (NHS) provides universal healthcare. In 2019/20, the NHS spent £8.54 billion on pharmaceuticals or just £152.55 per capita.

The NHS exercises its market power to negotiate low prices. As theory predicts, the NHS gets lower prices by reducing purchases or threatening to do so. The National Institute for Clinical Excellence (NICE) recommends drugs according to cost-effectiveness.

The US biopharmaceutical manufacturer Vertex developed the combination drug Lumacaftor/Ivacaftor, branded as Orkambi, for treatment of cystic fibrosis. In 2016, Vertex offered the drug to the NHS at £104,000 per patient per year, which NICE rejected as not being cost-effective.

Four years later, Vertex conceded to reduce the price. NHS Chief Executive Sir Simon Stevens explained that "the company has now agreed confidential commercial terms that constitute good value for British taxpayers."

Key takeaways

- Gain market power by limiting competition and making demand less price elastic.
- To maximize profit, produce if total revenue covers total cost, and produce at the scale where marginal revenue equals marginal cost.
- When demand or costs change, adjust production to the rate where marginal revenue equals marginal cost.
- To maximize profit, spend on advertising to the level where the advertising–sales ratio equals the incremental margin percentage multiplied by the advertising elasticity of demand.
- To maximize profit, spend on R&D to the level where the R&D–sales ratio equals the incremental margin percentage multiplied by the R&D elasticity of demand.
- Sellers with market power restrict sales to raise margins and profit.
- To maximize profit, purchase at the rate where marginal benefit equals marginal expenditure.

Review questions

1. By way of an example, explain how product differentiation contributes to market power.
2. What are the major forms of intellectual property?
3. Explain how economies of scale can contribute to market power.
4. For a seller with market power, why is marginal revenue less than or equal to price?
5. True or false? A seller with market power can either set the price and let the market decide how much to buy, or set the quantity to sell and let the market decide the price, but not set both price and quantity.
6. A software publisher has priced a new database program such that its marginal revenue is more than its marginal cost. Advise the company how to raise its profit.
7. Why should a seller take account of both the marginal revenue and the marginal cost when considering how to adjust price following a change in costs?
8. Why should a seller take account of both the marginal revenue and the marginal cost when considering how to adjust price following a change in demand?

9. The profit-maximizing price for a new smartphone is \$500. At that price, sales are 500,000 units a year and the advertising elasticity of demand is 0.01. The marginal cost of production is \$100 per unit. How much should the manufacturer spend on advertising?
 10. The demand for your product has become less elastic with respect to advertising. How should you adjust advertising expenditure?
 11. Explain the factors underlying the R&D elasticity of demand.
 12. For a medical device, the R&D to sales ratio exceeds the incremental margin percentage multiplied by the R&D elasticity of demand. How can the manufacturer increase profit?
 13. Compare the production under a monopoly with perfect competition.
 14. A buyer with market power restrains its purchases to reduce the market price. True or false?
 15. Compare purchases and price with a monopsony and perfectly competitive buyers.
-

Discussion questions

1. Vertex Pharmaceuticals manufactures Ivacaftor, the only treatment for cystic fibrosis in children below the age of two with a specific genetic mutation. Bayer manufactures aspirin, which is not covered by patent, and is one of several drugs that relieve the symptoms of the common cold.
 - (a) Which company has relatively more market power: Vertex over drugs to treat cystic fibrosis among infants, or Bayer over drugs for relieving the common cold? Explain your answer.
 - (b) How is the difference between price and marginal revenue related to the price elasticity of demand?
 - (c) Ivacaftor is manufactured through a biological process which is more costly than the chemical synthesis used to manufacture aspirin. How does this difference affect the pricing of Ivacaftor compared with aspirin?
2. Pfizer and Astellas sell the prostate cancer drug Xtandi in the United States and rest of the world respectively. In 2018, the price of Xtandi in the United States was US\$88,704 per treatment, as compared with US\$36,288 in England. (*Hint: Assume any data necessary to draw the figures below.*)
 - (a) Suppose that the marginal cost of producing Xtandi is US\$4,400 and Pfizer sets the price to maximize profit in the United States. Illustrate the profit maximum.
 - (b) On a similar figure as in (a), assume that Astellas sets the price to maximize profit in England. Illustrate the profit maximum.

- (c) Compare the demand curves in the United States and England. Which is more price elastic?
3. In May 2021, Ericsson and Samsung entered into a multiyear cross-licensing agreement settling various disputes over patents for mobile network equipment and handsets. Ericsson expected the agreement to more than double its licensing revenues.
 - (a) Assuming any relevant data, illustrate Samsung's demand and costs of producing mobile handsets, and the profit maximum.
 - (b) Under the agreement, Samsung made back payments for the period January–May 2021. How would these affect the profit-maximizing price and production?
 - (c) What if the agreement stipulates a royalty per unit of production? How would this affect Samsung's profit-maximizing price and production?
4. China is the world's largest manufacturer and buyer of electric cars. The government targets electric cars to account for 20% of car sales by 2025. In January 2021, the government reduced consumer subsidies on electric cars from 16,200 to 13,000 yuan and from 22,500 to 18,000 yuan for those with range of 300–400 km and 400km or more respectively.
 - (a) BYD of Shenzhen is a leading manufacturer of electric cars. How would the subsidy cut affect the demand for BYD?
 - (b) Assume any data necessary to draw the figure. Illustrate the effect of the subsidy cut on BYD's profit-maximizing price and production.
 - (c) Use your figure to explain the: (i) incidence of the subsidy cut on BYD, and (ii) effect on BYD's profit.
5. Pfizer divested its consumer businesses in 2019, and its off-patent and generic businesses in 2020. The company then focused on the development and production of patent-protected pharmaceuticals sold by prescription.
 - (a) Explain why the demand for prescription drugs depends on physicians and insurance companies.
 - (b) Compare the advertising elasticity of demand of consumers vis-à-vis physicians and insurance companies.
 - (c) Compare the price elasticity of demand for off-patent vis-à-vis patented drugs.
 - (d) Explain why, between 2018 and 2020, Pfizer cut expenditure on advertising from 6.6% to 5.8% to 4.3% of revenue.
6. At Google's 2013 third quarter earnings call, analyst Carlos Kirjner remarked, "the perception by people outside the company is that Google spends a material amount in long-term R&D that will not generate revenue in the next two years or so." CEO Larry Page countered that, with respect to large innovations, "I think you overestimate short-term and underestimate long-term." In 2013, Google's revenue, gross profit, and R&D expenses were US\$59.8 billion, US\$34.0 billion, and US\$8.0 billion respectively.

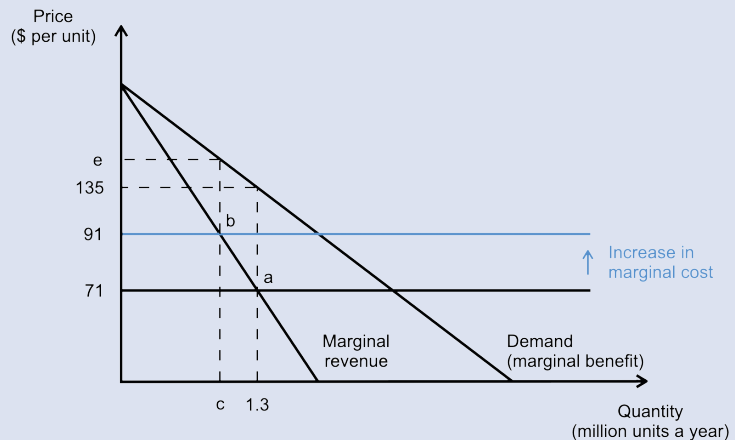
- (a) Explain the formula for the profit-maximizing level of R&D in terms of the R&D elasticity of demand and incremental margin percentage.
 - (b) Interpret the discussion between analyst Carlos Kirjner and CEO Larry Page in terms of the R&D elasticity of demand.
 - (c) Approximate the incremental margin percentage by the ratio of gross profit to revenue. Suppose that the R&D elasticity of demand was 0.2. Calculate how much R&D would have maximized Google's profit.
 - (d) Compare your calculation in (c) with Google's actual R&D expense.
7. Go-Jek and Grab provide ride hail and delivery services in Southeast Asia. In early 2018, following months of bruising price competition with local competitors, Uber decided to exit Southeast Asian markets. Both Go-Jek and Grab negotiated to buy Uber's businesses.
- (a) Why would Go-Jek and Grab be willing to pay more for Uber's Southeast Asian businesses than other potential buyers? Explain in terms of (i) demand and (ii) cost.
 - (b) Eventually, Uber sold to Grab. How should Grab adjust its prices in the Singapore market?
 - (c) After Uber exited the Singapore market, Go-Jek entered. Use your answer in (b) to explain why.
8. The National Collegiate Athletic Association (NCAA) regulates competitive sports at member colleges and universities. The NCAA restricts the pay of student athletes (typically to the cost of their education) and requires student athletes to attend full-time study. In September 2019, California enacted a law to allow student athletes to hire agents and earn fees from endorsements.
- (a) What market power does the NCAA have, and what are its sources?
 - (b) How would the California law affect the: (i) earnings of student athletes, and (ii) profits of the NCAA colleges and universities?
 - (c) How would the California law affect professional sports leagues?
9. Some automobile parts, such as batteries and tires, wear out with use and must be replaced frequently. Suppliers of these parts sell their products both as original equipment to auto manufacturers and as replacement parts to car owners. By contrast, supplies of air bags and ignition systems sell mainly to auto manufacturers.
- (a) Assess the power of automobile manufacturers over suppliers of (i) batteries and tires as compared to (ii) air bags and ignition systems.
 - (b) For products like batteries and tires, do you expect prices to be higher in the original equipment market or the replacement market?
 - (c) Suppose that the supply of batteries is perfectly competitive. Using an appropriate diagram, explain how an automobile manufacturer would determine the quantity of batteries to buy.

You are the consultant!

Consider some good or service that your organization produces. If your organization produced and sold 5% more, what would be the effect on revenue and cost? If your organization produced and sold 5% less, what would be the effect on revenue and cost? Is your organization maximizing profit?

Progress check answers

- 7A. Barriers to competition and the elasticity of demand or supply.
- 7B. If the demand is very elastic, then the marginal revenue will be close to the price.
- 7C. It should raise price, so reducing sales up to the production where its marginal cost equals its marginal revenue.
- 7D. The new marginal cost will cross the (unchanged) marginal revenue at a smaller rate of production. Hence, Luna should set a higher price to induce that level of sales and production. See diagram.



- 7E. Advertising expenditure = $(135 - 71) \times 0.14 \times 1.3 = \11.65 million.
- 7F. With a higher price and lower marginal cost, the incremental margin will be higher, and so R&D expenditure should be higher.
- 7G. To depress the market price and increase its profit.
- 7H. Luna's total expenditure is represented by either the area $Ovxu$ under the marginal expenditure curve from a quantity of 0 to 6,000 tons, or the rectangle $Ovzt$.

Review answers

1. [Omitted.]
2. Patents, copyright, and trademarks. Strictly, trade secrets are not intellectual property.
3. With economies of scale, a producer that produces on a larger scale will have a cost advantage over other producers. So, it can price lower and dominate its market.
4. To sell additional units, a seller must reduce its price. So, when increasing sales by one unit, the seller will gain the price of the marginal unit but lose revenue on the infra-marginal units. Hence, the marginal revenue is less than or equal to the price.
5. True.
6. The publisher should reduce its price and sell additional units. For these units, the marginal revenue is greater than marginal cost, thereby increasing total profit. It should reduce price until the marginal revenue equals the marginal cost.
7. The profit-maximizing quantity is such that the marginal revenue equals the marginal cost. Hence, after a change in costs, the seller should look for the quantity where the marginal revenue equals the marginal cost. So, it must consider both the marginal revenue and the marginal cost.
8. The profit-maximizing quantity is such that the marginal revenue equals the marginal cost. Hence, after a change in demand, the seller should look for the quantity where the new marginal revenue equals the marginal cost. So, it must consider both the marginal revenue and the marginal cost.
9. Advertising expenditure = $(500 - 100)/500 \times 0.01 \times (500,000 \times 500) = \2 million.
10. Reduce advertising expenditure until the advertising-sales ratio equals the incremental margin multiplied by the advertising elasticity of demand.
11. The R&D elasticity of demand depends on two factors: one is the effectiveness of R&D in generating new products and enhancing existing products, and the other is the effect of new and enhanced products on demand.
12. Raise R&D expenditure until the R&D-sales ratio equals the incremental margin multiplied by the R&D elasticity of demand. Intuitively, the higher is the incremental margin and the more sensitive is demand to R&D expenditure, the more the business should spend on R&D.
13. Production under monopoly would be less than perfect competition.
14. True.
15. In a perfectly competitive market, every buyer purchases at a scale where its marginal expenditure equals the market price; hence, its

incremental margin percentage is zero. By contrast, a monopsony restricts purchases to get a lower price and increase its net benefit above the competitive level. The more inelastic is the market expenditure, the more the buyer can reduce price below its marginal expenditure.

Discussion answers

1. (a) Infants suffering from cystic fibrosis do not have an alternative to Ivacaftor. People suffering from the common cold can choose from many drugs including Bayer's aspirin. Accordingly, Vertex Pharmaceuticals has relatively more market power.
- (b) If the demand is very elastic, then the marginal revenue will be close to the price, and hence the difference between price and marginal revenue will be small. If, however, the demand is very inelastic, then the marginal revenue will be much lower than the price, and hence the difference between price and marginal revenue will be large.
- (c) Referring to (a), the demand for Ivacaftor is relatively inelastic, and so, Vertex will set a relatively higher incremental margin of price over marginal cost. Moreover, the marginal cost is high, and so, adding the incremental margin, the price would be even higher.

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CHAPTER 8

Pricing

LEARNING OBJECTIVES

- Apply uniform pricing.
- Appreciate how price discrimination can increase profit beyond uniform pricing.
- Understand complete price discrimination.
- Apply direct segment discrimination.
- Apply indirect segment discrimination.
- Choose between alternative pricing policies.

8.1 Introduction

Founded in 1920, the Qantas Group provides domestic and international services branded as Qantas and Jetstar. In the year 2019–2020, the group earned A\$14.3 billion in revenue with seat factor (capacity utilization) of 82.3%. Its fleet comprised 314 aircraft.

Qantas operates flight QF422 on weekdays at 8.30am from Melbourne to Sydney. At the time of writing, the airline offered two economy class fares on the 16 June 2021 flight – the Red e-Deal for A\$383 and Flex fare for A\$522. The Flex fare allowed changes and could be canceled for a fee of A\$99. The Red e-Deal allowed changes but could not be canceled.

Those willing to travel 30 minutes later could get the Red e-Deal on QF426 for just A\$99. However, the Qantas website warned that the Red e-Deal was “nearly gone.”

Pricing is crucial for airlines. People vary widely in how much they are willing to pay for travel. Moreover, airline operations involve substantial fixed costs and relatively low variable costs. Consequently, airlines invest in reservations and yield management systems to manage fares and seats.

This chapter ties threads from previous chapters on demand, elasticity, costs, and monopoly to analyze how a seller with market power should set prices to maximize profit. The key concept is price discrimination, which is to set prices that realize different margins from various market segments.

Such discrimination explains why Qantas set different prices for different flights, and did not allow travelers to cancel Red e-Deal fares. By doing so, it could earn more from travelers who prefer particular times, and from those who might change their plans. Qantas limited the availability of the Red e-Deal to prevent high-fare travelers from switching to the Red e-Deal.

Any seller with market power can use the techniques of pricing to increase profit or better achieve other objectives.

8.2 Uniform pricing

Whenever managers are asked why they do not set a higher price, the most frequent response is: “Because I would lose sales.” This does not, however, answer the question. Unless the demand is completely inelastic, a higher price will always result in lower sales. The real issue is how the increase in price will affect the profit of the business. As we will show, the answer depends on the price elasticity of demand and the marginal cost.

Uniform pricing: The same price for every unit of the product.

Here, we begin with the simplest pricing policy – **uniform pricing**, where the seller charges the same price for every unit of the product.

Price elasticity

Suppose that Luna Airlines carries passengers between two cities at a constant marginal cost of \$80 per seat. How should Luna price the service? For simplicity, suppose that the profit contribution is large enough to exceed the fixed cost, so Luna should continue in operation.

Recall from Chapter 3 that demand is *elastic* if a 1% price increase causes the quantity demanded to drop by more than 1%, and *inelastic* if a 1% price increase causes the quantity demanded to fall by less than 1%. Generally, if the demand is inelastic, an increase in price will lead to a higher profit. Accordingly, a seller that faces an inelastic demand should raise the price.

Profit-maximizing price: The incremental margin percentage equals the reciprocal of the absolute value of the price elasticity of demand.

Profit-maximizing price

Indeed, the seller should raise price until the demand is elastic. In the price elastic range, what price maximizes the seller's profit? Chapter 7 identified the profit-maximizing sales and price by the rule that marginal revenue equals marginal cost. Figure 8.1 shows the profit-maximizing sales and price for Luna Airlines.

Managers usually do not readily have information about marginal revenue. Typically, however, they have better information about the price elasticity of demand. So, it is more convenient to apply a pricing rule based on elasticity.

A rule equivalent to marginal revenue being equal to marginal cost is that the incremental margin percentage equals the reciprocal of the absolute value of the price elasticity of demand. So a seller maximizes profit by setting a **price** where

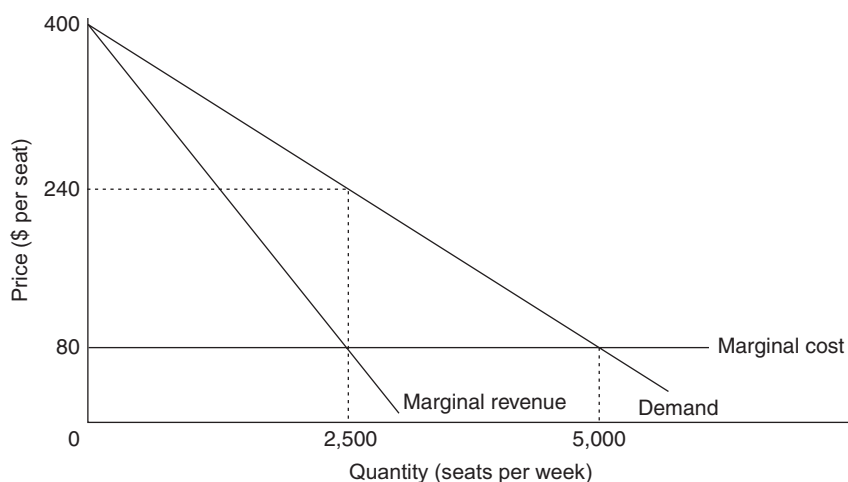


Figure 8.1 Uniform pricing

$$\text{Incremental margin percentage} = -\frac{1}{\text{price elasticity of demand}}$$

The price elasticity of demand is negative; hence, the minus sign on the right-hand side of the pricing rule ensures that the entire right-hand side is positive.

Let us apply the rule to Luna's pricing. Suppose that the price elasticity of demand is -1.5 . Then, for Luna to maximize its profit, the incremental margin percentage must be $1/1.5 = 2/3$. Representing the price by p , and recalling that the marginal cost is \$80, the rule implies that

$$\frac{p - 80}{p} = \frac{2}{3}.$$

By solving this equation, we find that $p = 240$. Hence, the price that maximizes Luna's profit is \$240 (as Figure 8.1 shows, we get the same price if we look for the sales where the marginal revenue equals the marginal cost). At the price of \$240, the quantity demanded is 2,500 seats per week. Hence, Luna's total revenue is $240 \times 2,500 = \$600,000$ per week. Luna's total cost is $80 \times 2,500 = \$200,000$. Thus, its profit contribution is \$400,000 per week.

The price elasticity may vary along a demand curve. Further, the marginal cost may change with the scale of production. Accordingly, determining the profit-maximizing price involves a series of trials with different prices until finding a price such that the incremental margin percentage equals the reciprocal of the absolute value of the price elasticity.

Demand and cost changes

The pricing rule shows how a seller should adjust its price when there are changes in the price elasticity of demand or marginal cost. Consider changes in the price elasticity. If the demand is more elastic, then the price elasticity will be a larger negative number. So, by the rule, the seller should aim for a lower incremental margin percentage.

For instance, suppose that, in Luna's case, the price elasticity is -2 rather than -1.5 . Then the profit-maximizing incremental margin percentage will be $1/2 = 50\%$. Letting the price be p , we have $(p - 80)/p = 0.50$, which implies that the profit-maximizing price is \$160.

By contrast, if the demand were less elastic, say, with an elasticity of -1.33 , then the profit-maximizing incremental margin percentage would be $1/1.33 = 75\%$. Again, representing the price by p , we would then have $(p - 80)/p = 0.75$, which implies that the profit-maximizing price would be \$320.

Next, let us consider changes in the seller's marginal cost. In our original example, the price elasticity was -1.5 , while the marginal cost was \$80. Suppose that the marginal cost is lower at \$60. How should Luna adjust its price? Using the pricing rule, the profit-maximizing price must satisfy $(p - 60)/p = 1/1.5$, which implies that $p = 180$. Notice that, although the marginal cost is \$20 lower, the profit-maximizing price is \$60 lower.

Similarly, we can show that, if the marginal cost is higher, Luna should not raise its price by the same amount. The reason is that Luna must consider the effect of the price change on the quantity demanded.

These examples demonstrate that the way a seller should adjust its price to changes in either price elasticity or marginal cost depends on both the price elasticity and the marginal cost. In particular, this means that a seller should not necessarily adjust the price by the same amount as a change in marginal cost.

Progress check 8A. In the case of Luna Airlines, suppose that the price elasticity of demand is -2 , while the marginal cost is \$70 per seat. Calculate the price that maximizes profit.

Common misconceptions

A common mistake in pricing is to set the price by marking up average cost. Cost-plus pricing gives no guidance as to the appropriate mark-up on average cost. Should a seller apply the same or different mark-ups to different products? Suppose that a seller wants to set the mark-up to maximize profits. Then the seller must go back to considering the price elasticity of demand and marginal cost.

Another common mistake is to believe that the profit-maximizing price depends only on the price elasticity. To illustrate the correct approach, consider a hotel mini-bar. Suppose that the guest's price elasticities of demand for beer and soft drinks are

the same. Should the hotel set the same price for both items? Absolutely not. The hotel should set the same incremental margin percentage on the two items. Since the marginal cost of beer is higher than that of soft drinks, this implies a higher price for the beer.

Price elasticity: who is the customer?

Whenever anyone brings a damaged car for repair, one of the first questions that will be asked is: "Are you covered by insurance?" Why does the repair shop care about insurance coverage?

In automobile repair, the demand side comprises two persons: the car owner who makes the buying decision and the insurer who pays the bill. Owners covered by insurance are less sensitive to the cost of repairs. Indeed, they might ask the repair shop to fix some other damage at the insurer's expense.

Generally, demand is less sensitive to price whenever one person makes the buying decision and another pays the bill. Auto repair shops exploit this split. However, the car owner will be concerned about the cost of repairs to the extent that their future insurance premium depends on past claims.

8.3 Complete price discrimination

The previous section introduced a rule for uniform pricing: set the price so that the incremental margin percentage equals the reciprocal of the absolute value of the price elasticity of demand. However, closer examination shows that uniform pricing does not yield the maximum possible profit. This suggests that we should look for better pricing policies.

Shortcomings of uniform pricing

Referring to Figure 8.2, recall that the demand curve also reflects the marginal benefits of the various buyers. At the price of \$240 per seat, the benefit for the marginal buyer is just equal to the price. For all the other (inframarginal) buyers, who account for 2,499 seats, the benefit exceeds the price. Each of these inframarginal buyers enjoys some buyer surplus. The market buyer surplus is the area *adb*.

With uniform pricing, the inframarginal buyers do not pay as much as they would be willing to pay. This suggests that, by taking some of the buyer surplus, Luna could increase its profit.

Another shortcoming of uniform pricing is that it sells an economically inefficient quantity. (Recall from Chapter 5 on economic efficiency that the production of an item is economically efficient if the marginal benefit equals the marginal cost.)

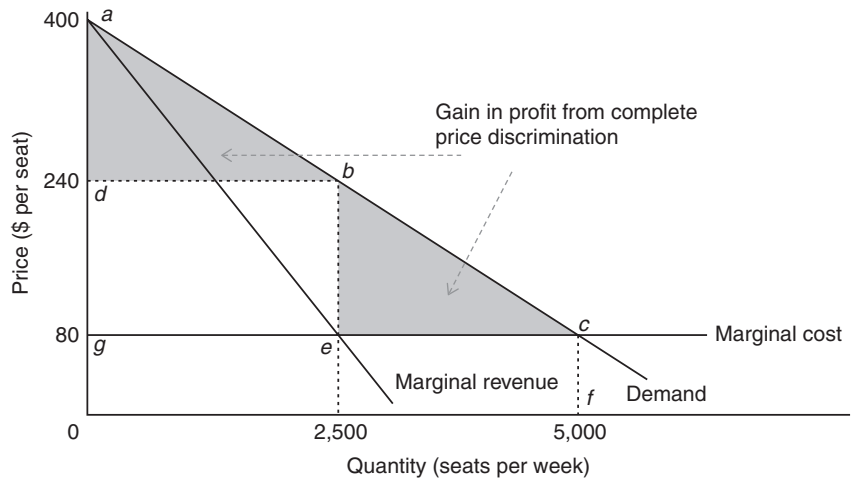


Figure 8.2 Complete price discrimination

The marginal buyer derives a benefit of \$240, while the marginal cost is only \$80. This economic inefficiency identifies an opportunity for profit. By providing the service to everyone whose marginal benefit exceeds the marginal cost, Luna can increase profit.

Progress check 8B. What are the two shortcomings of uniform pricing?

Price discrimination:

Pricing so as to earn different incremental margins on various units of the same or a similar product.

Complete price discrimination:

Pricing each unit at the buyer's benefit and selling a quantity such that marginal benefit equals marginal cost.

Price discrimination

Ideally, Luna should sell each seat at the respective buyer's benefit. Referring to Figure 8.2, this would be like selling down the market demand curve. Then Luna would earn a higher incremental margin from buyers with higher benefit and a smaller margin from buyers with lower benefit.

Any pricing policy under which a seller sets prices to earn different incremental margins on various units of the same or a similar product is called **price discrimination**. (This term simply means setting different prices, and is not normative. An equivalent term would be "price differentiation.")

Complete price discrimination is the pricing policy which prices each unit at the buyer's benefit and sells a quantity such that the marginal benefit equals the marginal cost. This policy is called "complete" because it charges every buyer the maximum that they are willing to pay for each unit. Hence, the policy leaves each buyer with no surplus.

To illustrate complete price discrimination, consider Luna Airlines' pricing of air service. Referring to Figure 8.2, the demand curve is a straight line with a slope

of $-320/5,000 = -0.064$. This means that the first traveler is willing to pay $400 - 0.064 = \$399.936$ for a seat, the second traveler $400 - 2 \times 0.064 = \$399.872$, and so on. Hence, under complete price discrimination, Luna should charge the first traveler \$399.936, the second traveler \$399.872, and so on.

Luna should *not* stop selling at the 2,500th seat. The reason is that the 2,501st traveler derives a benefit of $240 - 0.064 = \$239.936$, which exceeds Luna's marginal cost of \$80. This means that Luna can raise its profit by selling a seat to that traveler.

Indeed, Luna should sell up to the quantity where the marginal benefit just equals the marginal cost. Referring to Figure 8.2, this balance occurs at a quantity of 5,000 seats per week. The 5,000th traveler is willing to pay exactly \$80 for a seat, which is Luna's marginal cost. If Luna tried to sell beyond 5,000 seats, it would make a loss on additional units. Under complete price discrimination, the buyer of the 5,000th seat is the marginal buyer.

With complete price discrimination, Luna's total revenue is the area *Ofca* under the demand curve from the quantity of 0 up to 5,000 seats per week. This area is $(400 + 80)/2 \times 5,000 = \1.2 million per week. As for costs, Luna's total cost is area *Ofcg*, which is $80 \times 5,000 = \$0.4$ million per week. Hence, with complete price discrimination, Luna's profit contribution is \$800,000 per week.

By contrast, the preceding section showed that Luna's maximum profit contribution with uniform pricing is \$400,000 per week. So, Luna earns more profit with complete price discrimination than with uniform pricing.

Under a policy of complete price discrimination, the seller should sell each unit for the benefit that it provides its buyer and sell the quantity where the buyer's marginal benefit just equals the marginal cost. Complete price discrimination resolves the two shortcomings of uniform pricing:

- By pricing each unit at the buyer's benefit, the policy extracts all the buyer surplus.
- It provides the economically efficient quantity; hence, it exploits all opportunity for additional profit through increasing sales.

In the example of Luna Airlines, the policy of complete price discrimination enables Luna to extract higher prices for the 2,499 seats that would be inframarginal under uniform pricing. This increase in profit contribution is represented by the area *adb* in Figure 8.2. Second, with complete price discrimination, Luna would sell 2,500 more seats. These additional seats raise the profit by the area *bec* in Figure 8.2. The total increase in profit contribution is the sum of the areas *adb* and *bec*.

Economic efficiency

We motivated complete price discrimination as a way to increase profit. Interestingly, it also achieves economic efficiency. In this sense, maximizing profit is aligned with the social goal of economic efficiency.

To the extent that price discrimination achieves economic efficiency, it is useful for non-profit and government organizations such as hospitals, museums, and universities. By applying price discrimination, they may be able to expand their service to more people. For instance, by charging higher prices to customers who are willing to pay more, a non-profit can use the additional revenue to provide service to poorer customers.

Information and resale

Under complete price discrimination, the seller charges each buyer a different price for each unit of the product. To implement complete price discrimination:

- The seller must know each potential buyer's individual demand curve. It is not enough to know the price elasticities of the individual demand curves. Rather, the seller must know the entire individual demand curve of each potential buyer.
- The seller must be able to prevent customers from buying at a low price and reselling to others at a higher price.

Typically, it is more difficult to resell services, especially personal services, than goods. For instance, it is more difficult to resell medical treatment than pharmaceuticals, and it is more difficult to resell tax planning advice than tax preparation software. Accordingly, price discrimination is relatively more widespread in services than goods and is especially common in personal services.

Progress check 8C. In Figure 8.2, the profit contribution from complete price discrimination exceeds the profit contribution from uniform pricing by areas adb and bec . Calculate the dollar values of these areas.

Does the doctor really need to know your occupation?

Price discrimination is common in medical services. Physicians treat patients on an individual basis. A physician's first step in treatment is always to record the patient's history. This routinely includes questions about occupation, employer, home address, and insurance coverage.

This information is very useful in assessing the patient's health as well as gauging their ability to pay. Physicians can then charge different prices for the same treatment. The result is close to complete price discrimination.

Google auctions

In 2020, Google earned revenues of \$168.6 billion, primarily from advertising. Advertisers bid for slots on Google search pages and other websites. In an instantaneous auction, Google awards each slot according to a combination of the advertiser's maximum bid, the relevance of the advertisement to the consumer, and its expected impact.

Google's continuous auction of advertising slots approximates complete price discrimination. Each advertiser pays a different price for each slot, depending on the competition among the bids.

China Mobile: extracting buyer surplus

China Mobile provides mobile telecommunications services in Hong Kong. In June 2021, it offered multiple 24-month plans, all of which included unlimited voice calls. The smallest plan provided ten gigabytes of data for HK\$168 per month, the next larger provided 30 gigabytes for HK\$198 per month, and the next larger provided 100 gigabytes for HK\$298 per month.

The package deal is a pricing technique to fully extract the subscriber's buyer surplus by charging a lump sum for the economically efficient consumption. Through the various plans, China Mobile aims to extract the buyer surplus of customers with different needs for data.

8.4 Direct segment discrimination

To implement complete price discrimination, a seller must know the entire individual demand curve of each potential buyer. What if the seller does not have so much information? A seller without sufficient information to price on an individual basis may still be able to discriminate among *segments* of buyers. A **segment** is a substantial cohesive group of buyers within a larger market.

We give the name **direct segment discrimination** to the policy of setting different incremental margins for each identifiable segment.

Segment: A significant cohesive group of buyers within a larger market.

Homogeneous segments

Suppose that Luna Airlines transports adults and seniors at the same marginal cost of \$80 per seat. Adults are willing to pay exactly \$360 per seat, while seniors are willing to pay just \$90. Both segments are willing to pay more than the marginal cost.

Luna can divide the market into two segments according to age. It should price the regular adult fare at \$360 and the senior fare at \$90. Luna would earn incremental

Direct segment discrimination: Pricing to earn different incremental margins from each identifiable segment.

margins of $360 - 80 = \$280$ from each adult passenger, and $90 - 80 = \$10$ from each senior.

In this simple scenario, direct segment discrimination extracts each traveler's buyer surplus and sells the economically efficient quantity. It achieves complete price discrimination.

Heterogeneous segments

What if adults differ in their willingness to pay, or seniors differ in their willingness to pay? Then the profit-maximizing pricing policy depends on whether Luna can identify sub-segments within the broader segments of adults and seniors and prevent resale within the sub-segments.

If Luna does not have sufficient information to identify such sub-segments or cannot prevent resale within segments, it has two choices for pricing within the adult and senior segments. One is to apply uniform pricing *within* each segment. The other is to apply *indirect* segment discrimination within each segment. Here, we focus on within-segment uniform pricing, leaving indirect segment discrimination to section 8.5.

Within each segment, applying the rule for uniform pricing, the price should be such that the incremental margin percentage equals the reciprocal of the absolute value of the price elasticity of demand.

Let the adults' and seniors' demands be as shown in Figure 8.3. Consider first the demand from adults. Suppose that the profit-maximizing price is a . Through a process of trial and error, we find that, at the price a , the price elasticity of demand is -1.5 . Accordingly, Luna should set the price a so that the incremental margin percentage is $1/1.5 = 67\%$. This means $(a - 80)/a = 0.67$; hence, the price of an adult fare is $a = \$240$. Suppose that, at this price, the quantity demanded is 2,500 seats.

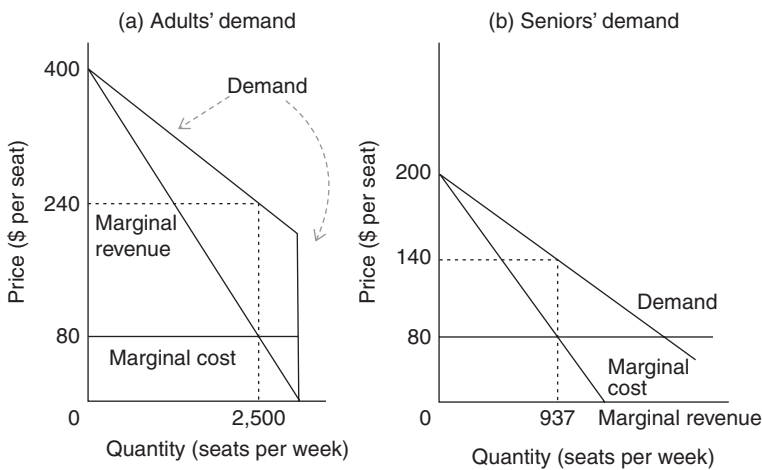


Figure 8.3 Direct segment discrimination

Next, consider the demand from seniors. Seniors derive lower marginal benefits; hence, their demand curve is lower than that of adults. Suppose that the profit-maximizing price is s . Through trial and error, we find that, at the price s , the price elasticity of demand is $-7/3$. Hence, Luna should set the senior fare so that the incremental margin percentage is $3/7$. Then $(s - 80)/s = 3/7$, which implies that the senior fare is $s = \$140$. Suppose that, at this price, the quantity demanded is 937 seats.

In this example, the adult demand is less elastic. Therefore, Luna should set a relatively higher incremental margin percentage on regular adult fares. Luna's profit contribution from the adult segment is $(240 - 80) \times 2,500 = \$400,000$. Further, its profit contribution from the senior segment is $(140 - 80) \times 937 = \$56,220$. So, its total profit contribution with direct segment discrimination is \$456,220 per week. By contrast, its profit contribution with complete price discrimination is \$800,000 per week, while its profit contribution with uniform pricing is \$400,000 per week.

Generally, in a policy of direct segment discrimination coupled with uniform pricing within segments, the seller should set prices in the following way. Get a relatively lower incremental margin percentage from the segment with the more elastic demand and a relatively higher incremental margin percentage from the segment with the less elastic demand.

Implementation

To implement direct segment discrimination, the seller must identify and be able to use some identifiable and fixed buyer characteristic that segments the market. The characteristic must be fixed; otherwise, a buyer might switch segments to take advantage of a lower price.

The other condition for direct segment discrimination is that the seller must be able to prevent arbitrage. Consumers getting lower prices must not be able to resell to those targeted with higher prices.

Progress check 8D. Referring to Figure 8.3, suppose that the marginal cost is \$100. Use the graph to illustrate the new prices for adult and senior fares.

National University Hospital: your identity card, please

The National University Hospital provides tertiary level healthcare in Singapore. Like other public-sector hospitals, the National University Hospital charges different prices to Singaporeans and foreigners.

For the first outpatient consultation, subsidized rates, available only to Singapore citizens and permanent residents, range from S\$38 to S\$56. Foreigners must pay the private rates, which range from S\$109.14 to S\$145.52.

Financial Times

A business newspaper is suited to discrimination by location. Few executives would trade off a lower price for old news. On 4 June 2021, the *Financial Times* priced the paper weekday edition at A\$7 (US\$5.43) in Australia, HK\$33 (US\$4.26) in Hong Kong, 650 yen (US\$5.94) in Japan, and S\$5.80 (US\$4.39) in Singapore.

8.5 Indirect segment discrimination

A seller may know that specific segments have different demand curves but cannot find a fixed characteristic with which to discriminate directly. For instance, suppose that the demand for Luna Airlines’ service comprises two segments. Referring to Table 8.1, the benefit to business travelers is \$501, and the benefit to leisure travelers is \$201.

Ideally, Luna would apply direct segment discrimination, but it cannot. It may still be able to discriminate on price, but *indirectly*.

Structured choice

Consider the travelers’ plans in more detail. Vacationers can fix their plans well in advance. By contrast, business travelers may need to change their plans to fit work requirements. So, business and leisure travelers are differentially sensitive to fees for changes in flight bookings.

Luna could offer two fares: a more expensive, unrestricted fare with no fees for changes; and a cheaper, restricted fare with a fee and limitations on changes. As Table 8.1 shows, the benefit of the restricted fare to business travelers is \$101, and the benefit to leisure travelers is \$181. Both business and leisure travelers get more benefit from unrestricted than restricted fares. However, business travelers get relatively more benefit from unrestricted fares and relatively less benefit from restricted fares.

Suppose, for instance, that Luna prices the unrestricted fare at \$500, and the restricted fare at \$180. How would the business travelers choose? They would not buy the restricted fare, as the price exceeds their benefit. They would buy the unrestricted fare, and get a buyer surplus of $\$501 - \$500 = \$1$.

Table 8.1 Indirect segment discrimination

	Benefit (\$)		Price (\$)	Marginal cost (\$)	Profit contribution per traveler (\$)
	Business travelers	Leisure travelers			
Unrestricted fare	501	201	500	80	420
Restricted fare	101	181	180	80	100

As for the leisure travelers, they would not buy the unrestricted fare, as the price exceeds their benefit. They would buy the restricted fare, and get a buyer surplus of $\$181 - \$180 = \$1$. Table 8.1 shows the airline's profit contribution from each traveler.

The two segments – business and leisure travelers – have different demand curves. The airline, however, has no way to directly identify the segments. So instead it structures a choice between unrestricted and restricted fares which exploits business and leisure travelers being differentially sensitive to fees for changes.

We give the name **indirect segment discrimination** to the policy of structuring a choice for buyers so as to earn different incremental margins from each segment. Indirect segment discrimination uses product attributes to discriminate indirectly among the various buyer segments.

Essentially, the seller uses the product attributes to proxy for buyer attributes. To determine the profit-maximizing prices, the seller must consider how buyers with different attributes substitute among the various choices. Hence, the seller must not price any product in isolation, but must set the prices of all products together.

Indirect segment discrimination:

Structuring choice for buyers to earn different incremental margins from each segment.

Implementation

To implement indirect segment discrimination, the seller must control some variable to which buyers in the various segments are differentially sensitive. The seller can then use this variable to structure a set of choices that will discriminate among the segments.

The other condition for indirect segment discrimination is that buyers must not be able to circumvent the discriminating variable. Suppose, for instance, that Luna were to allow travelers holding restricted fares to change their flights without any fee. Then business travelers would switch from unrestricted to restricted fares, which would undermine the segment discrimination.

Progress check 8E. Referring to Table 8.1, suppose that the restricted fare yields benefit of \$401 to the business traveler, and \$101 to leisure traveler. Calculate the buyer surpluses of the business and leisure travelers from the unrestricted and restricted fares. Can Luna Airlines implement indirect segment discrimination?

Qantas: Flex or Red e-Deal?

Airlines engage in price discrimination intensively. They take care to match passengers to tickets (indeed, with increases in airport security, the government lends a helping hand). So, passengers cannot resell tickets to one another.

Fares vary by day of the week and time of day, and by the changes allowed and the fees for changes. On flight QF422 from Melbourne to Sydney, scheduled for 16 June 2021, Qantas offered the Flex fare for A\$522 and Red e-Deal for A\$383.

The more expensive fare targeted business travelers. The Flex fare allowed changes and could be canceled for a fee of A\$99. The Red e-Deal allowed changes but could not be canceled.

IKEA: pick up or delivery?

IKEA sells furniture throughout the world online as well as through brick-and-mortar stores. In June 2021, the IKEA Germany website priced the Bekant desk at 169 euros, including value added tax (VAT). At checkout, IKEA offered a choice between store pick up or delivery for charge of 39 euros to central Munich.

The choice between pickup and delivery indirectly discriminates among consumers by their cost of time. People with higher income (and willing to pay more) would be more likely to choose delivery.

8.6 Selecting the pricing policy

Generally, the pricing policy that yields the most profit is complete price discrimination. This, however, also requires the most information. The next most profitable pricing policy is direct market segmentation. With direct segment discrimination, the seller discriminates directly on some fixed attributes of the buyer. The seller must be able to identify each buyer segment and prevent one segment from buying the product targeted at another segment.

The third most profitable pricing policy is indirect segment discrimination, which works indirectly through product attributes rather than directly through buyer attributes. This policy is less profitable as the design of product attributes may reduce the benefit to buyers and differentiating the products may be costly.

The least profitable pricing policy is uniform pricing. This does not discriminate at all, but is the simplest, requiring the least information. Table 8.2 ranks the various pricing policies in order of profitability and information requirement.

Technology

The rapid development of information technology has had profound but conflicting effects on price discrimination. Information technology both facilitates and impedes price discrimination.

Table 8.2 Pricing policies: information and profitability

<i>Profitability</i>	<i>Policy</i>	<i>Information and administration</i>
Lowest	Uniform pricing	Lowest
	Indirect segment discrimination	
	Direct segment discrimination	
Highest	Complete price discrimination	Highest

As consumers browse the Internet, marketers collect detailed information about their preferences. In addition, falling costs of computing have reduced the cost of storing, analyzing, and applying the consumer information. So sellers can better design and target offers to particular segments. Moreover, technology also facilitates the differentiation of products to target different customer segments.

On the other hand, the falling costs of computing have also promoted the growth of consumer-oriented search services. Continuously prowling the Internet, these services help consumers to compare products and prices, thus identifying the best offer and circumventing price discrimination.

HP ink cartridge: regional pricing

Hewlett-Packard (HP) prices ink cartridges by geographical region. At the time of writing, the price of the HP62 cartridge was £17.99 (US\$25.07) in England, S\$28 (US\$20.86) in Singapore, and US\$18.99 in the United States.

One reason for the price differences is retail taxes. Under the extreme assumption that HP bears the entire tax, the prices would be US\$20.89 in England and US\$19.50 in Singapore. So, the prices reveal some degree of price discrimination.

Ink cartridges are small and light but fairly expensive, so it would be profitable to arbitrage the price differences. However, technology supports direct segment discrimination at minimal cost. HP encodes inkjet printers to restrict the cartridge that they can use. Printers, being bulky and heavy, are not profitable to arbitrage.

Cannibalization

Cannibalization occurs when high-benefit buyers switch from high incremental margin products to low incremental margin products. Some examples of cannibalization are business travelers flying on restricted fares and wealthy consumers redeeming supermarket coupons.

Cannibalization:

High-benefit buyers switch from high incremental margin products to low incremental margin products.

The basic reason is that the seller cannot discriminate directly, and hence must rely on a structured choice of products to discriminate indirectly. To the extent that the discriminating variable does not perfectly separate the buyer segments, cannibalization will occur.

There are several ways to mitigate cannibalization. One is to use product design. Upgrading the high-margin item would make it relatively more attractive, and hence, less likely to be cannibalized. Degrading the low-margin item would make it less attractive, and thus less likely to cannibalize the demand for the high-margin item.

Further, the products can be designed with multiple discriminating variables. For instance, airlines specify multiple conditions for restricted fares, including minimum and maximum stay, limits on stopovers at intermediate destinations, and penalties for cancelation or changes in itinerary. Each of these conditions helps to reduce the degree to which the restricted fare would cannibalize the demand for the unrestricted fare.

Finally, cannibalization can be mitigated by controlling availability. Limiting the availability of the low-margin item would make it less attractive. Airlines, for instance, limit the number of seats allocated to lower fares.

Progress check 8F. Explain how technology supports price discrimination.

China Mobile: mitigating cannibalization

China Mobile offers various SIM-only data plans with unlimited voice calls in Hong Kong. The cheapest plan provides ten gigabytes of data for HK\$168 per month. The next higher plan provides 30 gigabytes of data for HK\$198 per month.

Let Figure 8.4 depict the demand curves of Angela and Maggie for mobile service. Suppose that Angela buys the ten gigabyte plan. She would consume ten gigabytes and her total benefit would be area Oba , or $\frac{1}{2} \times \text{HK\$}36 \times 10 = \text{HK\$}180$. Her buyer surplus would be $\text{HK\$}180 - \text{HK\$}168 = \text{HK\$}12$. Indeed, she would buy the plan.

What about Maggie? Suppose that she buys the ten gigabyte plan. Then, she would consume ten gigabytes and her total benefit would be area $Obca$, or $\frac{1}{2} \times (\text{HK\$}24 + \text{HK\$}36) \times 10 = \text{HK\$}300$. Her buyer surplus would $\text{HK\$}300 - \text{HK\$}168 = \text{HK\$}132$.

Suppose that Maggie buys the 30 gigabyte plan. Then, she would consume 30 gigabytes and her total benefit would be area Oda , or $\frac{1}{2} \times \text{HK\$}36 \times 30 = \text{HK\$}540$. Her buyer surplus would $\text{HK\$}540 - \text{HK\$}198 = \text{HK\$}342$, which exceeds her buyer surplus with the ten gigabyte plan. Maggie would choose the 30 gigabyte plan.

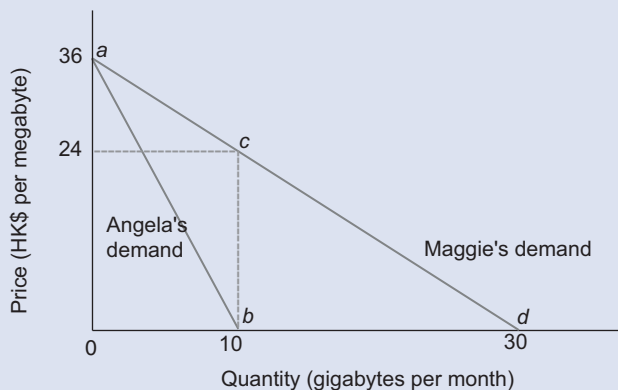


Figure 8.4 Product line pricing

When designing the ten gigabyte plan for light users, China Mobile must take care not to cannibalize the demand of heavy users for the 30 gigabyte plan. This means increasing the price or reducing the size of the small plan, or reducing the price or increasing the size of the large plan.

Key takeaways

- To maximize profit with uniform pricing, set the price so that the incremental margin percentage equals the reciprocal of the absolute value of price elasticity of demand.
- Price discrimination can increase profit by taking buyer surplus and providing a quantity closer to the economically efficient level.
- Complete price discrimination charges a different price for each unit of the product.
- Direct segment discrimination sets prices to earn different incremental margins from each segment.
- Indirect segment discrimination structures a choice for buyers to earn different incremental margins from each segment.
- The ranking of pricing policies from most to least profitable is complete price discrimination, direct segment discrimination, indirect segment discrimination, and uniform pricing.

Review questions

1. Many supermarkets sell both branded and own-label merchandise. A supermarket estimates that the demand for its own-label cola is less elastic than the demand for Coca-Cola. Should it set a higher price for own-label cola?
2. Consider a manufacturer of LED bulbs. The marginal production cost is \$2 per unit, while the price elasticity of demand is -1.25 . With uniform pricing, what price would maximize profits?
3. A tire manufacturer has reduced the marginal cost of production from \$50 to \$40. Should it reduce the selling price of a tire by \$10?
4. Book publishers typically set prices by the number of pages multiplied by a standard price per page. Comment on this pricing policy.
5. How does complete price discrimination increase profit as compared with uniform pricing?
6. What conditions are necessary to implement complete price discrimination?
7. Give an example of direct segment discrimination. Discuss whether the example meets the conditions for such discrimination.
8. Direct segment discrimination always yields less profit than complete price discrimination. True or false?
9. A manufacturer of luxury goods sets higher prices in China than France. What pricing policy is it applying?
10. Give an example of indirect segment discrimination. Discuss whether the example meets the conditions for such discrimination.
11. Typically, car rental agencies charge much higher prices for gasoline than nearby gas stations. Explain how this indirectly segments between drivers who are paying for the rental themselves and those who are renting at the expense of others.
12. Suppose that consumers whose time is more costly are less likely to use coupons. How can consumer goods manufacturers use coupons to discriminate on price?
13. Rank the various pricing policies in terms of information required.
14. How does information technology affect a seller's ability to discriminate on price?
15. What is cannibalization?

Discussion questions

1. In November 2014, Morgan Stanley, Citigroup, Deutsche Bank, and JP Morgan led a three-year \$300 million loan to Alibaba. They set the interest

rate at the London Interbank Offer Rate (Libor) plus 52 basis points (0.52%). Banks source funds from demand, savings, and time deposits, as well as the interbank market. Libor is typically higher than interest rates on deposits.

- (a) Does Libor reflect a typical bank's average or marginal cost of funds?
 - (b) For purposes of pricing, explain which is relevant – average or marginal cost?
 - (c) Explain the banks' pricing policy in terms of the incremental margin percentage and the price elasticity of demand.
2. Doctors routinely ask patients for personal information such as occupation, employer, home address, and insurance coverage.
 - (a) How do the following factors affect the scope to price discriminate in healthcare? (i) Patients are treated individually and it is impossible to transfer healthcare among people. (ii) Characteristics such as occupation and home address are quite fixed.
 - (b) Using a suitable figure, explain how doctors using price discrimination can treat more patients than if they use uniform pricing.
 - (c) Discuss how your answer to (b) depends on the size of fixed costs.
 3. Dubai Electricity and Water Authority (DEWA) supplies electricity in Dubai. At the time of writing, its price of electricity for residential and commercial users ranged from 23 fils per kWh up to 2,000 kWh to 38 fils per kWh for 6,001 kWh and above. Its price of electricity for industrial users ranged from 23 fils per kWh up to 10,000 kWh to 38 fils per kWh for 10,001 kWh and above. All customers had to pay a fuel surcharge of 5 fils per kWh.
 - (a) What type of price discrimination is DEWA applying?
 - (b) Discuss the challenges to price discrimination.
 - (c) DEWA can inspect customer premises for technical reasons. Discuss whether this helps to address the challenges in (b).
 - (d) Discuss how the following would justify prices that increase with consumption: (i) Fixed cost of serving each customer; (ii) Cost of generating electricity; (iii) Encouraging energy conservation.
 4. In October 2019, Tesla opened a factory in Shanghai, China, to assemble the Models 3 and Y. One year later, Tesla cut the price of the basic Model 3 in China by 8% to 249,900 yuan (US\$36,805). In the United States, the manufacturer's suggested retail price was US\$39,990.
 - (a) What type of price discrimination (between China and the United States) did Tesla apply?
 - (b) Suppose that the marginal cost of manufacturing is lower in China than the United States. Using suitable demand and cost curves, illustrate the profit maximizing prices and production in the two markets.
 - (c) In setting the US price for the Model 3, why must Tesla take account of the price in China?

5. Heinz dominates the market for tomato ketchup. On the demand side, the market comprises retail and institutional segments. Institutions order larger quantities and may employ professional purchasing staff. Retail consumers are supplied through supermarkets and grocery stores.
 - (a) Explain why institutional demand for ketchup is likely to be more price elastic than retail demand. How would Heinz like to apply price discrimination?
 - (b) If Heinz supplies both institutional customers and retail distribution channels through wholesalers, explain how the wholesalers might undermine direct segment discrimination.
 - (c) Compare the problem in (b) for ketchup in bottles as compared with individual packets.
 - (d) Why does Heinz mark ketchup sold to restaurants “not for retail sale”?
6. The National Palace Museum, Taiwan, hosts one of the largest collections of Chinese imperial artifacts and art in the world. In June 2021, the price of general admission was NT\$350, discounted to NT\$150 for local citizens and students. Admission was free for all aged 17 and below, local students, and disabled persons. For local seniors, admission was free on weekdays and NT\$75 on weekends.
 - (a) Explain how the Museum uses direct segment discrimination. Discuss whether the pricing meets the conditions for such discrimination.
 - (b) Explain how the Museum uses indirect segment discrimination. Discuss whether the pricing meets the conditions for such discrimination.
 - (c) Considering that the marginal cost of admission is congestion, comment on the policy of granting free admission to seniors only on weekdays.
7. In June 2021, the *Financial Times* (FT) priced the paper weekday edition at HK\$33 (US\$4.26) in Hong Kong, 650 yen (US\$5.94) in Japan, and S\$5.80 (US\$4.39) in Singapore. The FT offered new print subscribers a discount of over 30% for the first three months followed by automatic renewal at the regular price.
 - (a) Explain how the FT directly discriminates in pricing. Discuss whether the pricing meets the conditions for such discrimination.
 - (b) Suppose that the marginal cost of printing is the same in Hong Kong and Japan. Using suitable demand and cost curves, illustrate the profit maximizing prices and production in the two markets.
 - (c) How does the pricing of print subscriptions exploit individual behavioral biases?
 - (d) Discuss the challenges to discrimination by customer location in the pricing of digital subscriptions.
 - (e) How might locally customized editions address the issues in (d)?

8. In mid-2020, National University of Singapore student Li Zi En and professor Julian Wright carried out a field experiment on an online meal delivery platform. For the same order, iPhone users paid 12 cents or 6% more for delivery than Android users. Those who registered through Google or Facebook paid 38 to 44 cents more than those who registered by email.
 - (a) Why would the platform charge more to iPhone users?
 - (b) Discuss how the platform applied price discrimination.
 - (c) What role did technology play in the price discrimination?
 - (d) If privacy regulators disallow collection of information such as the consumer's brand of smartphone, how would that affect the platform?
9. Qantas sells tickets through travel agents, online intermediaries, as well as its own call center and website. Typically, an airline's cost is lowest for bookings through its own website and highest for bookings through travel agents. Qantas's cheap fare, the Red e-Deal, is only available online.
 - (a) How does technology affect an airline's ability to discriminate on price?
 - (b) Considering Qantas's cost of bookings and travelers' elasticity of demand, explain why the airline only sells the Red e-Deal online.
 - (c) On flight QF422 from Melbourne to Sydney, scheduled for 16 June 2021, Qantas offered the Flex fare for A\$522 and Red e-Deal for A\$383. Explain the difference in pricing.
 - (d) Explain why Qantas limits the number of Red e-Deal fares.

You are the consultant!

Consider some good or service that your organization sells with uniform pricing. Write a memo to the chief financial officer explaining how to increase profit by direct and/or indirect segment discrimination.

Progress check answers

- 8A. $(p - 70)/p = 1/2$, so, price = \$140.
- 8B. It does not extract the entire buyer surplus, and it does not provide the economically efficient quantity.
- 8C. Area $adb = 0.5 \times 2,500 \times (400 - 240) = \$200,000$; area $bec = 0.5 \times 2,500 \times (240 - 80) = \$200,000$.
- 8D. Adults: With the marginal cost of \$100, the marginal cost = marginal revenue at a smaller quantity. At the new quantity, the price would

be higher. Seniors: With the marginal cost of \$100, the marginal cost = marginal revenue at a smaller quantity. At the new quantity, the price would be higher.

- 8E. Buyer surplus of business traveler: unrestricted = \$501 – \$500 = \$1; restricted = \$401 – \$180 = \$221. Buyer surplus of leisure traveler: unrestricted = \$201 – \$500 = –\$299; restricted = \$101 – \$180 = –\$79. The leisure traveler will not buy either the unrestricted fare or the restricted fare. So indirect segment discrimination will not work.
- 8F. Technology reduces the cost of collecting and analyzing consumer information, and also facilitates the differentiation of products to target different customer segments.

Review answers

1. With uniform pricing, the price of a product depends on both the price elasticity of demand and marginal cost. Whether to set a higher price for the private-label merchandise depends on two factors. (a) Since the demand for the private-label is less elastic than branded good, the incremental margin percentage should be higher for the private-label good. (b) However, the marginal cost of the private-label good would be lower than the branded good.
2. $\frac{P-2}{P} = \frac{1}{1.25}$
Hence, price = \$10.
3. No. It should adjust price so that the incremental margin percentage, $(p - 40)/p$, equals the absolute value of the reciprocal of the price elasticity of demand.
4. The pricing method used by the book publishers is cost-plus pricing. It ignores the price elasticity of demand.
5. Complete price discrimination increases profit by resolving two shortcomings of uniform pricing. It extracts the entire buyer surplus by pricing each unit at the buyer's benefit. In addition, it provides the economically efficient quantity, where marginal benefit equals the marginal cost.
6. The two conditions that are necessary to implement complete price discrimination are: (a) Seller must know each potential buyer's individual demand curve; (b) Seller must be able to prevent customers from buying at a low price and reselling to others at a higher price (arbitrage).
7. [Omitted.]

8. False. If the segments are homogeneous, direct segment discrimination yields the same profit as complete price discrimination.
9. Direct segment discrimination, by location.
10. [Omitted.]
11. Those who are renting at the expense of others will be less sensitive to the higher gasoline prices at the car rental agencies and will not spend additional effort to look for cheaper gasoline. The person who makes the buying decision does not have to pay the bill.
12. Coupons can be used to discriminate on price because it takes time and effort to redeem a coupon. To the extent that consumers whose demand is more price elastic are also those whose time is less valuable, they will redeem the coupon and get a lower price.
13. From highest information requirement to lowest: complete price discrimination, direct segment discrimination, indirect segment discrimination, and uniform pricing.
14. Information technology both assists and hinders the seller's ability to discriminate on price. Through the Internet, marketers can collect detailed information on consumer preferences. Furthermore, technology helps to reduce the cost of storing, analyzing, and applying this information, enabling sellers to offer products that better suit customer demand. However, technology has enabled the growth of search services. So, consumers can more easily compare products and prices.
15. Cannibalization occurs when high-benefit segments buy the item aimed at low-benefit segments.

Discussion answers

1. (a) Since banks prefer to source funds from sources other than the London Interbank market, Libor reflects a bank's marginal cost of funds.
- (b) Marginal cost. This is the effect on cost of producing an additional unit. It should be compared with the additional revenue from the additional unit.
- (c) The spread, 0.52%, reflects the difference between price and the marginal cost for the loan (Libor plus an appropriate adjustment for risk). Then, 0.52%, when divided by the total interest rate on the loan, should be equal to the reciprocal of the absolute value of the price elasticity of demand.

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CHAPTER 9

Strategic thinking

LEARNING OBJECTIVES

- Appreciate strategic situations.
- Apply games in strategic form to situations with simultaneous moves.
- Appreciate the use of randomization in competitive situations.
- Distinguish zero-sum from positive-sum games.
- Apply games in extensive form to situations with sequential moves.
- Plan strategic moves and conditional strategic moves, both threats and promises.

9.1 Introduction

Airbus and Boeing dominate the market for medium-size (single-aisle) commercial aircraft with their A320 and 737 families. However, in the 2000s, competitors loomed. Indeed, at the Paris Air Show in June 2011, Jim Albaugh, CEO of Boeing Commercial Airplanes, conceded: “The days of the duopoly with Airbus are over.”

Bombardier, headquartered in Canada, manufactured regional jets (aircraft with up to 120 seats). In 2008, upon securing interest for 60 planes from Deutsche Lufthansa, it began developing the larger CSeries, a family of 100- to 149-seat aircraft. By September 2014, Bombardier had accumulated 203 orders.

Government-owned Commercial Aircraft Corporation of China (COMAC) spearheads the national plan to produce commercial aircraft. In 2006, COMAC launched the C919, a new 150-seat airliner. Within four years, COMAC announced 100 orders, mainly from Chinese airlines. By 2014, COMAC reported 400 cumulative orders from 16 customers.

Empresa Brasileira de Aeronáutica (Embraer) is another manufacturer of regional jets. At the time, it was listed on the Sao Paulo and New York Stock Exchanges. Embraer hesitated to build larger planes. Also at the Paris Air Show, Frederico Curado, CEO, remarked: “Going up against Boeing and Airbus in head-to-head competition is really tough, not only because of their size, but because of their existing product line and industrial capacity.”

How did the difference in ownership between COMAC and Embraer affect their decisions? Why do airplane manufacturers publicize new orders, especially of models under development?

Strategic situation: Where the parties consider interactions with one another in making decisions.

Strategy: A plan for action in a strategic situation.

The situation among Airbus, Boeing, and other manufacturers is *strategic*. A **strategic situation** is one where the parties consider interactions with one another in making decisions. Airbus and Boeing watch each other closely, as well as Bombardier, COMAC, and Embraer. A **strategy** is a plan for action in a strategic situation.

This chapter explains how to organize thinking and make more effective strategic decisions, based on a set of principles called *game theory*. The first set of principles is the model of games in *strategic* form, which applies to situations where parties choose strategies at the same time. COMAC and Embraer could each apply a game in strategic form in its decision whether to produce a medium-size jet.

The second set of principles is the model of games in *extensive* form, which applies to situations where parties act in sequence. Applying a game in extensive form, Embraer could appreciate that, through government support and the orders for 400 planes, COMAC had established a first-mover advantage. COMAC would be more likely to produce the new aircraft even if Embraer entered the market.

The principles of game theory guide decision-making in many strategic situations. Investment bankers apply game theory in leveraged buyouts and takeovers. Unions apply game theory in bargaining with employers. And, of course, game theory is useful to any business with market power in deciding competitive strategy.

Progress check 9A. The button manufacturing industry is almost perfectly competitive. Your company is deciding whether to manufacture buttons. Explain why this decision is not strategic.

9.2 Nash equilibrium

To introduce a framework for situations where parties choose strategies at the same time, consider the following example. Jupiter and Saturn operate adjacent gasoline stations. Each station independently decides its price. Should Jupiter maintain or cut price? What about Saturn?

The situation between Jupiter and Saturn is clearly strategic. Consumers are price sensitive and would switch to the station offering a lower price. Jupiter’s sales and profit depend on Saturn’s price, and likewise, Saturn’s sales and profit depend on Jupiter’s price. How should Jupiter act?

Let us clarify Jupiter’s position in the following way. Jupiter has a choice of two strategies – maintain price or cut price. Likewise, Saturn has a choice of the same two strategies. In Table 9.1, mark Jupiter’s strategies along the rows, and Saturn’s strategies along the columns. The columns and rows delineate four cells. Each cell describes one outcome.

Table 9.1 Gasoline stations: price war

		Saturn	
		Maintain price	Cut price
Jupiter	Maintain price	J: 1,000 S: 1,000	J: 700 S: 1,300
	Cut price	J: 1,300 S: 700	J: 800 S: 800

In each cell, the first entry is Jupiter’s daily profit and the second entry is Saturn’s daily profit. For instance, in the cell where both Jupiter and Saturn maintain price, “J: 1,000” and “S: 1,000” mean that Jupiter’s profit would be \$1,000, while Saturn’s profit would be \$1,000. Similarly, in the cell where Jupiter cuts price and Saturn maintains price, “J: 1,300” and “S: 700” mean that Jupiter’s profit would be \$1,300, while Saturn’s profit would be \$700.

Table 9.1 is called a **game in strategic form**. It helps to organize thinking about strategic decisions that parties must take simultaneously.

Let us use the game in strategic form to consider how Jupiter should act. First, look at the situation from Saturn’s position. If Jupiter maintains price, then Saturn will earn \$1,000 if it maintains price or \$1,300 if it cuts price, so Saturn prefers to cut price. Now, if Jupiter cuts price, then Saturn will earn \$700 if it maintains price or \$800 if it cuts price, so, Saturn prefers to cut price.

Hence, regardless of Jupiter’s move, Saturn should cut price. For Saturn, the strategy of maintaining price is *dominated* by the strategy of cutting price. A strategy is **dominated** if it generates worse consequences than some other strategy, regardless of the other party’s choices. It makes no sense to adopt a dominated strategy.

For Saturn, maintaining price is a dominated strategy. Accordingly, Jupiter can guess that Saturn will cut price. Similarly, by studying the situation from Jupiter’s position, it is easy to see that, for Jupiter also, maintaining price is a dominated strategy. Hence, Jupiter also should cut price.

This situation is an example of the *prisoner’s dilemma*. Each station knows that, if they both maintain price, then they would earn higher profit. However, when each station acts independently, it will cut price. The final outcome is that both stations earn less profit.

Definition

The pair of strategies – Jupiter to cut price and Saturn to cut price – is the obvious way for the two stations to act. Moreover, this pair of strategies is a stable situation in the following sense. Even if Saturn knows that Jupiter will cut price, Saturn’s best action is to cut price, so it will not change its strategy. Likewise, even if Jupiter knew that Saturn would cut price, Jupiter would still cut price.

Game in strategic form: Depicts one party’s strategies in rows, other party’s strategies in columns, and consequences in corresponding cells.

Dominated strategy: Generates worse consequences than some other strategy, in all circumstances.

Nash equilibrium:
Given that the other parties choose their Nash equilibrium strategies, each party prefers its own Nash equilibrium strategy.

In a game in strategic form, a **Nash equilibrium** is a set of strategies such that, given that the other parties choose their Nash equilibrium strategies, each party prefers its own Nash equilibrium strategy. In the Nash equilibrium, no party can become better off by changing strategy. Among the gasoline stations, the pair of strategies in which both Jupiter and Saturn cut price is a Nash equilibrium.

What justifies a Nash equilibrium as a reasonable way for the relevant parties to act? The Nash equilibrium strategies are stable in the sense that, if other parties choose their Nash equilibrium strategies, each party prefers its own Nash equilibrium strategy. Equivalently, in the Nash equilibrium, no single party can benefit by deviating to another strategy.

Moreover, in many strategic situations, the Nash equilibrium strategies seem the most reasonable and obvious way to act. This suggests that in other settings, the relevant parties should also adopt Nash equilibrium strategies.

Solving equilibrium – formal method

How should parties solve a game in strategic form for the Nash equilibrium? The formal solution for a Nash equilibrium is, first, to rule out dominated strategies and, next, to check all the remaining strategies, one at a time.

The competition among the gasoline stations is easy to solve. First, rule out the dominated strategies: for Jupiter, maintaining price is dominated, and for Saturn, maintaining price is dominated. Then each station has only one strategy left – to cut price – so that must be the equilibrium.

To illustrate the Nash equilibrium in another setting, consider a contest between aircraft manufacturers Luna and Solis to develop and produce a new medium-size jet. Market research shows that there is sufficient demand for only one new aircraft.

Table 9.2 presents the game in strategic form. Each manufacturer has two strategies: produce or not produce. Each cell presents the profits of Luna and Solis in billions of dollars.

Recall that the solution for a Nash equilibrium is, first, to rule out dominated strategies and, next, to check all the remaining strategies, one at a time.

First, look at the situation from Luna’s position. If Luna produces, then Luna would lose \$1 billion if Solis produces and earn \$2 billion if Solis does not produce. If Luna

Table 9.2 Medium-size jet

		Solis	
		Produce	Not produce
Luna	Produce	L: -1 ↓ S: -1	L: 2 ↑ S: 0
	Not Produce	L: 0 ↓ S: 2	L: 0 ↑ S: 0

does not produce, then Luna would earn nothing if Solis produces and also earn nothing if Solis does not produce. For Luna, neither strategy is dominated.

Similarly, if we examine the situation from Solis's position, we see that neither strategy is dominated. Going through the strategies, we find two equilibria. In one, Luna produces while Solis does not, and in the other, Luna does not produce while Solis produces. In this game, the outcome is ambiguous.

Solving equilibrium – informal method

A simple, informal method of finding a Nash equilibrium is to draw arrows between the cells as follows. Suppose that Luna produces, then for Solis draw an arrow from “S: -1” in the top left-hand cell to “S: 0” in the top right-hand cell (this arrow represents Solis preferring not to produce). Next, suppose that Luna does not produce, then for Solis draw an arrow from “S: 0” in the bottom right-hand cell to “S: 2” in the bottom left-hand cell (this arrow represents Solis preferring to produce).

Now, suppose that Solis produces, then for Luna draw an arrow from “L: -1” in the top left-hand cell to “L: 0” in the bottom left-hand cell (this arrow represents Luna preferring not to produce). Finally, suppose that Solis does not produce, then for Luna draw an arrow from “L: 0” in the bottom right-hand cell to “L: 2” in the top right-hand cell (this arrow represents Luna preferring to produce).

This “arrow” technique reveals if a strategy is dominated. A strategy is dominated if the row or column which represents the strategy has all the arrows pointing out towards another strategy. In Table 9.2, there are no dominated strategies.

The arrow technique also easily identifies an equilibrium. If there is a cell with all arrows leading in, then the strategies marking that cell are a Nash equilibrium. There are two Nash equilibria. In one, Luna produces while Solis does not, and in the other, Luna does not produce while Solis produces.

Non-equilibrium strategies

We have explained how to analyze a strategic situation using the concept of a Nash equilibrium. Given that the other players choose their Nash equilibrium strategies, each party's best choice is its own Nash equilibrium strategy. But what if some party does not follow its Nash equilibrium strategy? Then the other parties may find it better to deviate from their respective Nash equilibrium strategies.

However, if the alternative to the Nash equilibrium strategy is a dominated strategy, then the Nash equilibrium strategy is better, even if the other party does not follow its Nash equilibrium strategy.

Progress check 9B. In Table 9.1, use the arrow technique to identify the Nash equilibrium strategies.

9.3 Randomized strategies

When the various parties act strategically, it seems reasonable for them to choose Nash equilibrium strategies. In some situations, however, there is no Nash equilibrium of the type that we have been considering.

To illustrate, suppose that Table 9.3 represents the competitive situation between the two gasoline stations. The change from the original scenario is that Jupiter has a segment of loyal customers, so, if Saturn cuts price, Jupiter earns more by maintaining price.

Pure strategy:
Does not involve randomization.

By applying the arrow technique to Table 9.3, we can see that there is no Nash equilibrium in *pure strategies*: no cell has all the arrows leading inward. A **pure strategy** is one that does not involve randomization. In Table 9.3, Jupiter has two pure strategies, maintain price and cut price, and Saturn also has two pure strategies, maintain price and cut price.

Although there is no Nash equilibrium in pure strategies, there is another way for Jupiter and Saturn to act. Essentially, Jupiter does not want Saturn to know or predict its price. One way is to *randomize* the choice between maintaining and cutting price. If Jupiter randomizes its strategy, even it will not know its price, and of course, Saturn would not know either. Similarly, Saturn does not want Jupiter to know or predict its price. If Saturn randomizes its price, Jupiter cannot guess or learn it.

Randomized strategy: Choose each pure strategy according to a specified probability.

With a **randomized strategy**, the party specifies a probability for each of the alternative pure strategies. It then adopts each pure strategy randomly according to the probabilities. The probabilities must add up to 1.

Nash equilibrium in randomized strategies

Suppose that Jupiter adopts the following randomized strategy: maintain price with probability 1/2 and cut price with probability 1/2. To implement this strategy, Jupiter’s manager marks a coin “maintain price” on one side and “cut price” on the other side, then gives the coin to the pump attendant. Jupiter then orders the pump attendant to toss the coin and fix the price according to which side of the coin faces up.

Given that Jupiter has chosen this randomized strategy, how should Saturn act? Referring to Table 9.3, let us calculate the expected profit for Saturn from maintaining price. Saturn’s profit would be \$900 if Jupiter maintains price, and \$500 if Jupiter cuts

Table 9.3 Gasoline stations: price war (modified)

		Saturn	
		Maintain price	Cut price
Jupiter	Maintain price	J: 900 ↓ S: 900	J: 1,000 ↑ S: 800
	Cut price	J: 1,300 ↓ S: 500	J: 600 ↑ S: 600

price. Hence, Saturn's expected profit from maintaining price is $(\$900 \times 1/2) + (\$500 \times 1/2) = \$700$. Similarly, we can calculate that, if Saturn cuts price, its expected profit would be $(\$800 \times 1/2) + (\$600 \times 1/2) = \$700$.

What should Saturn do? Note that Saturn gets the same expected profit from the two pure strategies, maintain price and cut price. Hence, it is indifferent between two pure strategies, and so, it would be willing to randomize between them. Specifically, suppose that Saturn maintains price with probability $1/2$.

How will Jupiter act? If Jupiter maintains price, its expected profit would be $(\$900 \times 1/2) + (\$1,000 \times 1/2) = \$950$. Similarly, if Jupiter cuts price, its expected profit would be $(\$1,300 \times 1/2) + (\$600 \times 1/2) = \$950$. Therefore, given Saturn's strategy, Jupiter is indifferent between maintaining and cutting price.

A Nash equilibrium in randomized strategies is like a Nash equilibrium in pure strategies: given that the other players choose their Nash equilibrium strategies, each party's best choice is its own Nash equilibrium strategy. The following randomized strategies constitute a Nash equilibrium in the (modified) gasoline station price war: Jupiter maintains price with probability $1/2$ and Saturn maintains price with probability $1/2$ (see Appendix 9.A).

Why randomize?

Suppose that Jupiter has adopted the Nash equilibrium strategy of maintaining price with probability $1/2$. Suppose further that Saturn knows Jupiter's strategy. How can Saturn exploit this information? The answer is that it cannot – as we have calculated earlier, whether Saturn maintains or cuts price, its expected profit will be \$700. Generally, whenever a party adopts a Nash equilibrium strategy, the other parties cannot benefit from learning the strategy.

Randomization is useful in competitive contexts. The advantage of randomization comes from its being *unpredictable*. To implement the randomized strategy, Jupiter must leave its strategy to the coin toss. Jupiter must not make any conscious decision on pricing. If it decides in a conscious way, Saturn may be able to guess or learn Jupiter's decision and act accordingly.

Progress check 9C. Referring to Table 9.3, suppose that Jupiter maintains price with probability $2/5$. Calculate the expected profit for Saturn if it: (a) maintains price; and (b) cuts price.

Supermarkets: price high or low?

Supermarket chains Giant and Sheng Siong cater to the mass market in Singapore. On 21 May 2021, Sheng Siong cut the price of Golden

Pineapple rice to S\$12.50 for four weeks. On 3 June 2021, Giant discounted Golden Eagle rice to S\$12.90 for one week.

Supermarkets are torn between pricing high to extract buyer surplus from loyal consumers and pricing low to grab price-sensitive consumers. The dilemma is compounded in the presence of competition. Cutting price may not raise profit if a competitor also cuts price.

The solution is to randomize the price discounts. Indeed, the dazzling array of supermarket promotions do appear like randomized discounts. By discounting randomly, a supermarket can attract price-sensitive consumers while avoiding competitors undercutting on price.

9.4 Competition or coordination

Zero-sum game:

One party can be better off only if another is worse off.

Positive-sum game:

One party can be better off without another being worse off.

Strategic situations can be classified by their outcomes as either zero-sum games or positive-sum games. A **zero-sum game** is one where one party can become better off only if another is made worse off. If the outcomes for the parties add up to the same number (whether negative, zero, or positive) in every cell of the game in strategic form, then one party can become better off only if another is made worse off. Such a strategic situation is a zero-sum game. A zero-sum game characterizes the extreme of *competition*: there is no way for all parties to become better off.

By contrast, a **positive-sum game** is one where one party can become better off without another being made worse off. It involves at least some element of *coordination*. For instance, in the gasoline station price war (Table 9.1), both Jupiter and Saturn could agree that both maintaining price is better than both cutting price. However, the challenge for them is to enforce the agreement. Each station, acting independently, would cut the price.

Some situations involve elements of both competition and coordination. In the contest over medium-size jets (Table 9.2), the total profit of the two manufacturers is not a constant. It is largest when one produces and the other does not. The contest is a positive-sum game.

While the contest involves coordination, it also has an element of competition. Both manufacturers will be better off if they choose different strategies. But one would benefit relatively more – the manufacturer which produces. Accordingly, there are elements of competition (to produce) as well as coordination (choosing different strategies).

Progress check 9D. Check whether the modified gasoline station price war (Table 9.3) is a zero-sum game.

Roger Federer: Wimbledon champion

Championship tennis is a zero-sum game. Every match ends with a winner and a loser. Eight-time Wimbledon champion Roger Federer wins through strategy rather than power.

Federer's service gives his opponent minimal time to prepare. He turns away from his opponent, and always tosses the ball in the same way. Essentially, Federer randomizes his service. American Andy Roddick famously lamented, "I could never read Roger's serve."

9.5 Sequencing

So far, we have focused on situations where the various parties move simultaneously. What if the parties move one at a time? To organize thinking about strategic situations in which the parties act in sequence, we use the *game in extensive form*.

A **game in extensive form** explicitly depicts the sequence of moves and the corresponding outcomes. It consists of nodes and branches: a node represents a point at which a party must choose a move, while the branches leading from a node represent the possible choices at the node.

Let us apply the game in extensive form to the contest over medium-size jets (Table 9.2) assuming that Solis can decide whether to produce before Luna. In Figure 9.1, at the first node, A, Solis must choose between producing (the upper branch) and not producing (the lower branch).

Luna has the next move. If Solis chooses to produce, then Luna will be at node B and must decide between produce and not produce. If Solis chooses not to produce, then Luna will be at node C and must decide between produce and not produce.

The consequences for Luna depend on Solis's choice. At the end of each branch, we mark the profits to Solis and Luna, respectively. If Solis produces and Luna also

Game in extensive form: Depicts the sequence of moves and corresponding outcomes.

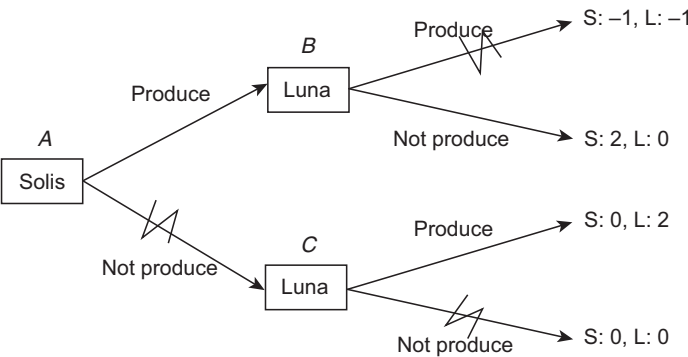


Figure 9.1 Medium-size jets: extensive form

produces, they both lose \$1 billion. If Solis produces while Luna does not, then Solis earns \$2 billion and Luna earns nothing. If Solis does not produce while Luna does, then Solis earns nothing and Luna earns \$2 billion. Finally, if neither manufacturer produces, then each earns nothing.

Backward induction

Backward induction:

Look forward to final nodes and reason backward toward the initial node.

How should the two manufacturers act? We solve the game in extensive form by **backward induction**, which means looking forward to the final nodes and reasoning backward toward the initial node.

There are two final nodes: *B* and *C*. At node *B*, Luna can produce, which yields a loss of \$1 billion, or not produce, which yields nothing. Clearly, at node *B*, Luna would choose not to produce. Accordingly, we cancel the produce branch. Now consider node *C*. Here, Luna must choose between produce, which yields \$2 billion, and not produce, which yields nothing. It will choose to produce, so we cancel the not produce branch.

Having determined how Luna will choose at the possible nodes, *B* and *C*, we work back to the initial node, *A*. There, if Solis chooses to produce, it can foresee that Luna will not produce, so Solis will earn \$2 billion. On the other hand, if Solis chooses not to produce, it can foresee that Luna will produce, so Solis will earn nothing. Therefore, Solis should choose to produce, and then Luna will not.

Equilibrium strategy

Equilibrium strategy:

The sequence of best actions, with each action decided at the corresponding node.

In a game in extensive form, a party's **equilibrium strategy** consists of a sequence of its best actions, where each action is decided at the corresponding node. When Solis can move first, its equilibrium strategy is to produce, while Luna's equilibrium strategy is not to produce.

What if Luna can move first? Then the game in extensive form would be like Figure 9.1, except that Luna would choose at node *A*, and Solis would choose at node *B* or *C*. Then Luna's equilibrium strategy would be to produce, and Solis's equilibrium strategy would be not to produce.

Practically, what is the difference between the equilibrium strategy in a game in extensive form and the Nash equilibrium strategy in a game in strategic form? In the case of the medium-size jets, when the two manufacturers move simultaneously, there are two Nash equilibria in pure strategies (plus one in randomized strategies).

But when the manufacturers move in sequence, there is only one equilibrium. The equilibrium in the extensive form is also a Nash equilibrium in the strategic form. In other situations, however, the equilibrium in the extensive form might not be a Nash equilibrium in the strategic form.

Accordingly, when analyzing a strategic situation, it is important to consider carefully the structure of the moves: do the parties move simultaneously or sequentially? The equilibria with simultaneous moves and with sequential moves may be different.

First-mover advantage

When Solis can move first, its equilibrium strategy is to produce, while Luna's equilibrium strategy is not to produce. When Luna can move first, its equilibrium strategy is to produce, while Solis's equilibrium strategy is not to produce. In this situation, the party which moves first gains an advantage.

There is **first-mover advantage** in any strategic situation where one party gains advantage by moving before others. Analyzing the game in extensive form reveals whether the first mover has an advantage.

First-mover advantage: One party gains advantage by moving before others.

Progress check 9E. In the gasoline station price war (Table 9.1), does Saturn have first-mover advantage? Why or why not?

COMAC: first mover

In the market for a new medium-size jet, the government of China funds COMAC. Also, COMAC aggressively signed up customers. If COMAC could convince Embraer that it is committed to produce, it might persuade Embraer to keep out of the market.

First-mover advantage is a concept that is much emphasized in corporate strategy. However, it is not a universal rule in strategic situations. For instance, to launch a new product category, such as driverless cars, the pioneer must invest in infrastructure and educate consumers. Other sellers can piggyback on the pioneer's investment and introduce their products at lower cost.

9.6 Strategic move

In the contest between the aircraft manufacturers over medium-size jets, the first mover has an advantage. Each manufacturer would like to move first and commit to produce.

Suppose that Solis moves first, but Luna outsources the development of the new plane and pays the vendor a non-refundable lump sum of \$1.5 billion. Figure 9.2 illustrates the game in extensive form (modified from Figure 9.1).

We analyze by backward induction. At node *B*, if Luna produces, it will lose \$1 billion, but if it does not produce, it will lose even more, \$1.5 billion, so, it will produce. At node *C*, Luna will produce. At node *A*, Solis will anticipate that, if it produces, Luna will produce, and Solis will incur a loss of \$1 billion. If it does not produce, Luna will produce, and Solis will earn nothing.

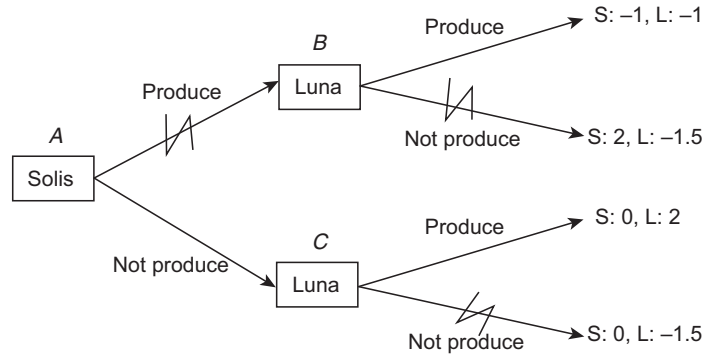


Figure 9.2 Medium-size jets (modified)

Thus, in equilibrium, Solis will not produce and earn nothing, while Luna will produce and earn \$2 billion. By sinking the cost of developing the new plane, Luna nullifies Solis's first-mover advantage.

Luna's use of the sunk cost is a *strategic move*. A **strategic move** is an action to influence the beliefs or actions of other parties in a favorable way. In order to influence the other parties, the strategic move must be credible.

Strategic move: An action to influence beliefs or actions of other parties in a favorable way. To be effective, a strategic move must be credible.

Airbus vs Boeing: strategic moves

Until 2017, Airbus's product line comprised aircraft with 150 to 240 seats. Then, Airbus bought half of Bombardier's CSeries business, and so extended its products to include smaller 100- to 150-seat planes.

In July 2018, Airbus rebranded the CSeries as the A220 in conjunction with an order of 60 planes from JetBlue. JetBlue would replace Embraer 190s with the new planes and create an all-Airbus fleet. With the A220, Airbus closed a gap that competitors might exploit to engage JetBlue and then upsell larger planes.

Meanwhile, Boeing agreed to buy 80% of Embraer's commercial aircraft business for US\$4.2 billion. The deal would have extended Boeing's product line to regional jets and added engineering resources.

However, following two crashes of the 737Max and the Covid-19 outbreak, Boeing abandoned the deal. Besides financial constraints, another reason might have been strategic. Bombardier sold its regional jet business to Mitsubishi Heavy Industries of Japan rather than Airbus.

Sunk costs: no turning back

In 207 BCE, Xiang Yu, Marquis of Lu, led a small force to attack the larger Qin army at Julu. Upon crossing the Zhang river, Xiang Yu famously gave the order to sink all the boats and destroy the cooking utensils. He distributed just three days' rations to the soldiers.

In 1519, the Spanish conquistador, Hernando Cortés, led a small expedition from Cuba against the Aztec Empire in Mexico. After landing at Veracruz, some members wanted to turn back. Cortes ordered his men to dismantle their ships and use the materials in the landward advance.

By cutting off the means of retreat, both Xiang Yu and Cortés persuaded (or compelled) their soldiers to fight harder. Both generals succeeded despite their forces being outnumbered. Xiang destroyed the Qin army and Cortés conquered Mexico.

9.7 Conditional strategic move

A more accurate name for an action like Luna outsourcing the development of the new plane is an *unconditional strategic move* because the action always takes place. An unconditional strategic move usually involves a cost under all circumstances.

By contrast, a **conditional strategic move** is an action under specified conditions to influence the beliefs or actions of other parties in a favorable way. Conditional strategic moves are more cost-effective than unconditional strategic moves to the extent that the action need not actually be carried out. Conditional strategic moves take two forms – promises and threats.

Conditional strategic move:

An action under specified conditions to influence the beliefs or actions of other parties in a favorable way.

Promise

A **promise** conveys benefits, under specified conditions, to influence the beliefs or actions of other parties in a favorable way. To illustrate, suppose that, in the contest over medium-size jets, the government promises Luna to reimburse 110% of any losses on developing and producing a new airplane.

Figure 9.3 depicts the game in extensive form. Relative to the original game, the only change is at node *B*, if Solis produces and Luna also produces. Then, Luna would lose \$1 billion but would receive \$1.1 billion from the government, and so Luna would earn \$0.1 billion. Hence, at node *B*, Luna would produce.

At node *A*, looking forward, Solis would choose not to produce. Hence, the government's promise nullifies Solis's first-mover advantage. In the new equilibrium, Solis does not produce and Luna produces. Then Luna would earn \$2 billion and the government need not pay anything on the promise.

Promise:

Conveys benefits, under specified conditions, to change the beliefs or actions of other parties in a favorable way.

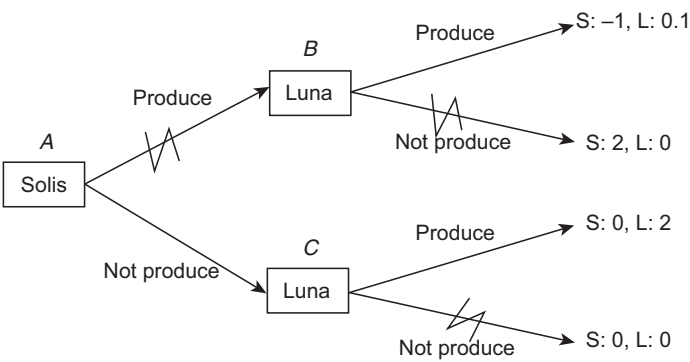


Figure 9.3 Medium-size jets: promise

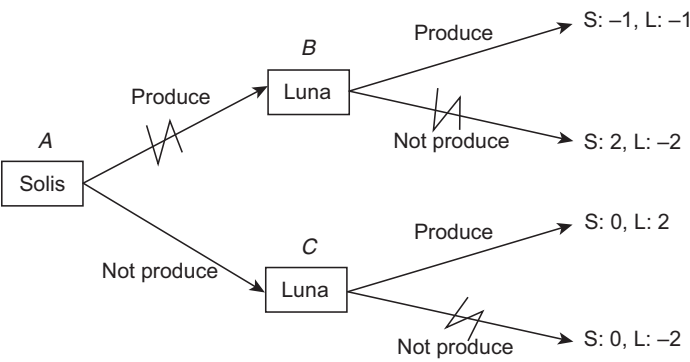


Figure 9.4 Medium-size jets: threat

Threat

Threat: Imposes costs, under specified conditions, to change the beliefs or actions of other parties in a favorable way.

A **threat** imposes costs, under specified conditions, to influence the beliefs or actions of other parties in a favorable way. To illustrate, suppose that the government threatens to fine Luna \$2 billion if it does not develop and produce a new airplane.

Figure 9.4 depicts the game in extensive form. Relative to the original game, the outcomes change if Luna does not produce. At node B, if Luna does not produce, it will lose \$2 billion, so Luna will choose to produce. At node C, if Luna does not produce, it will lose \$2 billion, so Luna will choose to produce.

At node A, looking forward, Solis would choose not to produce. Hence, the government's threat nullifies Solis's first-mover advantage. In the new equilibrium, Solis does not produce and Luna produces. Then Luna would earn \$2 billion and the government need not carry out the threat.

Progress check 9F. Suppose that the government threatens to fine Luna \$500 million if it does not develop and produce the new airplane. What is the equilibrium?

Embraer: worried by Airbus and Boeing

As of the Paris Air Show in June 2011, Embraer had not yet decided to produce a medium-size jet to compete with the Airbus A320 and Boeing 737. Embraer CEO Frederico Curado remarked: "Going up against Boeing and Airbus in head-to-head competition is really tough.... They can have a very quick response and literally flood the market."

Airbus and Boeing could develop new models at relatively lower cost, taking advantage of economies of scope from existing models. Indeed, both Airbus and Boeing increased production of their existing models. Curado might have interpreted these increases as a threat, hence his worry about "flood[ing] the market."

WarnerMedia + Discovery: break-up fee

In May 2021, telecommunications giant AT&T agreed to spin off WarnerMedia and combine it with Discovery. The new company would have an enterprise value of US\$132 billion, including US\$56 billion in debt. It was expected to yield synergies of US\$3 billion per year.

The agreement stipulated that, if AT&T terminated the deal, it must pay US\$1.77 billion to Discovery, while if Discovery terminated the deal, it must pay US\$720 million to AT&T. The termination fees were promises that served as threats to other potential bidders. If another company tried to acquire Discover, they must pay US\$720 million to AT&T.

Key takeaways

- A situation is strategic if the parties consider interactions with one another in making decisions.
- Never use a dominated strategy.
- In a situation of simultaneous moves, a Nash equilibrium strategy is stable in the sense that, if other parties choose their Nash equilibrium strategies, each party prefers its own Nash equilibrium strategy.

- In competitive situations, it may help to randomize.
- Zero-sum games characterize extreme competition: one party can be better off only if another is worse off.
- In a situation of sequential moves, plan by looking forward to the final nodes and reasoning backward toward the initial node.
- Use strategic moves to influence the beliefs or actions of other parties in a favorable way. To be effective, they must be credible.
- If possible, use conditional strategic moves, both threats and promises, as they are more cost-effective than unconditional strategic moves.

Review questions

1. In situations of (a) perfect competition and (b) monopoly, does it matter whether the seller acts strategically?
2. Explain why you should not use a dominated strategy.
3. Why should you use a Nash equilibrium strategy?
4. If others do not act strategically (for instance, they use a non-equilibrium strategy), should I follow?
5. Explain the meaning of a randomized strategy.
6. Some right-handed boxers also train themselves to box with their left hands. Which of the following strategies will be more effective? (a) Throw a left-hand punch after every three right-handers. (b) Box mainly with the right hand and throw a left-hand punch at random.
7. Explain the relations between: (a) zero-sum game and competition; and (b) positive-sum game and coordination.
8. In a game in strategic form, the consequences to the two players in every cell add up to -10 . Is this a zero-sum game?
9. In analyzing a strategic situation, why should we consider the timing of actions?
10. In a game in extensive form, what is wrong with planning by reasoning forward from the initial node?
11. What is first-mover advantage? How can you identify it?
12. Why are conditional strategic moves better than unconditional strategic moves?
13. Suppose a bank offers deposit insurance to its depositors, with the compensation to be paid from its own funds. Why is this not credible?
14. In bargaining, a common tactic is to “walk away.” Is this credible?
15. Loan sharks are not allowed to use the legal system to collect debts. Does this explain why they employ violence?

Discussion questions

1. Angela and Maggie stole a car and have been caught by the police. Detective Lenny Briscoe does not have sufficient evidence to convict them of auto theft. He ushers Angela and Maggie into separate interview rooms and offers each a \$1,000 reward for a confession if the other suspect does not confess. Each suspect knows that if neither confesses, they will be let off. If only one confesses, they will get the \$1,000 reward, while the other will be jailed for one year. If both confess, each will be jailed for one year.
 - (a) Construct a game in strategic form to analyze the choices of Angela and Maggie between confessing and not confessing.
 - (b) Identify the equilibrium/equilibria.
 - (c) Compare this situation to the gasoline station price war in Table 9.1.
2. The National Collegiate Athletic Association (NCAA) limits pay to student athletes.
 - (a) Suppose that Ivy and State choose between obeying NCAA rules and paying more to attract better players. If both colleges obey NCAA rules, each would earn \$30 million. If one pays more while the other obeys NCAA rules, they would earn \$50 million and \$10 million respectively. If both colleges pay more, they would merely increase their costs and each would earn \$20 million. Construct a game in strategic form and identify the equilibrium/equilibria.
 - (b) By law, the NCAA can punish colleges that breach the NCAA rules. How would this affect the equilibrium/equilibria?
 - (c) Explain which of the following concepts best describes the NCAA rules on player salaries: (i) monopoly; (ii) monopsony; (iii) economies of scale; (iv) economies of scope.
3. Supermarket chains Giant and Sheng Siong cater to the mass market in Singapore. On 21 May 2021, Sheng Siong cut the price of Golden Pineapple rice to S\$12.50 for four weeks. On 3 June 2021, Giant discounted Golden Eagle rice to S\$12.90 for one week.
 - (a) Construct a game in strategic form as follows. Each supermarket chooses between maintaining and cutting the price of rice. If both maintain price, each would earn \$30,000. If one cuts price while the other maintains price, they would earn \$35,000 and \$25,000 respectively. If both cut price, each would earn \$20,000.
 - (b) Is this a zero or positive-sum game?
 - (c) Find the Nash equilibrium/equilibria in pure strategies, if they exist.
 - (d) Verify that the following is a Nash equilibrium in randomized strategies: each supermarket maintains price with probability $1/2$.

4. On 19 May 2012, the UEFA Champions League final between Bayern Munich and Chelsea was decided by a penalty shoot-out. Manuel Neuer took Bayern's third kick with Chelsea goalkeeper Petr Čech defending.
 - (a) Construct a game in strategic form as follows. Neuer chooses among kicking to the left, center, or right. Čech chooses among blocking the left, center, or right. If Neuer scores, Bayern wins one point while Chelsea loses one point. If Čech succeeds in blocking, both teams get zero.
 - (b) Is this a zero or positive-sum game?
 - (c) Find the Nash equilibrium/equilibria in pure strategies, if they exist.
 - (d) Verify that the following is a Nash equilibrium in randomized strategies: each player plays left/center/right with probability $1/3$.

5. Nasdaq-listed 51job provides human resource services in China. In 2020, its revenues, cost of services, and operating expenses were 3.69, 1.26, and 1.56 billion yuan respectively, and operating income was 867 million yuan. The company was financed with 12.40 billion yuan of equity and no debt. In May 2021, CEO Rick Yan and two private equity firms offered to buy 51job at US\$79.05 per share, or 29% above the last closing price. The company had 67.1 million shares outstanding.
 - (a) Construct a game in extensive form as follows. Initially, the private equity group decides whether to acquire 51job and recapitalize the company with 9 billion yuan of debt at a 10% interest rate. Then, management chooses between working as usual and cutting operating expenses by X million yuan. Assume that revenues and cost of services do not change, and net income equals operating income minus interest expense.
 - (b) Suppose that, if the private equity group acquires 51job and the company's net income is negative, management would be fired. Explain by how much management would cut operating expenses.
 - (c) Discuss how the leveraged buyout works as a strategic move to cut costs.

6. The Bulgarian central bank has committed to exchange euros for leva at the fixed rate of 1.95583 leva to one euro. As of May 2021, the central bank had issued 22.1 billion leva of currency, and held foreign assets worth 54.2 billion leva. Local currency is more convenient for daily use than euros.
 - (a) Construct a game in extensive form as follows. Initially, Zhivkov chooses between redeeming leva for euros and not redeeming. Then, the central bank either has sufficient assets to meet the redemption, or has insufficient assets and becomes insolvent.
 - (b) As of May 2021, would Zhivkov redeem his leva?
 - (c) Suppose that the central bank has issued 60 billion leva of currency. Explain how Zhivkov's decision whether to redeem depends on his beliefs about whether others would redeem.

7. In early June 2021, Mexican cement manufacturer Cemex planned to issue hybrid US dollar bonds. At the time, Cemex was rated below investment grade. The interest rate on the bonds would step up by 25 basis points after 5.25 years, and another 75 basis points after 15 years. However, the second step up would be delayed by five years if Cemex is re-rated to investment grade.
 - (a) Construct a game in extensive form as follows. Initially, in year 6, Cemex must choose between two plans until year 10. The safe plan would increase profit contribution by US\$5 million per year. The risky plan would increase interest payment by US\$3.75 million per year. It would increase profit contribution by US\$20 million per year but only with probability half. (*Hint: If Cemex chooses the risky plan, mark a circular node and branches leading to increase or no increase in profit contribution.*)
 - (b) Calculate Cemex's change in profit per year in each possible outcome.
 - (c) Explain how you would choose between the two plans.
 - (d) Explain how the possible delay in the second step up works as a conditional strategic move to motivate Cemex to avoid risks.
8. In May 2021, telecommunications giant AT&T agreed to spin off WarnerMedia and combine it with Discovery. The new company would have an enterprise value of US\$132 billion and was expected to yield synergies of US\$3 billion per year. The agreement stipulated that if Discovery terminated the deal, it must pay US\$720 million to AT&T.
 - (a) Construct a game in extensive form as follows. Initially, Discover decides whether to agree the US\$720 million termination fee or not. Then, a potential bidder decides whether or not to bid for Discover. If it does bid, earns profit contribution of US\$P million but incurs a cost US\$50 million and must pay the termination fee to AT&T. At each outcome, write the bidder's profit.
 - (b) Compare the minimum profit contribution that the bidder must expect for it to bid if Discover agrees or does not agree to the termination fee.
 - (c) Considering such competing bids, should Discover shareholders demand a lower or higher termination fee?
9. In the early 2010s, COMAC and Embraer were poised to enter the market for medium-size jets. Suppose that Table 9.2 represents their strategies and profits if they act simultaneously. (Replace Luna and Solis with COMAC and Embraer respectively.)
 - (a) Using a suitable game in extensive form, show that this is a situation of first-mover advantage.
 - (b) Suppose that the government of China promises to reimburse COMAC 120% of any losses on developing and producing a new jet. How does that affect the equilibrium/equilibria in (a)?
 - (c) Explain how much the Chinese government should budget for the promise.

You are the consultant!

Consider some strategic situation – between your organization and a competitor, between your organization and a supplier or customer, or even between you and a rival at work. Apply a game in strategic form or extensive form to plan your strategy.

Progress check answers

- 9A. In perfect competition, there are so many producers that decisions made by a single producer do not affect others. Any increase in the production of buttons (by your company) will not affect the market price, so this decision is not strategic.
- 9B. The Nash equilibrium is for both Jupiter and Saturn to cut price.
- 9C. (a) If Saturn maintains price, its expected profit is $(2/5 \times \$900) + (3/5 \times \$500) = \$660$.
- (b) If Saturn cuts price, its expected profit is $(2/5 \times \$800) + (3/5 \times \$600) = \$680$.
- 9D. Positive-sum game. The sums of the outcomes for the parties are different (between 1,200 and 1,800) in the various cells of the game in strategic form.
- 9E. Saturn does not gain any advantage by moving first. The equilibrium is the same – both cut price – whether Saturn or Jupiter moves first.
- 9F. If Solis produces, Luna would not produce (it would rather lose \$500 million than \$1 billion). Hence the equilibrium is still for Solis to produce and Luna not to produce.

Review answers

- (a) In perfect competition, there are so many sellers that decisions made by a single player would not affect others. So, a seller cannot act strategically. (b) In monopoly, there is only one seller. However, it must consider potential entrants to its market. Therefore, it has to act strategically.
- A dominated strategy generates worse consequences than some other strategy, *regardless* of the other parties' choices. Therefore, we should not adopt a dominated strategy.

3. The Nash equilibrium strategies are stable in the sense that, if other parties choose their Nash equilibrium strategies, each party prefers its own Nash equilibrium strategy.
4. If others do not act strategically, I should choose the best strategy, even if it is not a Nash equilibrium strategy. But, I should never use a dominated strategy.
5. In a randomized strategy, the party specifies a probability for each of the alternative pure strategies. Then, it adopts each pure strategy randomly according to the probabilities. The probabilities must add up to 1.
6. Strategy (b) is more effective. It is random and unpredictable, and so the boxer's opponent will not be able to anticipate the move and counter it.
7. In a zero-sum game, the outcomes for the parties add up to the same number in every cell of the game in strategic form. Therefore, one party can become better off only if another is made worse off – which is the essence of competition. By contrast, in a positive-sum game, the outcomes for the parties add up to different numbers in the various cells. Hence, by coordinating, both parties can become better off.
8. Yes. This is because the outcomes for the parties add up to the same number in every cell of the game in strategic form.
9. Because the equilibrium may differ according to the timing of moves.
10. By reasoning forward from the initial node, the party will not be able to anticipate the other parties' responses and adjust its own action to maximize its expected outcome.
11. There is first-mover advantage in any strategic situation where one party gains advantage by moving before others. Analyzing the game in extensive form reveals whether the first mover has an advantage.
12. An unconditional strategic move will involve a cost under all circumstances. If the conditional strategic move (promised or threatened action) need not actually be carried out, the cost would be zero. Hence, conditional strategic moves are more cost-effective than unconditional strategic moves.
13. Deposit insurance pays compensation to depositors if the bank becomes insolvent. If the bank becomes insolvent, it may not have funds to pay the compensation. So, deposit insurance funded by the bank itself may not be credible.
14. The "walk away" tactic is credible only if the person has a better offer elsewhere and is better off by walking away. So, the credibility of "walking away" depends on the probability that the person has a better offer elsewhere.

15. Both the legal system and violence are threats to persuade borrowers to repay their loans. Since loan sharks are not allowed to use the legal system to collect debts, they employ violent threats (costs) to persuade borrowers to repay.

Discussion answers

1. (a)

		Maggie	
		Confess	Not confess
Angela	Confess	A: Jail 1 year M: Jail 1 year	A: \$1,000 M: Jail 1 year
	Not confess	A: Jail 1 year M: \$1,000	A: Let off M: Let off

- (b) Maggie prefers the \$1000 reward to being “let off,” and so, “not confess” is dominated by “confess.” The same is true for Angela. Hence, there is one Nash equilibrium: both Angela and Maggie confess.
- (c) This strategic situation is essentially the same as the gasoline station price war. For each player, one strategy dominates the other. There is only one Nash equilibrium.

Appendix 9.A
Solving Nash equilibrium in randomized strategies

This chapter has introduced the concept of randomization and showed its usefulness, especially in competitive contexts. There are two ways to solve for the Nash equilibrium with randomized strategies – graphical and algebraic. Let us apply the two methods to the (modified) situation of the gasoline stations described in Table 9.3.

Graphical solution

In Figure 9.A1, the horizontal axis depicts the probability that Jupiter maintains price, and the vertical axis shows Saturn’s expected profit. We draw two lines in the figure. One line shows Saturn’s profit if it maintains price, as a function of the probability that Jupiter maintains price. By Table 9.3, if Jupiter maintains prices with certainty, Saturn’s profit from maintaining price would be \$900. However, if Jupiter maintains price with zero probability (cuts price), Saturn’s profit from maintaining price would be \$500.

The other line shows Saturn's profit if it cuts price, as a function of the probability that Jupiter maintains price. By Table 9.3, if Jupiter maintains price with certainty, Saturn's profit from cutting price would be \$800. However, if Jupiter maintains prices with zero probability (cuts price), Saturn's profit from cutting price would be \$600.

The two lines cross at one point. At that point, Saturn's profit is the same whether it maintains or cuts price. That point marks Jupiter's Nash equilibrium probability, which turns out to be $1/2$.

We can use a similar graph to determine Saturn's equilibrium probability, which also turns out to be $1/2$.¹

Algebraic solution

Another way to find the Nash equilibrium probabilities is to use algebra. In equilibrium, both Jupiter and Saturn must randomize. Suppose that Jupiter maintains price with probability q . For Saturn to be willing to randomize, it must be indifferent between the two pure strategies: maintain price and cut price. This means that Saturn must receive the same expected profit from the two pure strategies.

To calculate Saturn's expected profit from maintaining price, refer to Table 9.3. Saturn's profit would be \$900 if Jupiter maintains price, which occurs with probability q , while Saturn's profit would be \$500 if Jupiter cuts price, which occurs with probability $1 - q$. Hence, Saturn's expected profit from maintaining price would be $(900 \times q) + (500 \times (1 - q)) = 500 + 400q$.

Similarly, we can calculate Saturn's profit from cutting price, which would be $(800 \times q) + (600 \times (1 - q)) = 600 + 200q$. In randomized strategy equilibrium, Saturn must receive the same expected profit from pricing low and high. This means that $500 + 400q = 600 + 200q$, which implies that $q = 1/2$.

Likewise, we can determine Saturn's Nash equilibrium strategy. Suppose that Saturn maintains price with probability p . For Jupiter to be indifferent between its alternative pure strategies, it must earn the same expected profit from maintaining and cutting price. This means that $900p + 1,000(1 - p) = 1,300p + 600(1 - p)$, or $p = 1/2$.

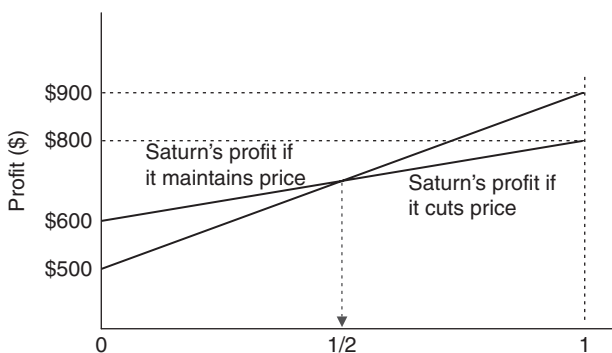


Figure 9.A1 Nash equilibrium in randomized strategies: graphical solution

Note

- 1 This technique is based on Avinash Dixit and Barry Nalebuff, *Thinking Strategically: The Competitive Edge in Business, Politics, and Everyday Life*, New York: Norton, 1991, Chapter 7.

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PART III

Imperfect markets



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CHAPTER 10

Externalities

LEARNING OBJECTIVES

- Understand positive and negative externalities.
- Appreciate economic efficiency as a benchmark and the opportunity to profit by resolving an externality.
- Appreciate how to resolve externalities and the corresponding barriers.
- Understand network effects and appreciate how to manage demand with network effects.
- Understand public goods.
- Appreciate how to provide public goods commercially.

10.1 Introduction

Xiaolan Metro Mall, located in the Xiaolan District of Zhongshan City, Guangdong Province, China, comprises leasable area of 77,700 square meters and 626 car parking spaces. At the time of writing, Dasin Retail Trust Management managed the mall, with responsibility for maintenance and repair, and advertising and promotion.

In June 2016, Xiaolan Metro Mall was 100% occupied by 136 tenants, who paid gross rent of 7.78 million yuan. The mall was forecast to attract 22.7 million visitors per year.

Anchoring the mall with 17,882 square meters, supermarket RT-Mart paid monthly rent of 34.8 yuan per square meter. By contrast, the other tenants paid 119.6 yuan per square meter, or 3.43 times as much. Most rents were either fixed subject to increases of 6% to 10.0% per year, or calculated as a percentage of sales revenue subject to some minimum.

Why did Xiaolan Metro Mall charge a lower rent to RT-Mart than to other retailers? Why did the mall spend on advertising and promotion? Why did it base rent on retailers' sales revenue?

Externality: A benefit or cost directly conveyed to others.

Public good: One person's consumption does not reduce the quantity available to others.

Positive externality: A benefit directly conveyed to others.

We can address these questions through the concepts of *externality* and *public good*. An **externality** arises when one party directly conveys a benefit or cost to others (not through a market).

A supermarket generates a positive externality for other stores by attracting additional shoppers to the mall. These new consumers would also patronize the other stores. If not compensated, the level of the externality would be less than economically efficient. Shopping malls charge lower rents to recruit anchor tenants and compensate them for attracting shoppers to other stores.

An item is a **public good** if one person's consumption does not reduce the quantity available to others. Advertising and promotion by the mall to attract more shoppers are a public good for the tenants. The additional shoppers benefit all the stores in the mall, and in turn, the mall collects more rent through the percentage of sales revenue.

10.2 Positive externality

A **positive externality** arises when one party directly conveys a benefit to others. Consider a supermarket which advertises to attract customers. The customers would increase the store's sales. Some would also visit nearby shops, and so the supermarket generates a positive externality to the other shops.

Individual maximum

To illustrate, Table 10.1 presents the supermarket's revenues and costs by the number of customers on a monthly basis. For instance, with 50,000 customers, revenue would be \$1.86 million, while variable cost would be \$1.0 million, and so the profit contribution would be \$860,000. The cost of advertising to attract 50,000 customers is \$200,000, and so profit would be \$660,000.

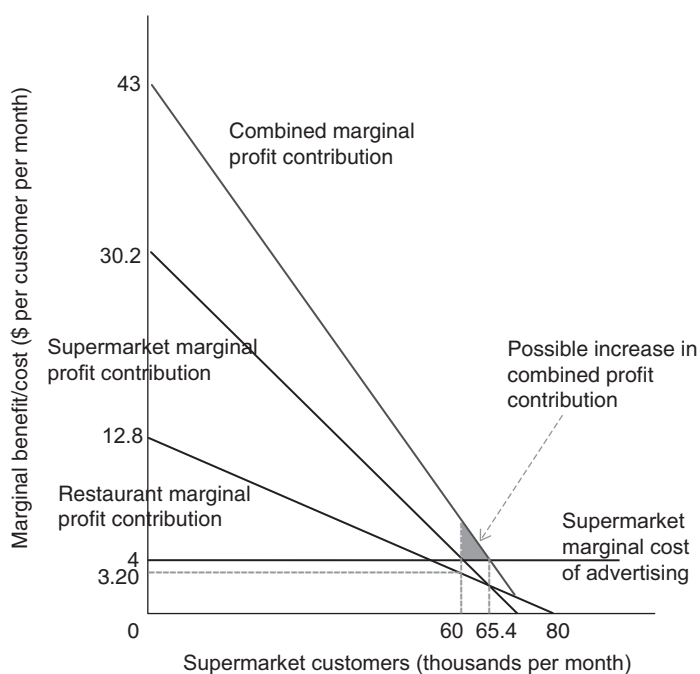
The marginal profit contribution is the increase in profit contribution due to an increase in customers. At 50,000 customers, the marginal profit contribution is $$(860 - 776)/(50 - 40) = \8.4 per customer. The marginal customer cost is the additional advertising expenditure needed to attract the customers. At 50,000 customers, the marginal customer cost is $$(200 - 160)/(50 - 40) = \4 per customer.

How many customers maximize profit? Referring to Table 10.1, the maximum profit is \$660,000, achieved with 60,000 customers. At that level, the marginal profit contribution and the marginal customer cost are both \$4 per customer. (Strictly, the profit would be even higher between 50,000 and 60,000 customers. For simplicity, we focus on 60,000 as the profit maximizing number.)

Figure 10.1 represents the same analysis graphically. The level of customer traffic that maximizes the supermarket's profit is that where the marginal profit contribution equals the marginal cost.

Table 10.1 Customers: individual maximum

Customers ('000)	Revenue (\$ '000)	Variable cost (\$ '000)	Profit contribution (\$ '000)	Marginal profit contribution (\$)	Advertising expenditure (\$ '000)	Marginal customer cost (\$)	Profit (\$ '000)
0	0	0	0		0		0
10	460	200	260	26	40	4	220
20	876	400	476	21.6	80	4	396
30	1,248	600	648	17.2	120	4	528
40	1,576	800	776	12.8	160	4	616
50	1,860	1,000	860	8.4	200	4	660
60	2,100	1,200	900	4	240	4	660
70	2,296	1,400	896	-0.4	280	4	616
80	2,448	1,600	848	-4.8	320	4	528
90	2,556	1,800	756	-9.2	360	4	396

**Figure 10.1** Positive externality: economic efficiency

Joint maximum

Next, consider a nearby restaurant. Table 10.2 presents its revenue and costs on a monthly basis. The restaurant revenue increases with the supermarket's customer traffic. For instance, with 60,000 customers, the revenue would be \$1.392 million, while the variable cost would be \$960,000, and so profit contribution and profit would be \$432,000. (Since the restaurant does not advertise, its profit contribution and profit are the same.)

If the supermarket acts independently, it would advertise to attract 60,000 customers. What if it brings in the 60,001st customer? That customer would raise the supermarket's profit contribution by a little less than \$4 and raise the supermarket's cost of advertising by \$4. Referring to Figure 10.1, that customer would raise the restaurant's profit contribution by \$3.20. So, the supermarket and restaurant would jointly be better off by slightly less than \$3.20.

Indeed, the supermarket could continue to increase the combined profit contribution of the supermarket and restaurant by increasing customer traffic up to the economically efficient level. Recall from Chapter 5 that economic efficiency is defined by marginal benefit equaling marginal cost.

Here, two parties benefit, and so, the relevant marginal benefit is the *combined* marginal benefit of the supermarket and restaurant. For instance, at 60,000 customers, the combined marginal benefit is \$4 + \$3.20 = \$7.20.

In Figure 10.1, the combined marginal benefit is the *vertical sum* of the supermarket's marginal profit contribution and the restaurant's marginal profit contribution. The combined marginal benefit equals the marginal cost of attracting customers at 65,400, which is the economically efficient level.

By increasing the number of customers from 60,000 to 65,400, the supermarket and restaurant can collectively gain the shaded area in additional profit contribution. So, if

Table 10.2 Customers: positive externality

Customers (‘000)	Revenue (\$ ‘000)	Variable cost (\$ ‘000)	Profit contribution = Profit (\$ ‘000)	Marginal profit contribution = Marginal profit (\$)
10	272	160	112	11.20
20	528	320	208	9.60
30	768	480	288	8.00
40	992	640	352	6.40
50	1,200	800	400	4.80
60	1,392	960	432	3.20
70	1,568	1,120	448	1.60
80	1,728	1,280	448	0.00
90	1,872	1,440	432	-1.60

the supermarket could charge a fee to the restaurant for attracting customers, it would maximize profit (from sales to customers and restaurant fee) at 65,400 customers.

Progress check 10A. Suppose that the restaurant's marginal profit contribution is lower by \$3.20 at all levels of customer traffic. Revise Figure 10.1 to show the economically efficient level of customer traffic.

Externalities in talent: Silicon Valley

Information technology related businesses are exceptionally concentrated in the vicinity of Stanford University and the Xerox Palo Alto Research Center (PARC). The area, aptly nicknamed Silicon Valley, is home to Apple, Facebook, Google, and Intel.

In the early 1970s, Jef Raskin, then a professor at the University of California, San Diego, visited Stanford and Xerox PARC. In 1978, he joined Apple and led the development of the Macintosh computer. He recalled that "most of the work [on human-computer interaction] I knew about was being done at PARC."

In 1996, two Stanford computer science graduate students, Sergey Brin and Lawrence Page, developed an algorithm for Internet search. Their research blossomed into Google.

10.3 Negative externality

Externalities can be negative. A **negative externality** arises when one party directly imposes a cost on others. For instance, a betting shop imposes a negative externality on a toy store by discouraging families with children from browsing nearby.

To illustrate, Figure 10.2 depicts the betting shop's marginal profit contribution and marginal cost of customers. The number of customers which maximizes the betting shop's own profit is 10,000, where the marginal profit contribution equals the marginal customer cost of \$2 per customer.

Next consider a nearby toy store. The sales and revenue of the toy store decrease with customers at the betting shop. Figure 10.2 also depicts the toy store's marginal cost (calculated as the marginal loss of profit contribution) as a function of the betting shop's customers.

If the betting shop acts independently, it would advertise to attract 10,000 customers. What if it reduces its customers by one to 9,999? Its own profit contribution would be \$2 lower, and its advertising cost would be \$2 lower. The toy store's cost would be \$4 lower.

Negative externality: A cost directly imposed on others.

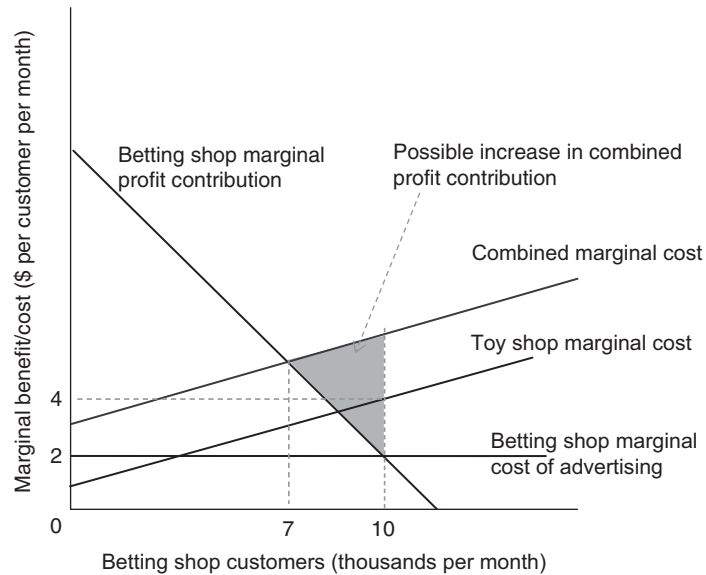


Figure 10.2 Negative externality: economic efficiency

So, the reduction of one customer would raise the combined profit contribution of the betting shop and toy store by \$4. Indeed, the betting shop could increase the combined profit contribution by reducing customer traffic down to the economically efficient level.

Economic efficiency is defined by marginal benefit equaling marginal cost. Here, two parties incur costs, and so, the relevant marginal cost is the *combined* marginal cost of the betting shop and toy store. For instance, at 10,000 customers, the combined marginal cost is $\$2 + \$4 = \$6$.

In Figure 10.2, the combined marginal cost is the *vertical sum* of the betting shop's marginal cost of advertising and the toy store's marginal cost (loss of profit contribution). The marginal benefit equals the combined marginal cost of customers at 7,000, which is the economically efficient level.

By reducing the number of customers from 10,000 to 7,000, the betting shop and toy store can collectively gain the shaded area in additional profit contribution. So if the betting shop could collect a fee from the toy store for reducing customer traffic, it would maximize profit (from sales to customers and toy store fee) at 7,000 customers.

Progress check 10B. Referring to Figure 10.2, suppose that the toy store suffers a stronger negative externality. How would this affect (a) the toy store's marginal cost curve, and (b) the number of customers that maximizes the combined profit?

Climate change

Motorcars are a major source of the emissions of greenhouse gases which trap heat in the atmosphere and cause global warming. To the extent that emitters do not pay for emissions, they generate negative externalities.

Compared to gasoline-powered cars, hybrid and pure electric cars generate less carbon (not zero because the generation of electric power also produces carbon emissions). Consultants Carbon Footprint estimated the carbon emissions of three cars sold in the US in 2020 over 10,000 miles. The basic Tesla Model 3, Toyota Prius, and Audi A3 would generate 0.67, 1.69 and 2.93 metric tons respectively.

10.4 Benchmark

Generally, in the presence of both positive and negative externalities, the source and recipient of the externalities maximize their combined profit at the economically efficient level of the externality. At this benchmark, the combined marginal benefits equal the combined marginal costs.

Chapter 5 showed that, in a perfectly competitive market, the invisible hand ensures economic efficiency. By definition, however, externalities do not pass through markets. Hence, externalities will be resolved only through deliberate action. One solution is government action, which we discuss in Chapter 13.

Another solution is private action – through merging the source and recipient of the externality, or by agreement among the source and recipient. However, private resolution may be impeded by two obstacles – the assignment of rights and possible free-riding.

Common ownership

In the example of the positive externality, if the supermarket owned the restaurant, it would consider all the benefits and costs of additional customers. Hence, it would increase advertising to attract the economically efficient number of customers. Similarly, in the example of the negative externality, if the betting shop owned the toy store, it would reduce advertising to attract the economically efficient number of customers.

These examples suggest one way to resolve an externality: combine the source and recipient of the externality under common ownership. The common owner would choose the economically efficient level of the externality, whether positive or negative.

Agreement

Another solution is for the source and recipient of the externality to negotiate and agree on the externality. For instance, the restaurant could offer to pay part of the

supermarket's advertising cost. This would encourage the store to increase advertising. Similarly, the toy store could pay the betting shop to reduce advertising.

Such an agreement involves two steps. First, the affected parties must agree on how to resolve the externality. This step involves collecting information about the benefits and costs to the various parties, and then agreeing on the level of the externality. The second step is to monitor the source of the externality and ensure that it complies with the agreed externality.

Assignment of rights

One hurdle to resolution of externalities is unclear assignment of rights. In the betting shop and toy store example, the externality can be resolved in two ways. The betting shop could reduce its advertising or the toy store could shut down.

So does the betting shop have the right to drive away customers from the toy store? Or does the toy store have the right not to suffer an externality? If rights are not clearly assigned, then the two parties would have difficulty negotiating common ownership or an agreement.

Free-riding

The other hurdle is possible free-riding. In the supermarket example, consider a florist that benefits from the supermarket's advertising but refuses to pay the supermarket. The supermarket would still advertise, while other retailers might still contribute. But their customers might still patronize the florist.

The florist is taking a free ride on the advertising by the supermarket and other retailers. Generally, a **free-rider** pays less than its marginal benefit to resolving the externality. At the extreme, the free-rider pays nothing at all.

Free-riding is more serious when the externality affects many recipients. In such circumstances, it is more difficult to exclude those who do not pay from benefiting from the externality. Also, the amount that each one must pay is small, and so the other recipients may pay to resolve the externality even if some recipients take a free ride.

Free-rider:

Contributes less than marginal benefit to resolving the externality.

Progress check 10C. In the example of the betting shop and toy store, what are the possible hurdles to resolving the externality?

Xiaolan Metro Mall: resolving positive externalities

In June 2016, Xiaolan Metro Mall, located in Zhongshan City, Guangdong Province, China, charged supermarket RT-Mart a monthly rent of 34.8 yuan per square meter for 17,882 square meters. It charged the other tenants 119.6 yuan per square meter, or 3.43 times as much.

RT-Mart served as an anchor tenant. By charging lower a rent to RT-Mart and higher rents to the other retailers, Xiaolan Metro Mall effectively compensated RT-Mart for attracting customers to the other retailers.

Malls also curate the mix of tenants to reinforce positive externalities and avoid negative externalities. Betting shops and adult stores rarely get into malls.

10.5 Network effects and externalities

A **network effect** is a benefit or cost that increases with the size of the network. The adjective *network* emphasizes that the benefit or cost is generated by the entire network of users.

The marginal benefit and demand from an item that exhibits network effects increases with other users. For instance, when one more person subscribes to an instant messaging service, the marginal benefit and demand curves of all other users will shift up.

Related to the concept of a network effect is the *network externality*. A **network externality** is a benefit or cost directly conveyed to others that increases with the size of the network. Essentially, a network externality is a network effect that is conveyed *directly*, and not through a market.

In markets with network effects, the character of demand and competition differs from that in conventional markets. We discuss each of these differences below.

Network effect: A benefit or cost that increases with the size of the network.

Network externality: A benefit or cost directly conveyed to others that increases with the size of the network.

Critical mass

In a market with network effects, the demand may be zero unless the users exceed critical mass. The **critical mass** is the set of users at which the demand becomes positive. Consider, for instance, instant messaging service. There is no demand if the users fall below some level. Who would want the service if there is no one with whom to communicate?

The demand for some items depends on complementary hardware. For instance, the demand for web-based social media depends on consumer access to computers and smartphones. In this context, the **installed base** is the stock of the complementary hardware in use.

Critical mass: The set of users at which demand becomes positive.

Installed base: The quantity of complementary hardware in use.

Expectations

In markets with network effects, user expectations play an important role. To illustrate, consider people deciding whether to subscribe to a new instant messaging service. Two equilibria are possible. In one, each person expects the others to subscribe, and accordingly subscribes. Then users exceed critical mass and the service succeeds as expected.

By contrast, in another equilibrium, people are pessimistic. Each one expects less than the critical mass to subscribe, and so does not subscribe. Then demand fails to reach critical mass and the service flops as expected.

In equilibrium, expectations – whether pessimistic or optimistic – can be self-fulfilling. Sellers of items with network effects may promote heavily to secure the critical mass.

Tipping

The demand in markets with network effects may be very sensitive to small differences among competitors. Consider several competing messaging services, each of whose users are close to critical mass. Suppose one service attracts a few more users. The increase would feed back through the network effect to attract even more users. That service would grow while the others would wither away.

Tipping: The tendency for demand to shift toward a product with a small initial lead.

Tipping is the tendency for demand to shift toward a product that has gained a small initial lead. Owing to network effects, users gravitate towards the market leader, resulting in “winner take all.”

Price elasticity

Network effects influence the price elasticity of demand in ways depending on whether users have reached critical mass. When the users are below critical mass, the demand will be zero, and hence extremely price inelastic. Price changes will not affect the quantity demanded at all.

When users exceed critical mass, the network effect causes the market demand to be relatively more price elastic. Consider, for instance, a price cut. This would increase the quantity demanded. The increase would feed back through the network effect to further increase the demand. Network effects amplify the effects of price changes.

Progress check 10D. How do markets with network effects fundamentally differ from conventional markets?

Google: harnessing network effects

Google harnesses network effects in a very subtle way. Whenever a user submits a search, Google uses its proprietary page-rank algorithm to display links to webpages in order of predicted relevance.

Google monitors the links that users click and updates its algorithms. Every search helps to refine the algorithms, and so the more people search on Google, the better the quality of its service.

FaceTime: growing network

For strategic reasons, businesses may deliberately limit network effects. At the time of writing, Apple restricted the use of its video call service, FaceTime, to Mac and iOS devices. The FaceTime network was limited by the installed base of Apple equipment.

Then, in June 2021, at its Worldwide Developers Conference, Apple announced that it would open FaceTime to Internet browsers. That would expand the FaceTime network to anyone using the Internet, including Android and Windows users.

10.6 Public goods

Closely related to the concept of an externality is the public good. Wireless radio broadcasting nicely illustrates the concept. An item is a public good if one person's consumption does not reduce the quantity available to others.

Equivalently, a public good provides *non-rival* consumption. Consumption is **non-rival** if one person's consumption does not reduce the quantity available to others. If one person listens to a radio broadcast, they do not reduce the quantity available to others. Radio broadcasts provide non-rival consumption and are a public good.

Another way to understand non-rival consumption is through the concept of economies of scale. Given that a program is being broadcast to one listener, the marginal cost of providing the same program to other listeners is zero.

There is an extreme economy of scale in providing a public good *with respect to the number of consumers*. The cost of provision is fixed and the marginal cost of serving an additional consumer is zero.

The economy of scale with respect to the number of consumers differs from an economy of scale with respect to quantity of the item. Increasing the length of a radio broadcast does involve more costs and need not exhibit economies of scale.

Non-rival

consumption: One person's consumption does not reduce the quantity available to others.

Rivalness

Public goods lie at one end of a spectrum of rivalness, with *private goods* at the other end. Consumption is **rival** if one person's consumption reduces the quantity available to others by the same amount. A private good provides rival consumption.

Scientific formulas, computer algorithms, and audiovisual compositions yield non-rival consumption. If one more person uses them, they do not reduce the quantity available for others.

By contrast, food and medical treatment are private goods. When a person eats an eight-ounce steak, there will be eight ounces less for others. When a doctor attends to a patient, that doctor is not available for others.

Rival consumption:

One person's consumption reduces the quantity available to others by the same amount.

Congestible

consumption: One person's consumption partly reduces the quantity available to others.

Intermediate between rival and non-rival consumption is **congestible consumption**. This means that one person's consumption partly reduces the quantity available to others. Congestible items are public goods when consumption is low but are private goods when consumption is high.

The Internet is congestible. At off-peak times, one person's usage does not affect the quality of service to others. At peak times, however, each additional user degrades the service for others.

Benchmark: economic efficiency

As with externalities, the economically efficient quantity of a public good is that where the combined marginal benefits equal the marginal cost. To illustrate, suppose that there are two segments of radio listeners, light and heavy, with marginal benefits as shown in Figure 10.3. The graph also shows the marginal cost of broadcasting, a constant \$560 per hour.

Consider one hour of broadcast. Since the broadcast is a public good, there will be one hour for every listener. Referring to Figure 10.3, the sum of the marginal benefits is \$400 + \$600 = \$1,000. The cost of one hour is \$560, hence the combined marginal benefit exceeds the marginal cost.

The excess of the combined marginal benefit over the marginal cost is an opportunity for profit. Consumers are willing to pay more than the cost of provision. This same argument applies for additional quantities up to the economically efficient

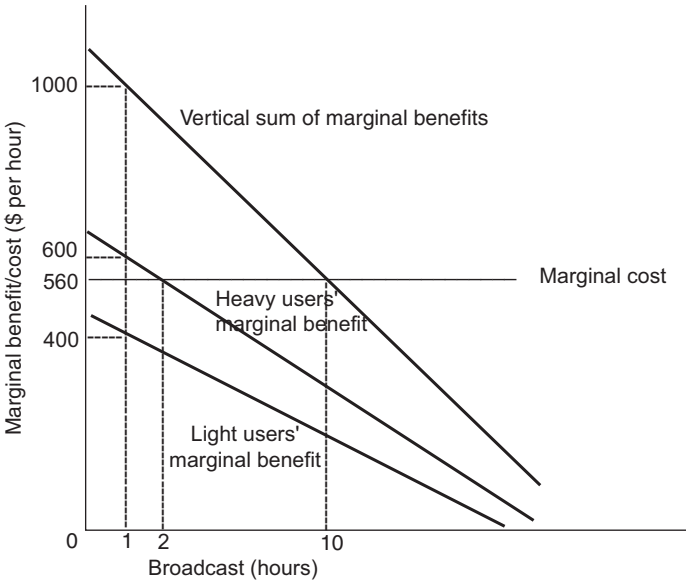


Figure 10.3 Public good: economic efficiency

quantity, ten hours. At that quantity, there are no further opportunities to profit from providing more of the public good.

Progress check 10E. In Figure 10.3, include a marginal benefit curve for moderate consumers and show the impact on the economically efficient quantity of broadcasting.

Xiaolan Metro Mall: advertising and promotion

Xiaolan Metro Mall spends on advertising and promotion to attract shoppers. The additional shoppers benefit all the retailers in the mall, and are a public good for them. The additional shoppers would increase the rent that retailers pay as a percentage of sales revenue. The mall collects a return on its advertising and promotion spending through the percentage rent.

Paris Agreement

Greenhouse gases trap heat in the atmosphere and warm the planet. In December 2015, the 21st Conference of the United Nations Framework Convention on Climate Change in Le Bourget, France, adopted the Paris Agreement. The Agreement aims to limit the increase in the global average temperature to less than 2 degrees Celsius above pre-industrial levels.

Reducing emissions of greenhouse gases in the atmosphere is a public good. The reduction yields benefits that are non-rival: every current and future resident on planet Earth would benefit.

10.7 Excludability

Having appreciated the nature of public goods and their economically efficient quantity, we now discuss how public goods can actually be provided. The provision depends on excludability.

Consumption is **excludable** if the provider can exclude particular consumers. Typically, commercial provision of any item, whether private or public good, depends on the seller being able to exclude those who do not pay.

The basic problem is that, whenever consumption of a public good is non-excludable, individual consumers will have an incentive to free-ride. In the radio example, light consumers might refuse to pay, hoping to free-ride on heavy consumers.

Excludable consumption:

The provider can exclude particular consumers.

Referring to Figure 10.3, in a market comprising only heavy consumers, the marginal benefit would equal the marginal cost at two hours. Free-riding by light users would cut the seller's revenues and reduce provision to less than the true economically efficient quantity.

As the radio example makes clear, commercial provision depends on consumption being excludable. Excludability differs between content and delivery, and depends on two factors – law and technology.

Content and delivery

Television programming can be broadcast over the air or by cable. Regardless of the method of delivery, the content is non-rival. If one person watches the evening news, they do not affect the quantity of news available to others. This is true whether the signal comes over the air or by cable.

The method of delivery, however, may be a public or private good. Delivery by free-to-air transmission is a public good. The same signal can serve any number of TV sets within the range of transmission. Delivery by cable, however, is a private good. Each cable serves only one TV set.

Scientific knowledge also illustrates the distinction between content and delivery. The formula for a Covid-19 vaccine is a public good. If one manufacturer uses the formula, it does not reduce the quantity available to other manufacturers. However, as delivered, the vaccine is a private good: if one person gets a dose, that dose is not available to others.

Law

The use of scientific formulas, computer algorithms, and audiovisual compositions is non-rival. However, through the legal concept of *intellectual property*, the law has made their use legally excludable. The objective of intellectual property rights is to encourage innovators to invest more in creative activities.

Two particular intellectual property rights are patents and copyright. A patent is a legal exclusive right to a product or process. Inventors of pharmaceuticals and electronic devices may seek patents.

A copyright is a legal exclusive right to an artistic, literary, or musical expression. Copyright is the intellectual property right most important to creators of software and art, music, and audiovisual entertainment.

Technology

Technology can also render consumption excludable. The content of TV broadcasts is a public good. But the medium of delivery can make consumption excludable. Free-to-air TV is not excludable. However, by scrambling the signal or delivering by cable, the broadcast can be made excludable.

Software provides another example. The algorithms and code underlying computer software are public goods. However, if the publisher includes in the software an activation code, then it can exclude those who do not pay.

Progress check 10F. Distinguish the content and delivery of a public good. How does this matter for commercial provision of a public good?

Free-to-air TV: commercial provision without exclusion?

Typically, commercial provision of a public good depends on excludability. Free-to-air TV is non-excludable. Yet, in the United States, four commercial networks – ABC, CBS, NBC, and Fox – provide free-to-air TV and quite successfully. What is their secret?

The networks' primary source of revenue is advertising. While viewers do not pay for TV directly, they do so indirectly. They pay by increasing their purchases of the advertised products and services. In the year 2020, Fox Corporation's TV business generated revenues of US\$4.17 billion from advertising.

Key takeaways

- Externalities are benefits or costs directly conveyed to others.
- The economically efficient level of an externality is where the combined marginal benefits equal the combined marginal costs.
- There is an opportunity to add value and profit by resolving an externality up to the economically efficient level.
- Resolve an externality through merger or agreement.
- The two hurdles to resolution of an externality are unclear assignment of rights and possible free-riding.
- Network effects are benefits or costs that increase with size of network.
- A public good provides non-rival consumption: one person's consumption does not reduce the quantity available to others.
- The economically efficient level of a public good is where the combined marginal benefits equal the marginal cost.
- Provide public goods on a commercial basis by excluding non-payers through law or technology.

Review questions

1. Explain the difference between a negative and a positive externality.
2. Luna and Solis both launched a new consumer electronic device. Luna's advertising is raising Solis's demand. What is the economically efficient level of Luna's advertising?
3. Explain the relation between the combined marginal benefit curve from additional customers for all retailers in a mall and the retailers' individual marginal benefit curves.
4. When the sum of the marginal costs from a negative externality exceeds the marginal benefit to the source, what is the profit opportunity? Explain.
5. Explain how the following action will help to resolve the externalities generated by a new subway line: the subway system buys the property around the new stations.
6. Discuss the possible free-rider problem in the following context. Saturn City lies two miles off a busy highway. The city's major businesses have proposed to build an exit from the highway to draw traffic into the city.
7. Why does the assignment of rights affect the resolution of an externality?
8. Explain the possible network effects in the demand for spreadsheet software.
9. Give an example of a network effect, and in that context explain the concepts of critical mass and tipping.
10. Does the presence of network effects cause demand to be more or less price elastic?
11. Give an example of a public good. Explain how the use of the good is non-rival.
12. Explain the difference between the marginal costs of (a) providing a public good to an additional consumer, and (b) increasing the quantity of a public good.
13. Which of the following are public goods? (a) Medical treatment at a public hospital. (b) Welfare payments to unemployed people. (c) National defense.
14. For a public good, why is the combined marginal benefit equal to the sum of the individual marginal benefits?
15. How do law and technology affect excludability?

Discussion questions

1. In June 2016, Xiaolan Metro Mall, located in Zhongshan City, Guangdong Province, China, charged supermarket RT-Mart a monthly rent of 34.8 yuan per square meter for 17,882 square meters. It charged the other tenants 119.6 yuan per square meter, or 3.43 times as much.

- (a) With a relevant diagram, illustrate the supermarket's marginal benefit from and marginal cost of attracting customers. Show the externality on another retailer and identify the economically efficient number of customers.
 - (b) Explain why Xiaolan Metro Mall charges lower rents to RT-Mart than to other retailers.
 - (c) Compare a supermarket on a public street with one in a shopping mall. Discuss how likely are externalities to nearby retailers to be resolved.
2. Consultants Carbon Footprint estimated the carbon emissions of three cars sold in the US in 2020 over 10,000 miles. The basic Tesla Model 3, Toyota Prius, and Audi A3 would generate 0.67, 1.69 and 2.93 metric tons respectively.
 - (a) Explain how emissions from cars generate a negative externality.
 - (b) Draw a figure with number of miles on the horizontal axis and marginal benefit/cost on the vertical axis. Using any data necessary, draw your marginal benefit and marginal cost of driving. Also draw the marginal cost of emissions to society.
 - (c) Ignoring the externality, how much would you drive?
 - (d) Compare the economically efficient driving of the Tesla, Prius, and Audi.
3. One of the world's most abundant anchovy fisheries lies off the Pacific coast of Peru. The government regulates the total catch of anchovies for human consumption but does not regulate individual fishing boats. The result is an "Olympic race" in fishing. Between 2013 and 2017, Peru produced 165,662 metric tons, of which 11% were processed into value-added products, but 41% were lost in processing.
 - (a) Explain the externalities under the "Olympic" system. Compare production relative to the economically efficient level.
 - (b) Suppose that the government sets individual quotas for each boat. How would that affect economic efficiency?
 - (c) How would the individual quotas affect the incentives of fishing businesses to: (i) process anchovies into value-added products, and (ii) reduce processing losses?
 - (d) Discuss whether the quotas should be transferable.
4. In 1951, Stanford University and the City of Palo Alto founded an industrial park. Subsequently named the Stanford Research Park, it covers 700 acres around the university. At the time of writing, it housed over 150 companies including Tesla, Argo.AI, and VMWare.
 - (a) Explain the externalities that Stanford generates to nearby businesses.
 - (b) Compare Stanford's incentive to invest in research if the Research Park did or did not exist.
 - (c) Should Stanford choose the tenants for the Research Park, and if so, how?

5. Major European companies have adopted English as a common language. English is also the standard language among aircraft pilots and air-traffic controllers. Linguists estimate that, within this century, nearly half of 7,000 languages worldwide will disappear.
 - (a) Considering people in different countries, compare the benefit of chefs vis-à-vis pilots speaking a common language.
 - (b) Discuss the externalities from the growth of English on: (i) people who are already fluent in English; (ii) people who do not speak English.
 - (c) Explain whether the externalities in (b) are network externalities.
 - (d) How do critical mass and expectations apply to the survival of a language?
6. Microsoft's Excel dominates the market for spreadsheet software. A key competitor is Google Sheets, which Google provides free of charge to individual users. Google emphasizes that Sheets "Works with Excel."
 - (a) Explain the network effects in the demand for spreadsheet software.
 - (b) Use the concept of critical mass and tipping to explain the dominance of Microsoft Excel.
 - (c) Why does Google emphasize that Sheets "Works with Excel"?
 - (d) Why does Google provide Sheets without charge?
7. In December 2015, the 21st Conference of the United Nations Framework Convention on Climate Change (UNFCCC) in Le Bourget, France, adopted the Paris Agreement. The Agreement aims to limit the increase in the global average temperature to less than 2 degrees Celsius above pre-industrial levels. By March 2021, 191 UNFCCC members had ratified the Agreement.
 - (a) Explain whether reduction of global warming is a public good for all countries.
 - (b) Discuss whether the UNFCCC can exclude any person or country from benefiting from reduction of global warming.
 - (c) In 2020, President Donald Trump withdrew the United States from the Agreement. Consider whether this action was free-riding.
 - (d) Developing economies argue that they have yet to industrialize like advanced economies and so they should be allowed more emissions. Interpret this reasoning through the marginal cost of reducing emissions.
8. Following the Covid-19 outbreak, pharmaceutical manufacturers urgently developed new vaccines. In Germany and the United States, BioNTech and Moderna used mRNA technology, while in China, Sinovac used inactivated viruses.
 - (a) Draw a figure with efficacy on the horizontal axis and marginal benefit/cost on the vertical axis. Using any data necessary, draw the US marginal benefit and (upward-sloping) marginal cost of a vaccine. Let the marginal benefit equal the marginal cost at an efficacy of 90%.

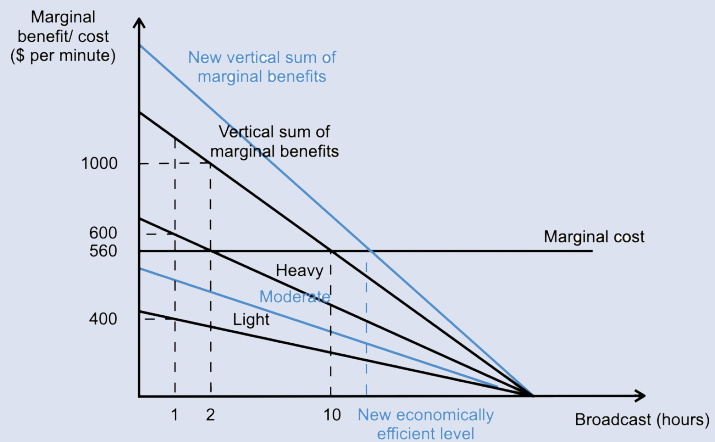
- (b) On a separate figure, draw the same marginal cost of R&D as in (a) and China's marginal benefit from a vaccine. Let the marginal benefit equal the marginal cost at an efficacy of 51%.
 - (c) Discuss why the US efficacy is higher than China's.
 - (d) On the figure in (a), combine the US and China's marginal benefit. Discuss the economically efficient efficacy.
9. Mikhail Kalashnikov invented the AK-47 assault rifle during World War II. Within 50 years, over 100 million AK-47s were produced. In the early 2000s, Russian arms manufacturer Izhmash owned patents to the AK-47. However, the US government bought AK-47s from unlicensed manufacturers in Bulgaria, Hungary, and Romania for its allies in Afghanistan and Iraq.
- (a) Use the AK-47 to explain how engineering design is a public good.
 - (b) Patents are only effective within national jurisdiction. Explain how manufacturers outside Russia could free ride on the AK-47 design.
 - (c) Arms expert Maxim Piadiyshev remarked that, with just eight moving parts, the AK-47 was very simple to produce, use, and maintain. How did this simplicity affect Izhmash's sales?

You are the consultant!

Identify any externalities or network effects in your organization's activities. How should your organization take advantage of the profit opportunities?

Progress check answers

- 10A. The new combined marginal profit contribution is lower by \$3.20. The new economically efficient level of customer traffic would be 60,000 customers a month.
- 10B. (a) The toy store's marginal cost curve will be higher. (b) The number of customers that maximizes the combined profit will be lower.
- 10C. The possible hurdle is the assignment of rights. Does the betting shop have the right to attract customers or does the toy store have the right not to be bothered by gamblers? (This situation involves only two parties, so free-riding will not arise.)
- 10D. In markets with network effects, the marginal benefit and demand increases with other users.
- 10E. An additional marginal benefit curve would raise the vertical sum of marginal benefits, and so possibly increase the economically efficient quantity.



- 10F. Music composed created by a composer is a public good. However, it can be delivered in the form of a private good through copyright. The ability to deliver a public good in a form of a private good enables the commercial provision of the public good.

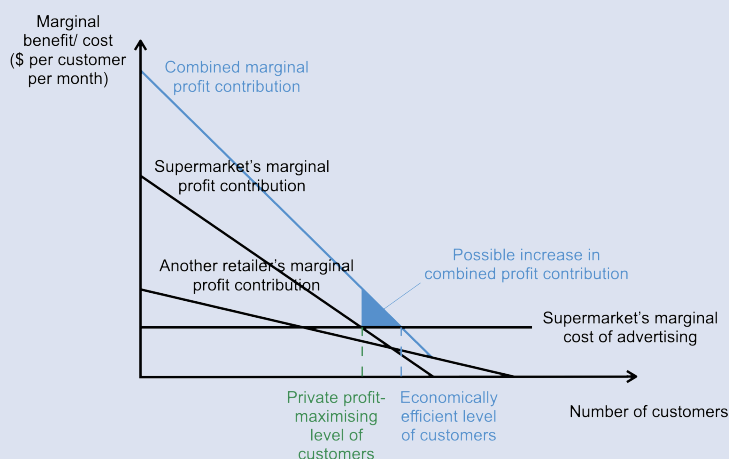
Review answers

1. A positive externality directly conveys benefits to others. A negative externality directly imposes costs to others.
2. The economically efficient level of advertising is where the combined marginal profit contribution equals the combined marginal cost of advertising.
3. The combined marginal benefit curve from additional customers for all retailers is the vertical sum of the retailers' individual marginal benefit curves.
4. The amount that the victims would be willing to pay to reduce the externality would exceed the amount needed to compensate the source to reduce the externality. Hence, the opportunity for profit.
5. Consumers benefit from easy transportation. The new subway will generate positive externalities for the owners of property around the stations. By buying the property, the subway company will capture the externalities.
6. Once the highway exit is built, it would be difficult to exclude any particular business from benefiting from the additional traffic. The free-rider problem is that each individual business would try to avoid contributing towards the cost of the highway exit (knowing that it could still enjoy the benefit).

7. If rights are not clearly assigned, then the source and recipient of externalities would have difficulty negotiating common ownership or an agreement.
8. The benefit of a spreadsheet program to a user increases with the number of other users. The more people use that program, the more convenient it will be for users to share their data and work.
9. [Omitted.]
10. It depends. If users fall below critical mass, the demand will be zero and extremely price inelastic. If users exceed critical mass, if price falls, this would increase the quantity demanded, which would feed back through the network effect to further increase the demand. So, the demand would be price elastic.
11. [Omitted.]
12. A public good provides non-rival consumption, so the marginal cost of serving an additional consumer is zero. The marginal cost of increasing the quantity of the public good is the total cost of producing the original quantity plus one minus the total cost of producing the original quantity. This would not be zero.
13. Only (c) is a public good.
14. The quantity of the public good available to each user is the same.
15. Law and technology may enable the provider of a public good to exclude specific individuals from benefiting from the public good.

Discussion answers

1. (a)



- (b) RT-Mart helps to attract customers to the mall, and so generates positive externalities to the other retailers.
- (c) Externalities to nearby retailers are more likely to be resolved for a supermarket in a shopping mall compared to a public street. Shops along a public street that receive positive externalities from the supermarket can simply refuse to pay the supermarket for the benefits. The supermarket cannot prevent its customers from patronizing shops that refuse to pay. By contrast, in a shopping mall, with the same management, the management can support positive externalities by charging lower rents to anchor stores and higher rents to specialty stores.

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CHAPTER 11

Asymmetric information

LEARNING OBJECTIVES

- Understand imperfect information and risk.
- Appreciate asymmetry of information and its consequences.
- Appreciate and apply appraisal to resolve information asymmetry.
- Appreciate and apply screening to resolve information asymmetry.
- Appreciate and apply signaling to resolve information asymmetry.
- Appreciate and apply contingent contracts to resolve information asymmetry.

11.1 Introduction

In June 2021, UK bank Barclays offered five-year fixed rate mortgages at average interest rates of 2.9%, 3.1%, and 3.3% for loans of up to 75%, 80%, and 85% of valuation respectively. These loans were subject to a processing fee of £999 and limited to existing customers of Premier Banking, a service for clients with high income or large deposits.

Barclays emphasized to all applicants for loans that it would check their income, debts, spending, and personal circumstances. The bank encouraged applicants to check their credit scores at credit reference agencies.

Typically, retailers offer better deals to new customers and discounts for larger purchases. By contrast, Barclays limited the mortgage loans to existing Premier Banking customers, and required higher interest rates for larger loans. Why?

Asymmetric information: One party has better information than another.

Mortgage lending illustrates *asymmetric information*. In a situation of **asymmetric information**, one party has better information than another. Borrowers have better information than banks about their ability and willingness to repay.

Bankers are aware of the risks due to asymmetric information. They may refuse to lend unless the information asymmetry is resolved. Barclays would have better information about its existing Premier Banking clients than other potential borrowers.

This chapter introduces four ways to resolve information asymmetry – appraisal, screening, signaling, and contingent contracts. Credit scores illustrate the technique of appraisal: lenders use credit scores to appraise the creditworthiness of borrowers.

Less-informed parties use screening to reveal the information of the better-informed parties. By stipulating higher interest rates to applicants for larger loans, Barclays screened applicants for their creditworthiness.

In contrast, better-informed parties use signaling to communicate their information to less-informed parties. A contingent contract specifies actions under particular conditions. Contingent contracts can be used to screen and signal.

Information asymmetry is widespread in commercial, non-commercial, and personal settings. The methods in this chapter can be applied to resolve information asymmetry, and so increase value added and profit.

11.2 Imperfect information

Before analyzing situations of asymmetric information, we should understand the concept of *imperfect information*. To have **imperfect information** about something means not having certain knowledge about it.

Imperfect information: The absence of certain knowledge.

Imperfect and asymmetric information

Asymmetric information involves two or more parties, one of whom has better information than the other or others. Asymmetric information will always be associated with imperfect information, because the less-informed party will have imperfect information. For instance, if the seller of wine knows whether it is good or bad, but a potential buyer does not, then the buyer has imperfect information.

Although the concepts of asymmetric and imperfect information are related, it is important to appreciate the distinction. The reason is that a market can be perfectly competitive even when buyers and sellers have imperfect information, so long as their information is symmetric. Under perfect competition, the allocation of resources is economically efficient; hence, nothing further can be done to increase profit or value added.

Consider, for instance, the market for heating oil. The demand and supply depend on expectations about temperatures in winter. Buyers and sellers have equal access to weather forecasts, and so formulate their demand and supply of heating oil. In a market equilibrium, the quantity demanded equals the quantity supplied, and the marginal benefit equals the marginal cost. Hence, additional production would not add value.

By contrast, a market where information is asymmetric cannot be perfectly competitive. This means that, if buyers and sellers can resolve the information asymmetries, they can increase their benefits by more than their costs, and so add value.

Risk

When information is imperfect, there is risk. To understand the meaning of *risk*, let us consider the following example. Angela knows that, with probability 1.5%, someone will steal her \$20,000 car within the next 12 months. If that were to happen, Angela would lose \$20,000. If Angela's car is not stolen, however, Angela will lose nothing. The probability that her car will not be stolen is $100 - 1.5 = 98.5\%$.

Angela has imperfect information about her future losses, because she does not know for sure whether her car will be stolen. Angela bears a risk: either she will lose \$20,000 with probability 1.5% or she will lose nothing with probability 98.5%. **Risk** is uncertainty about benefits or costs and arises whenever there is imperfect information about something that affects benefits or costs.

If Angela knew for sure that her car would not be stolen, then she would not bear any risk. Similarly, if she knew for sure that her car would be stolen, she would also not bear any risk. It is because her information is imperfect that she faces risk.

To explain the distinction between risk and imperfect information, consider Maggie, who is unrelated to Angela. Maggie also has imperfect information about whether Angela's car will be stolen. But the fate of Angela's car does not affect Maggie's benefits or costs. Hence, Maggie does not bear any risk with regard to Angela's car.

Risk: Uncertainty about benefits or costs.

Risk aversion

How a person responds to situations involving risk depends on the extent to which he or she is *risk averse*. A person is **risk averse** if she or he prefers a certain amount to risky amounts with the same expected value. A person is **risk neutral** if she or he is indifferent between a certain amount and risky amounts with the same expected value.

Given Angela's possible losses and the probabilities, her expected loss is $(\$20,000 \times 0.015) + (\$0 \times 0.985) = \$300$. If Angela is risk averse, she will prefer to lose \$300 for certain than to lose \$20,000 with probability 1.5% or lose nothing with probability 98.5%. If Angela is risk neutral, she would be indifferent between the two scenarios.

Risk-averse persons will pay to avoid risk. *Insurance* is the business of taking certain payments in exchange for eliminating risk. Suppose that an insurer offers Angela an insurance policy that pays her \$20,000 if her car is stolen but pays nothing if her car is not stolen.

If Angela has the policy and her car is stolen, she loses the car but receives \$20,000, so on balance, she gains and loses nothing. If her car is not stolen, the insurer will not pay her anything, so she gains and loses nothing. Thus, the insurance policy eliminates the risk that Angela must otherwise bear. Recall that, without insurance, Angela's expected loss is \$300. Hence, if she is risk averse, she would pay at least \$300 for the insurance policy.

Risk averse:
A person prefers a certain amount to risky amounts with the same expected value.

Risk neutral:
A person is indifferent between a certain amount and risky amounts with the same expected value.

How much risk-averse persons are willing to pay for insurance depends on their degree of risk aversion. A more risk-averse person will be willing to pay a larger amount to avoid risk. By contrast, a risk-neutral person will not pay more to avoid risk. For instance, suppose that Lisa is risk neutral and faces the same situation as Angela. She would pay no more than \$300 for insurance.

It is important to understand the meaning of risk and risk aversion because, whenever information is asymmetric, the less-informed party has imperfect information. To the extent that this means uncertainty about benefits or costs, the less-informed party faces risk.

Progress check 11A. Suppose that Angela buys an insurance policy that pays her \$20,000 if her car is stolen and nothing if her car is not stolen. Who of the following has imperfect information and who faces risk: (a) Angela; (b) the insurer?

11.3 Adverse selection

The quality of wine depends on multiple factors, including the grapes used, location of the vineyard, weather, method of production, and age. Producers of wine have better information about these factors and the quality of the wine than consumers. So information is asymmetric.

Let us use the example of wine to analyze the nature of equilibrium and the effect of price changes on the quantity demanded and supplied in a market with asymmetric information. Consider a very basic setting where wine producers have no reputation and produce wine in plain bottles without labels.

Demand and supply

Initially, suppose that producers offer only high-quality wine. Figure 11.1 shows the supply and demand for high-quality wine. In equilibrium at point *b*, the price would be \$50 per bottle and production would be 300,000 bottles a month.

Now suppose that producers also produce 100,000 bottles of low-quality wine, at marginal cost ranging from zero to \$1. In principle, two markets could exist: one for low-quality wine and another for high-quality wine. Suppose, however, that potential consumers cannot distinguish high from low quality. Then there can be only one market. In that single market, low-quality wine trades alongside high-quality wine, so the supply of high- and low-quality wine is combined.

Figure 11.2 illustrates the market with both low- and high-quality wine. The combined supply of low- and high-quality wine begins with the supply of low-quality wine from zero to 100,000 bottles at a marginal cost of \$1 per bottle. Then the combined supply curve runs parallel to the supply of high-quality wine.

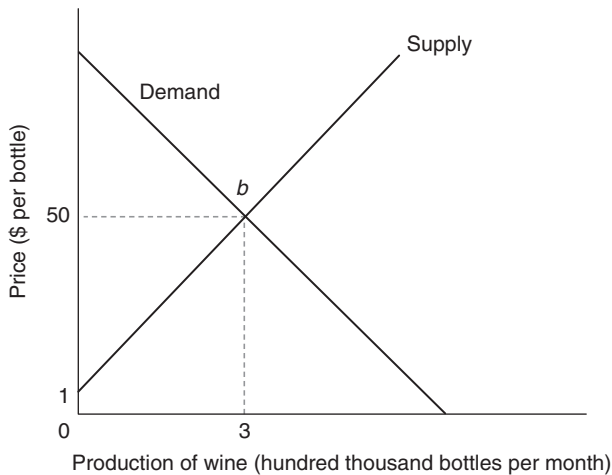


Figure 11.1 Market with symmetric information

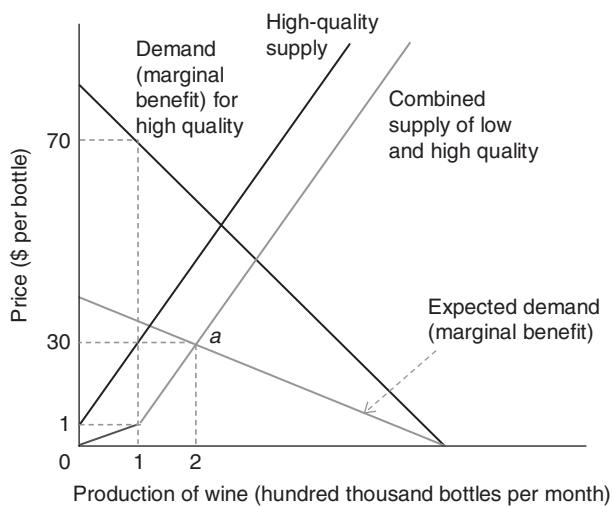


Figure 11.2 Market with asymmetric information

What about the demand side of the market? Consumers do not know whether the wine is of low or high quality. Assume that they are risk neutral. Each consumer has a marginal benefit curve for high-quality wine. Suppose that their marginal benefit from low-quality wine is zero. So, each consumer's *expected marginal benefit* is the marginal benefit from high quality multiplied by the probability of getting high quality.

Suppose that consumers buy a total of Q hundred thousand bottles, of which 100,000 are of low quality. Then each consumer has probability $1/Q$ of getting

low-quality wine and probability $(Q - 1)/Q$ of getting high-quality wine. So, the consumer's expected marginal benefit is $(Q - 1)/Q$ of her marginal benefit for high-quality wine. The consumer's expected marginal benefit curve (adjusted for the probability of getting low quality) is her marginal benefit curve for high-quality wine, shifted down by the proportion $1/Q$ at every quantity.

Accordingly, the expected demand for wine (adjusted for the probability of getting low quality) is the demand curve for high-quality wine shifted down by the proportion $1/Q$. Equivalently, at every possible quantity, the consumers' actual willingness to pay is only a fraction $(Q - 1)/Q$ of their willingness to pay for that quantity of high-quality wine.

Market equilibrium

Having laid out the demand and the supply, we can identify the equilibrium. The expected demand and the combined supply cross at point *a*, where the price is \$30 per bottle and the quantity *Q* is 200,000 units a month. Hence, the probability that a consumer gets low-quality wine is $100,000/200,000 = 50\%$ and the probability of getting high-quality wine is 50%.

Consumers cannot distinguish good from bad wines, and so they get an *adverse selection* – a mixture of bad and good wines. **Adverse selection** arises in situations of asymmetric information: the less-informed party draws a selection with relatively bad characteristics.

What if the production of low-quality wine is lower or higher? If, for instance, there are 50,000 bottles of low-quality wine, then the expected demand would be higher and the combined supply of low- and high-quality wine would be further to the left. Then the equilibrium will have a higher price. The equilibrium production, however, might be lower or higher: the demand is higher, but supply is further to the left.

By contrast, if the production of low-quality wine is larger, then the expected demand would be lower and the combined supply would be further to the right. Hence, the market price would be lower. Again, production might be lower or higher, depending on the balance between demand and supply.

Adverse selection:

The less-informed party draws a selection with relatively bad characteristics.

Progress check 11B. Using Figure 11.2, illustrate the market equilibrium with production of 50,000 bottles of low-quality wine at a marginal cost of up to \$1 per bottle.

Economic inefficiency

Referring to Figure 11.2, in the market equilibrium, the price is \$30 per bottle and production is 200,000 bottles a month. Production comprises 100,000 bottles of low-quality wine and 100,000 bottles of high-quality wine. By the supply curve of high-quality wine, the marginal cost of producing the 100,000th bottle is \$30. Consumers

buy up to the point that the expected marginal benefit (adjusted for the probability of getting low quality) equals the market price. Low-quality wine provides no marginal benefit, so, in equilibrium, the marginal benefit of consumers who get low-quality wine is less than the marginal cost.

By contrast, referring to the marginal benefit curve for high-quality wine, at 100,000 bottles a month, the marginal benefit is \$70 per bottle. This exceeds the marginal cost of producing the high-quality wine, \$30 per bottle. Accordingly, the equilibrium is not economically efficient.

If, somehow, another bottle of high-quality wine could be produced and sold, then there would be a consumer willing to pay a little less than \$70, and it would cost a little more than \$30 to produce. Accordingly, there is a potential value added of almost \$40.

Essentially, sellers of low-quality wine impose a negative externality on consumers and producers of high-quality wine. By Chapter 10, we know that the negative externality would exceed the economically efficient level. This means that a profit can be made by resolving the externality, which, in this setting, means resolving the information asymmetry.

Market failure

Before considering how to resolve an asymmetry of information, let us look at an extreme possibility. Suppose that wine producers produce F hundred thousand bottles of low-quality wine. Referring to Figure 11.3, the combined supply of low and high-quality wine has a kink at point c .

What if the quantity of low-quality wine is so large that the expected demand crosses the combined supply at some point d below the kink? In this case, there will be no supply of high-quality wine and the entire supply will be low-quality wine.

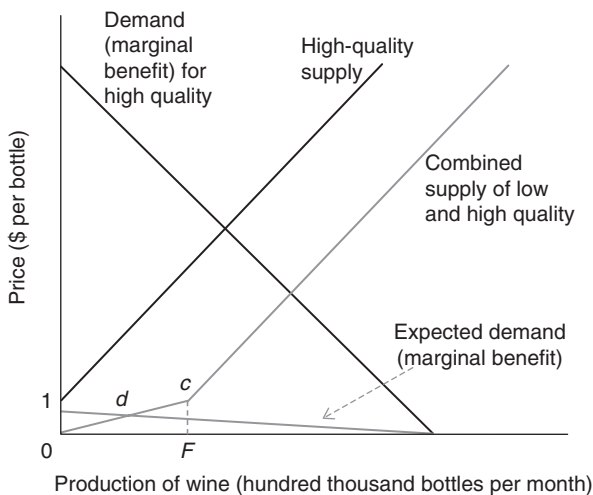


Figure 11.3 Market failure

Then a consumer's probability of getting high-quality wine would be zero. This means that the expected marginal benefit and the expected demand curve must coincide with the horizontal axis. Thus, the initial supposition that the expected demand crosses the combined supply at some point d is not valid.

So there cannot be a market equilibrium with the expected demand curve crossing the combined supply below the kink. Indeed, the same logic also shows that there cannot be an equilibrium with the expected demand curve crossing the combined supply above but close to the kink. If there cannot be an equilibrium, then the intrusion of low-quality wine has caused the entire market to fail!

Let us view the market failure from another perspective. A change in price has very different effects in a perfectly competitive market as compared to a market subject to adverse selection. Suppose that, in a perfectly competitive market, the quantity supplied exceeds the quantity demanded. Then a price reduction will reduce the quantity supplied and raise the quantity demanded. A sufficient reduction of the market price will restore equilibrium.

By contrast, suppose that the market for wine is out of equilibrium, with the quantity supplied exceeding the quantity demanded. Consider a reduction in the market price. The marginal cost of producing high-quality wine slopes upward from a minimum of \$1 per bottle. So, when the market price is lower, high-quality wine producers produce less.

However, a reduction in the market price (so long as it remains above \$1) does not affect the production of low-quality wine. Hence, the lower market price raises the proportion of low-quality wine, leaving consumers with a worse adverse selection. So their willingness to pay and the expected demand curve would fall.

Thus, in a market with adverse selection, a cut in price reduces both the quantity demanded and the quantity supplied, so it need not reduce the excess supply and restore equilibrium. At the extreme, if the price is cut very low, the expected demand curve would fall to zero and the market would fail completely.

Progress check 11C. Referring to Figure 11.3, suppose that the expected demand curve crosses the combined supply curve at point c . What would be the market equilibrium price and production?

Ethiopian coffee

The highly desired Arabica coffee bean originates from Ethiopia. In 2008, economist Eleni Gabre-Mahin established the Ethiopian Commodity Exchange with the exclusive right to trade coffee.

Crucially, the Exchange mixed the raw beans from different sources before auction. The mixing frustrated coffee traders who marketed traceable

coffee as a premium product. The mixing also weakened the incentive of the 5 million growers to increase quality.

Menno Simons, chief executive of Dutch coffee importer Trabocca, remarked, "The diversity of Ethiopia's coffee is unique... In terms of quality it's number one, with Kenya and Colombia number two." Yet, Ethiopian coffees sold for less than half of Kenyan.

Then, in 2017, the government reformed the industry to allow the beans to be separated until auction, enabling full traceability. The reforms also allowed foreign businesses to vertically integrate into planting coffee for direct export. State Minister Arkebe Oqubay expected the reforms to increase earnings five times.

Voluntary retirement: downsizing the humane way

Given a mandate to reduce headcount and budgets, one appealing way is to encourage employees to quit or retire voluntarily. In February 2021, Indian Finance Minister Nirmala Sitharaman announced that the government would privatize two banks.

Before the privatization, the banks would offer voluntary retirement to employees. Unnamed sources explained that the reduction of staff would make the banks more attractive to private sector buyers.

Voluntary separation seems much more humane than retrenchment. But who would volunteer? Would the schemes leave the banks with an adverse selection of personnel?

11.4 Appraisal

When information is asymmetric, the market outcome will not be economically efficient. Resolving the information asymmetry would raise benefits by more than costs, and so there is an opportunity to add value and make a profit.

The most obvious way to overcome asymmetric information is to obtain the information directly. In the wine example, referring to Figure 11.2, in the equilibrium at point a , the marginal benefit of high-quality wine is \$70, while the market price is \$30. There is a potential gain of almost \$40 from appraisal – getting an expert to identify the high-quality wine.

To the extent that appraisals are available, there will be a separate market for good wine. In that market, consumers and producers would have equal information, and so perfect competition will lead to economic efficiency.

An information asymmetry can be resolved by **appraisal** under two conditions. One is that the characteristic about which information is asymmetric must be

Appraisal: works if the characteristic about which information is asymmetric is objectively verifiable and if it is not too costly.

objectively verifiable. If different appraisers give different opinions, then information will still be asymmetric.

The other condition is that the potential gain from resolving the asymmetry must exceed the cost of appraisal. This, in turn, depends on the proportion of low relative to high quality, and the difference between the marginal benefit and marginal cost.

Progress check 11D. Will appraisals be more common in the market for cheap or more expensive products?

Credit rating

In the business-to-consumer market for retail loans, lenders refer to credit rating agencies. In the UK, credit rating agencies classify borrowers into excellent, good, fair, poor, and very poor. In the United States, most agencies use the Fair Isaac Corporation (FICO) score.

Similarly, in the business-to-business market for commercial loans, lenders refer to credit rating agencies. Since a credit rating is information, its use is non-rival. Typically, commercial borrowers pay for credit ratings which they provide to potential lenders. This is more efficient than if every potential lender were to procure a credit rating for the same borrower.

Appraisal on the Internet: TripAdvisor

Asymmetric information is rife in tourism. Travelers seek good value lodging from a plethora of establishments in distant places. The problem is especially severe for small hotels and lodgings not affiliated with any chain.

Enter technology-enabled TripAdvisor, which covers far more than professional guides like Fodor's, Frommer's, Lonely Planet, and Rick Steves. As of December 2020, TripAdvisor published 884 million reviews and opinions on 7.9 million lodgings, restaurants, and other travel activities.

Screening: An initiative of a less-informed party to indirectly elicit the better-informed party's characteristics.

11.5 Screening

While appraisal can directly resolve information asymmetries, it is costly and may not be feasible. So it is important to consider indirect ways to resolve asymmetric information. Here, we present *screening*, and discuss the two other methods – signaling and contingent contracts – below. **Screening** is an initiative of a less-informed party to *indirectly* elicit the better-informed party's characteristics.

Self-selection

Screening exploits the sensitivity of the better-informed party to some variable that the less-informed party can control. The strategy is to design choices around that variable to induce **self-selection**, meaning that parties with different characteristics choose different alternatives.

Self-selection:

Parties with different characteristics choose different alternatives.

Consider the market where consumers cannot distinguish low- from high-quality wine. The unknown characteristic is the true quality of the wine. Suppose that consumers insist that they get the first bottle of wine free and then buy a case of 12 for the price of 13 bottles. Can this deal effectively screen low- from high-quality wine?

Suppose that consumers who get high-quality wine would buy the case, while those who get low-quality wine would not buy the case. So producers of low-quality wine would not accept the deal. The deal makes sense only for high-quality producers. Thus, it credibly screens the two types of producers.

Screening is possible only if the less-informed party can control some variable to which the better-informed parties are *differentially* sensitive. In the wine example, low-quality producers are more sensitive to the follow-up purchase than high-quality producers.

By contrast with appraisal, screening reveals the information of the better-informed party indirectly. Consumers do not directly learn the quality of the wine. Rather, they require producers to make a choice that indirectly reveals their characteristics.

A key business application of screening is to pricing. Chapter 8 on pricing presented *indirect segment discrimination*. Such discrimination applies screening to induce self-selection among buyers with different price elasticities of demand.

Differentiating variables

In some instances, the less-informed party can choose between several differentiating variables. Then, the less-informed party should structure the choice that drives the most cost-effective wedge between the better-informed parties with the different characteristics. This may involve a combination of the differentiating variables.

Progress check 11E. Explain why screening depends on self-selection.

Motorcar insurance: choosing the deductible

Motorcar insurers are subject to asymmetric information relative to drivers. Drivers know more about their behavior – how carefully they drive, where they park, and who they allow to use their car. One way by which insurers screen drivers is the choice of deductible. The policy only pays for losses in excess of the deductible.

AMI provides motorcar insurance in New Zealand. For comprehensive insurance on a 2010 Toyota Corolla hatchback with deductibles of NZ\$100 and NZ\$2,000 covering a woman aged 51 with no accidents residing in Wellington, AMI quoted annual premiums of NZ\$647.45 and NZ\$371.45 respectively. The policy with higher deductible attracts better drivers.

Bank lending

By contrast with the typical retail pricing strategy of discounts for larger purchases, banks charge more for larger loans. In June 2021, UK bank Barclays offered five-year fixed rate mortgages at average interest rates of 2.9%, 3.1%, and 3.3% for loans of up to 75%, 80%, and 85% of valuation respectively.

People who have less wealth need to borrow more and impose more risk on the lender. Lenders charge higher interest rates on larger loans to screen between more and less risky borrowers.

11.6 Signaling

Signaling: An initiative of the better-informed party to communicate its characteristics to the less-informed party.

Besides screening, another indirect way to resolve asymmetric information is *signaling*. **Signaling** is an initiative of the better-informed party to communicate its characteristics to the less-informed party. The key is that the communication must be credible, that is, the parties with different characteristics choose different signaling policies.

Recall the wine market where consumers cannot distinguish low- from high-quality wine. Suppose that a high-quality producer offers to give a full refund to any consumer who returns a partly-consumed bottle. Does the refund offer credibly signal that the wine is indeed of high quality?

Consider a producer of low-quality wine. If it offers the refund, all consumers would return their purchases for refund. So the low-quality producer will not offer the refund. Thus, the refund does induce self-selection and credibly signals high quality.

Signaling indirectly communicates the characteristics of the better-informed party and thereby resolves the information asymmetry. The high-quality producer does not directly declare the product quality. Rather, it takes an action that indirectly and credibly communicates the high quality.

To be credible, a signal must induce self-selection among the better-informed parties. The cost of the signal must be sufficiently lower for parties with superior characteristics than for parties with inferior characteristics. Then only those with superior characteristics will offer the signal.

Suppose that a wine producer labels its product “high quality.” However, the cost of the label would be the same for high and low-quality producers. Hence, such a label alone will not induce self-selection and will not be credible.

Progress check 11F. Explain the difference between screening and signaling.

DBS Bank: making banking joyful

The largest bank in Singapore, DBS Bank, declared the vision of “making banking joyful.” Such a vision is a credible signal only if the required investment in better service induces self-selection among competing banks.

Self-selection depends on two conditions. The investment must be large and sunk. If the expenditure is reversible, then a low-quality seller can also make the same investment, pass on inferior products, and get its money back. A reversible investment will not be credible.

Second, buyers must be able to detect poor quality quickly. If a seller can fool buyers for a long time, then even a low-quality seller can afford the sunk investment.

11.7 Contingent contracts

Screening and signaling are two indirect ways to resolve information asymmetries. An important method of screening and signaling is the *contingent contract*. A **contingent contract** specifies actions under particular conditions.

Bets are contingent contracts: you get a dollar from me if the coin turns up heads, while I will get a dollar from you if it turns up tails. In this bet, the contingency is the side of the coin that faces up after the toss.

To see how contingent contracts can resolve an information asymmetry, consider a wine producer selling a vineyard. Suppose that the seller knows that the vines will yield an exceptional quality of grapes. However, it has no independent appraisal or other way to directly convince potential buyers.

What if the seller were to specify that it would sell the vineyard for a share of the grape production rather than a straight cash payment? By asking for a share, the seller is taking a payment that is contingent on the yield from the vines. If the yield is high, then the seller will get a larger payment, while if yield is low, then the seller will receive less.

By selling the vineyard for a share of the production, the seller can credibly convey its information to potential buyers. Sellers of average or relatively low-yielding vines would prefer to sell for cash. Hence, those selling relatively better vines can distinguish themselves by selling for a share of the production. The result is self-selection.

Contingent contract:

Specifies actions under particular conditions.

Contingent contracts can be used to screen and signal. The less-informed party can require a contingent contract to screen the better-informed parties. The better-informed party can offer a contingent contract to signal the less-informed parties.

Marital contingent contract: the prenup

Human relationships are rife with information asymmetry. A particular concern among the rich is that their loving spouse might be marrying for the money. But they can sleep more easily with a prenuptial agreement specifying the division of income and wealth.

Before their wedding in May 2014, Kim Kardashian and Kanye West signed a prenuptial agreement. The agreement provided Kardashian US\$1 million for every year of marriage up to a maximum of US\$10 million as well as title to a Bel Air mansion.

HP: US\$8.8 billion information asymmetry

In mergers and acquisitions, the seller is better informed than the buyer. One solution is to condition payments on sales or profit targets. Another way is to pay in shares, so that the value of the payment depends on the value of the acquisition.

In August 2011, Hewlett-Packard (HP) acquired British software developer Autonomy plc for US\$11.6 billion in cash without any conditions on future sales or profits. Analysts roundly criticized the acquisition. However, HP CEO Léo Apotheker explained: "We have a pretty rigorous process inside H.P. that we follow for all our acquisitions, which is a DCF-based model... And we try to take a very conservative view."

Within a month, HP dismissed Apotheker. Just over a year later, in November 2012, HP wrote down the acquisition by US\$8.8 billion.

Key takeaways

- Risk is uncertainty about benefits or costs.
- A risk-averse person will pay to avoid risk.
- If information is asymmetric, the allocation of resources is not economically efficient, and there is an opportunity to add value and profit by resolving the asymmetry.

- If adverse selection is severe, the market will fail.
- Use appraisal if the characteristic about which information is asymmetric is objectively verifiable and if it is not too costly.
- Use screening to indirectly elicit the characteristics of the better-informed party if the screening induces self-selection.
- A better-informed party can use signaling to indirectly communicate its characteristics if the signaling induces self-selection.
- Use a contingent contract to screen or signal.

Review questions

1. Explain the difference between imperfect information and risk.
2. In the following situations, explain the asymmetry of information, if any: (a) Investors do not know the next day's Standard & Poor's 500 Index. (b) Acquirer is planning a takeover bid for Target at \$50 a share, which is 25% above the current market price of \$40, and is secretly buying shares of Target.
3. A bank has just rejected Lisa's application for a loan. Lisa approaches the loan officer and offers to pay a higher interest rate. Why does the loan officer laugh?
4. A manufacturer of women's clothing pays production workers a piece rate. The human resources manager has proposed offering workers the choice of a fixed salary. Explain the possible adverse selection.
5. Jill is about to buy a secondhand car at a below-market price. The seller assured Jill that the car is in perfect condition. Why should Jill get an expert to evaluate the car?
6. Young people do not have much driving history. Does this explain why insurers are reluctant to insure young drivers?
7. Give an example of screening. Explain: (a) the asymmetry of information; and (b) self-selection.
8. If a borrower defaults on a loan secured by collateral, the creditor can seize the collateral. Explain why the interest rate on secured loans is lower than that on unsecured loans.
9. Motorcar insurers offer a choice of policies with higher deductibles and lower premiums and lower deductibles and higher premiums. Explain how this choice can screen among drivers with different behavior.
10. During peak hours, a tunnel is congested. From the standpoint of economic efficiency, the tunnel service should be allocated to the drivers

who value time most highly. Explain how a toll can achieve economic efficiency.

11. Give an example of signaling. Explain: (a) the asymmetry of information; and (b) self-selection.
 12. Consider a bank that offers deposit insurance, with the compensation to be paid from its own funds. Why is the deposit insurance not a credible signal?
 13. To signal to the enemy that you would defend to the last, which strategy would be more credible: (a) destroy all roads, bridges, and fuel supplies or (b) leave infrastructure intact?
 14. A magazine publisher offers full refunds to any dissatisfied purchaser. Is the refund policy a credible signal of product quality?
 15. How does the following contract help to resolve asymmetric information? Acquirer buys all of Target's shares and pays partly in cash and partly in Acquirer shares.
-

Discussion questions

1. In Hong Kong, insurer AIA offers medical insurance to the public. AIA's Flexi Plan covers the expenses on hospitalization and surgical care subject to limits of HK\$10 million per year and HK\$50 million lifetime.
 - (a) Explain the asymmetry of information between AIA and applicants for medical insurance.
 - (b) The Flexi Plan excludes pre-existing conditions that the applicant knew about. Explain why.
 - (c) How would a group policy, which covers all members of an organization, mitigate adverse selection for the insurer? Explain why adverse selection would be less in a larger group.
 - (d) Unlike falling sick or meeting with accidents, in many cases, women voluntarily enter into pregnancy. Explain why the Flexi Plan excludes coverage of pregnancy.
2. Some Chinese dairy farmers contaminated raw milk with melamine to increase the apparent protein content in testing. In 2008, contaminated infant formula killed six babies and harmed thousands of others. As Chinese parents flocked to buy infant formula in Hong Kong, retailers had to ration sales.
 - (a) Explain the asymmetry of information between producers and consumers of infant formula.
 - (b) Adapt Figure 11.2 to illustrate the equilibrium in the Chinese market for infant formula when consumers cannot distinguish pure from contaminated products.
 - (c) Using your diagram in (b), illustrate how the market can fail if farmers increase the production of contaminated milk.

3. In 2008, economist Eleni Gabre-Mahin established the Ethiopian Commodity Exchange (ECX) with the exclusive right to trade coffee. The Exchange mixed the raw beans from different sources before auction.
 - (a) Explain the asymmetry of information between coffee growers and buyers at the ECX.
 - (b) Adapt Figure 11.2 to illustrate the equilibrium in the ECX with raw beans mixed.
 - (c) Explain why the mixing weakened the incentive of growers to improve quality.
 - (d) From 2017, the government allowed growers to separate the beans until auction. How would this affect market prices and production?
4. Corporations which borrow may commission credit rating agencies to provide ratings to investors. Standard & Poor's ratings correlate well with actual defaults. Between 2001 and 2020, the average ten-year default rate was less than 0.4% among investment-grade (BBB and higher) issuers, and over 12.5% among speculative-grade (BB and lower) issuers.
 - (a) Explain the asymmetry of information between issuers of securities and potential investors.
 - (b) Why is it more cost-effective for issuers of securities rather than potential investors to commission credit ratings? (*Hint: information is non-rival.*)
 - (c) Why is it important that ratings have correlated well with actual defaults?
 - (d) By issuing more debt, a corporation may raise the probability of default. Should ratings be fixed or adjusted over time?
5. In June 2021, UK bank Barclays offered five-year fixed rate mortgages at average interest rates of 2.9%, 3.1%, and 3.3% for loans of up to 75%, 80%, and 85% of valuation respectively. These loans were subject to a processing fee of £999 and limited to existing customers of Premier Banking, a service for clients with high income or large deposits.
 - (a) Explain the asymmetry of information between Barclays and potential borrowers.
 - (b) How did limiting loans to existing Premier Banking customers affect the asymmetry of information?
 - (c) Barclays charged higher interest rates for larger loans. How did this screen among borrowers with different ability to repay?
 - (d) Discuss whether Barclays should charge lower or higher interest rates on unsecured loans as compared with mortgage loans.
6. The largest bank in Singapore, DBS Bank, declared the vision of "making banking joyful."
 - (a) Construct a game in extensive form for a joyful bank. At the initial node, it chooses whether to invest \$20 million in better service. If it does, at the next node, customers choose whether to try the service.

- If customers try, they would be delighted, and the bank would earn \$200 million. If customers do not try, the bank would lose \$20 million. However, if the bank does not invest in better service, it would earn nothing.
- (b) Discuss how the bank's equilibrium strategy depends on the probability that, if the bank invests, the customers would try the service.
 - (c) Construct a game in extensive form for a joyless bank as in (a) with one exception. If the bank invests \$20 million, and customers try, they would be disappointed, and the bank would lose \$10 million. What is the bank's equilibrium strategy?
 - (d) Referring to (b) and (c), under what conditions would the joyful banking strategy be credible?
7. In early 2014, Tesla announced an eight-year warranty on the battery pack and drive unit of its cars with no mileage limit. CEO Elon Musk emphasized: "If we truly believe that electric motors are fundamentally more reliable than gasoline engines... then our warranty policy should reflect that."
 - (a) Explain the asymmetry of information between Tesla and its potential customers.
 - (b) Explain the extended warranty in terms of a contingent contract.
 - (c) Under what conditions will an extended warranty be a credible signal of superior quality?
 - (d) How does Tesla's financial condition affect the credibility of the warranty as a signal?
 8. Genzyme manufactures drugs that treat rare genetic diseases. In July 2010, Sanofi offered to acquire Genzyme at \$69 per share. Genzyme's board rejected the offer and sought \$75. A key issue was the future sales of Genzyme's new multiple sclerosis drug, Lemtrada. Eventually, in February 2011, Genzyme accepted a revised offer of \$74 per share in cash plus a contingent value right (CVR) depending on the sales of Lemtrada and other milestones.
 - (a) Explain the asymmetry of information between Sanofi and Genzyme.
 - (b) Assuming that Genzyme had 271.5 million shares outstanding as of February 2011, estimate the dollar value of the asymmetry.
 - (c) How could the CVR resolve the asymmetry of information? Compare Sanofi's valuation of the CVR with Genzyme's valuation.
 - (d) Could the asymmetry be resolved directly by Sanofi inspecting Genzyme's accounts and facilities?
 9. Before marrying in May 2014, Kim Kardashian and Kanye West signed a prenuptial agreement. The agreement provided Kardashian US\$1 million for every year of marriage up to a maximum of US\$10 million.
 - (a) Explain the asymmetry of information in a marriage between a wealthy man or woman and a relatively poorer spouse.

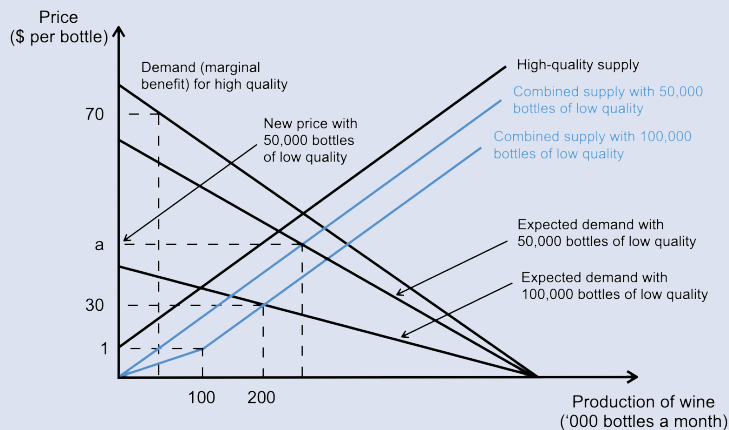
- (b) Explain the prenuptial agreement in terms of a contingent contract.
- (c) How can the prenuptial agreement screen gold-diggers from true life partners?
- (d) Can the relatively poorer person use the prenuptial agreement to signal their true quality?

You are the consultant!

Identify any asymmetry of information in your organization's activities. Write a memo to the board of directors explaining how your organization could exploit the profit opportunities.

Progress check answers

- 11A. Angela has imperfect information but does not face risk. The insurer has imperfect information and faces risk.
- 11B. Relative to the market with 100,000 bottles of low-quality wine, the combined supply would be closer to the supply curve of high-quality wine, and the market price and quantity produced would be higher.



- 11C. If the expected demand curve crosses the combined supply curve at point c, in the market equilibrium, all wine would be low quality. Hence, the expected demand would drop to zero, and the market would fail.

- 11D. Appraisals will be more common in the market for more expensive products. The incremental margin on the product would be more likely to cover the cost of appraisal.
- 11E. If the better-informed parties with different characteristics did not self-select, they would all make the same choice, and then, there would not be screening.
- 11F. Screening is an initiative of the less-informed party, while signaling is an initiative of the better-informed party.

Review answers

- 1. Imperfect information is the absence of certain knowledge. Risk is uncertainty about benefits or costs. A person can have imperfect information about something, but if that thing does not affect their benefits or costs, then it would not impose any risk on them.
- 2. (a) No asymmetry; (b) The directors of Acquirer have better information than the general investor.
- 3. Lisa's offer to pay a higher interest rate indicates that she is less likely to repay the loan.
- 4. The fixed salary will draw relatively less hardworking workers than a piece rate.
- 5. It is in the seller's interest to conceal negative information about the car.
- 6. With less information about the younger drivers, the insurers would be less able to distinguish between good and bad drivers among them. So insurers are more vulnerable to adverse selection.
- 7. [Omitted.]
- 8. Two reasons: (a) Less risk. If a borrower defaults on a secured loan, the creditor can seize the collateral. (b) Less adverse selection. The security serves to screen good from bad borrowers.
- 9. Drivers with a lower probability of accident will prefer a higher deductible as they are less likely to make a claim.
- 10. Drivers whose value of time is less than the toll will not pay, and hence will be screened away in favor of those whose value of time exceeds the toll.
- 11. [Omitted.]
- 12. Deposit insurance compensates depositors if the bank becomes insolvent. If the bank becomes insolvent, it may not have funds to pay the compensation. So, deposit insurance funded by the bank itself may not be credible.

13. Hesitant defenders would be reluctant to adopt (a), and so it would be a more credible signal of defense.
14. Yes. It is relatively more costly for publishers of worse magazines to offer the full refund, because their customers are more likely to demand the refund.
15. By accepting payment in Acquirer's shares, the actual amount that target receives will depend on Target's true value (which Target knows but Acquirer does not).

Discussion answers

1. (a) Applicants for medical insurance have better information about their health and lifestyles than providers of medical insurance.
- (b) Covering pre-existing conditions that the applicant knows would create an adverse selection problem. Those with such conditions would be more likely to buy the insurance.
- (c) A group policy covers all employees including those with better health and lifestyles and those with worse health and lifestyles. So, the risk profile of the insured people would be more typical and there would be less adverse selection. The larger the group, the less the adverse selection.
- (d) Pregnancy coverage would create an adverse selection problem. Women planning to become pregnant would buy the Flexi Plan, while others would not.

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CHAPTER 12

Incentives and organization

LEARNING OBJECTIVES

- Appreciate moral hazard.
- Apply monitoring and incentives to resolve moral hazard.
- Appreciate holdup and detailed contracting.
- Understand ownership and its consequences.
- Appreciate vertical integration.
- Understand and design organizational architecture.

12.1 Introduction

In 2020, electric car pioneer Tesla sold 499,647 vehicles for revenues of US\$31.54 billion. A key component of electric cars, costing about US\$7,350 per car, is the battery. Tesla assembles batteries for its Models 3 and Y from lithium-ion cells at Gigafactory Nevada.

Tesla contracted with Panasonic to manufacture lithium-ion cells at Gigafactory Nevada. In June 2020, Tesla and Panasonic renewed their manufacturing agreement for ten years after specified milestones. Tesla also agreed to buy the Panasonic production at specified prices for two years.

Three months later, Panasonic announced that it would upgrade its existing lines at Gigafactory Nevada to implement a more cost-efficient battery technology, and also add a 14th production line. Still, Tesla declared its long-term plan was to manufacture cells for itself, which would be “more efficient, manufacturable at greater volumes and cost-effective.”

Organizational architecture: The distribution of ownership, monitoring systems, and incentive schemes.

Why did Tesla ask Panasonic to produce lithium-ion cells at Gigafactory Nevada? Why did Tesla contract in advance to buy Panasonic's output at specified prices? Why does Tesla seek to manufacture cells for itself?

Organizational architecture comprises the distribution of ownership, monitoring systems, and incentive schemes. This chapter discusses how to design an efficient organizational architecture, which resolves holdup, moral hazard, and monopoly power, and exploits economies of scale and scope.

Holdup is an action to exploit the dependence of another party. Tesla depends on Panasonic for lithium-ion cells. Panasonic could hold up Tesla by withholding supply. This explains why Tesla seeks to manufacture cells for itself. In turn, Tesla could hold up Panasonic by withholding purchases. This explains why Tesla contracted in advance to buy Panasonic's output at specified prices.

Moral hazard arises when one party's actions affect but are not observed by another party. It results from asymmetry of information about actions. It may explain why Tesla asked Panasonic to produce lithium-ion cells at Gigafactory Nevada. Then Tesla would be better able to observe Panasonic's production.

The architecture of an organization affects the potential for holdup, degree of moral hazard, extent of internal monopoly power, and economies of scale and scope. Together, these determine the economic efficiency of the organization. To the extent of any inefficiency, correcting the inefficiency will add value and profit.

12.2 Moral hazard

To explain moral hazard, consider delivery worker Maggie employed by Luna Express. By the very nature of the job, a delivery worker operates independently and is difficult to monitor. Maggie alone decides how quickly to work.

The delivery worker is subject to moral hazard relative to her employer. A party is subject to **moral hazard** if its actions affect but are not observed by another party.

Moral hazard: One party's actions affect but are not observed by another party.

Asymmetric information about actions

If Luna could freely monitor Maggie, then it can directly specify her effort. Then Maggie would not be subject to moral hazard. Moral hazard arises because information is asymmetric. Luna depends on Maggie's effort but cannot observe it.

Chapter 11 discussed adverse selection, that is, asymmetric information about some fixed characteristic of the better-informed party. By contrast, here, the asymmetry of information concerns some action of the better-informed party. This information asymmetry is a necessary condition for moral hazard.

Economic inefficiency

Suppose that Maggie chooses effort to maximize her personal net benefit, which is her compensation less cost of effort. The level of effort that maximizes her net benefit is that where her marginal compensation equals her marginal cost. Referring to Figure 12.1,

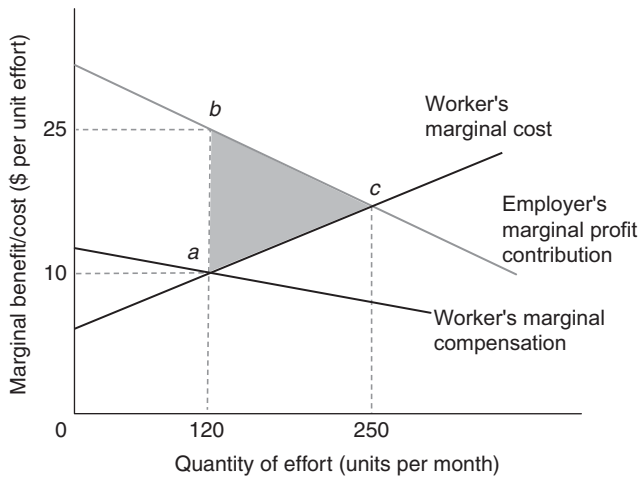


Figure 12.1 Moral hazard

Maggie will choose 120 units of effort. At that level, her marginal compensation and marginal cost are \$10 per unit of effort.

What if Maggie were to increase her effort by one unit? That would increase Luna's profit contribution. Referring to Figure 12.1, when Maggie exerts 120 units of effort, Luna's marginal profit contribution is \$25. So, Maggie's additional effort would increase Luna's profit contribution by \$25.

The cost to Maggie of the additional effort would be \$10. So, the additional effort would add value by increasing the employer's marginal profit contribution by more than the worker's marginal cost.

Indeed, referring to Figure 12.1, Maggie could continue adding value by raising effort up to 250 units. The additional value (the excess of profit contribution over cost) to the employer and worker would be the shaded area *abc*.

Essentially, Maggie generates a positive externality for her employer, Luna. So, as with any positive externality, if it is not resolved then there is an opportunity to add value and raise profit by resolving the externality.

In the delivery context, resolving the externality means resolving the moral hazard between the delivery worker and her employer. The shaded area *abc* represents the amount of value that can be added by resolving the moral hazard. The challenge then is how to do so.

Degree of moral hazard

Suppose that Maggie's marginal compensation coincides exactly with Luna's marginal profit contribution. Then Maggie would choose the economically efficient level of effort. Under these conditions, there will be no moral hazard.

We can measure the degree of moral hazard by the difference between the economically efficient action and the action chosen by the party subject to moral hazard. The

larger this difference is, the greater are the degree of moral hazard and the value that can be added by resolving the moral hazard.

Progress check 12A. Suppose that, in Figure 12.1, Maggie's marginal cost of effort is higher. How does this affect: (a) the economically efficient effort; (b) the effort that Maggie actually chooses?

Dentist at your service

Asymmetric information is rife in healthcare. Patients rely on doctors and dentists for advice and treatment. The dual role of healthcare professionals subjects them to moral hazard relative to patients.

In 2016, economists Felix Gottschalk, Wanda Mimra, and Christian Waibel carried out a field experiment on dental care in Zurich, Switzerland. They sent a man who did not need treatment to 180 dentists for assessment. Of the 180, 50 recommended at least one filling, with one advising six. The mean cost of the treatment was CHF 535.

Moral hazard at the top

Publicly listed companies have diverse shareholders ranging from pension funds with million-dollar holdings to individuals with several hundred shares. Their top executives are subject to moral hazard relative to shareholders. Shareholders are concerned about the value of their shares. By contrast, top executives may have different objectives.

On 20 April 2010, British Petroleum's oil rig, Deepwater Horizon, exploded in the Gulf of Mexico. BP's CEO, Tony Hayward, downplayed the incident, describing the Gulf as a "big ocean" and claiming that the environmental impact would be "very very modest."

During the ensuing crisis, Hayward took leave to sail his yacht. However, facing mounting criticism, he decided to resign. BP shares rose by 4.85%, increasing the market value of the company by US\$5.6 billion.

12.3 Monitoring and incentives

Moral hazard can be resolved in two complementary ways. One is to monitor the actions of the party subject to moral hazard. The other is to align the incentives of the party subject to moral hazard with those of the less-informed party.

Monitoring systems and incentive schemes are two elements of organizational architecture. They are complementary because incentives must be based on actions that can be observed, so the better the available information, the wider will be the choice of incentive schemes.

Monitoring

The simplest monitoring system focuses on objective measures of performance such as hours on the job. However, hours on the job and effort are not the same thing. Delivery worker Maggie could start at 8am and finish at 5pm, but do nothing during that time. So more information is needed.

One way to collect more information is through supervision. It is not cost-effective for supervisors to monitor subordinates all the time, however. So supervisors make random checks. Chapter 9 discussed the advantages of randomization. The same principle applies to supervision: the supervisor should check staff at random, rather than according to some regular pattern.

In business-to-consumer contexts, employers can enlist customers to monitor workers. Customers are naturally placed to monitor workers. Employers can encourage customers to report worker performance.

Incentives

The counterpart to monitoring systems is incentive schemes. Incentive schemes resolve moral hazard by paying workers according to performance. The schemes depend on a link between the *unobservable* action and some *observable* measure of performance.

An employer can use the information provided by monitoring systems to structure incentives for its workers. While Luna cannot observe Maggie's effort, it can observe her deliveries. So, Luna can pay Maggie according to the number of deliveries.

Suppose first that Luna pays her a fixed wage of \$4,000 per month. Maggie cannot affect her earnings in any way, however hard she works. Her marginal compensation from effort will be zero.

Referring to Figure 12.2, Maggie's marginal compensation with a fixed wage is the horizontal axis. This is lower than her marginal cost at all levels of effort. Hence, Maggie would choose zero effort.

Now suppose that Luna pays Maggie a commission of \$10 per delivery. The more deliveries Maggie makes, the more she will earn. With this incentive scheme, her marginal compensation from effort will be positive. The marginal compensation curve depends on how her effort affects deliveries.

Referring to Figure 12.2, Maggie's marginal compensation curve with \$10 commission crosses her marginal cost at an effort of 30 units. Hence, she chooses 30 units of effort and the commission partly resolves the moral hazard.

An incentive scheme is stronger if it raises the marginal compensation for effort. Suppose that Luna raises the commission to \$15 per delivery. Then her marginal

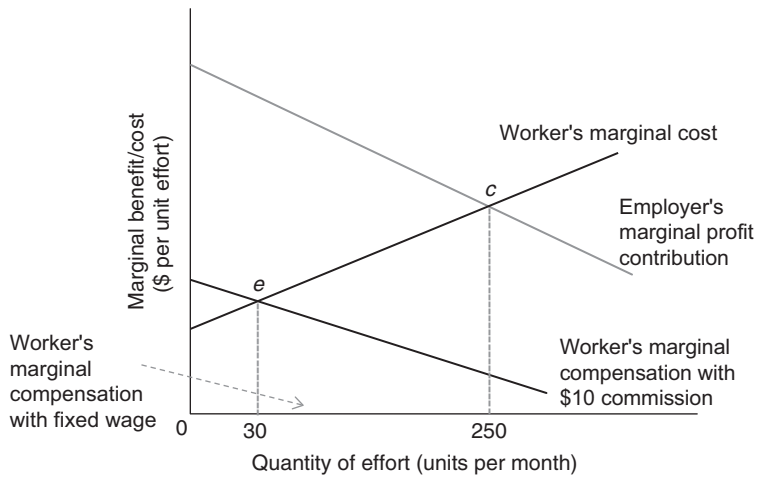


Figure 12.2 Incentives

compensation curve would be higher, and it would cross her marginal cost curve at a higher level of effort. A stronger incentive scheme reduces the moral hazard.

Risk

Incentive schemes resolve moral hazard by paying according to some observable measure of the unobservable action. But what if the measure is affected by extraneous factors other than the unobservable action? Then the payments will depend on these other factors and the uncertainty about these factors will impose risk.

Consider, for instance, Maggie's commission on deliveries. Besides her effort, the actual deliveries will depend on the number of orders and traffic conditions. Maggie would be uncertain about these factors, and so, the incentive scheme imposes risk on her. Risk will arise if the party subject to moral hazard is uncertain about her compensation.

To achieve economic efficiency, the incentive scheme must balance the incentive for effort with the cost of risk. The cost of risk depends on the degree to which the party subject to moral hazard is risk averse, the impact of the extraneous factors, and the strength of the incentive scheme. Stronger incentives would induce more effort. However, stronger incentives would also impose a heavier burden of risk.

Progress check 12B. Using Figure 12.2, draw a marginal compensation curve such that the delivery worker would choose the economically efficient level of effort.

Progressive: technology mitigates moral hazard

Drivers covered by motorcar insurance are subject to moral hazard. Insurers cannot easily observe drivers' behavior but must pay for loss and damage. However, information and communications technologies have changed that.

U.S. motorcar insurer Progressive Corporation offers Snapshot, a mobile application that records driving behavior. The app particularly monitors acceleration, hard braking, late-night driving, and use of the phone while driving.

At the time of writing, Progressive gave new clients an average discount of US\$47 for installing Snapshot. Among Snapshot clients, 80% earned an additional discount, averaging US\$146, while the remainder paid higher premiums.

12.4 Holdup

Moral hazard arises when one party's actions affect but are not observed by another party. A related managerial issue is *holdup*. To explain holdup, suppose that Maggie's working hours are 8am to 5pm. One day, however, there were so many orders that Luna asked her to work past 5pm. Maggie took the opportunity to demand twice the usual commission per delivery.

A **holdup** is an action to exploit another party's dependence. Holdup is distinct from moral hazard in that it does not require asymmetric information. For example, when Luna requested the extra work, Maggie openly demanded a higher commission. There was no asymmetry of information.

Holdup: An action to exploit another party's dependence.

Maggie's holdup has implications beyond the exceptional fee that Luna paid on one occasion. The potential for holdup in the future would lead Luna to take precautions. For instance, it might limit the number of delivery orders that it accepts, or it might even hire another delivery worker. These precautions would reduce revenues or increase costs.

Generally, whenever there is the potential for holdup, other parties will take precautions to avoid dependence. These precautions either reduce benefits or increase costs. So, the potential for holdup reduces overall value and economic efficiency. This means that there is an opportunity to add value and increase profit by resolving the holdup.

Specific investments

An important precaution against holdup is to reduce specific investments. Suppose that Luna trained Maggie to optimize delivery efficiency. This training is an investment

Specificity: The percentage of an investment that will be lost if the asset is switched to another use.

that is specific to employing Maggie. If Maggie were to quit, Luna would lose the benefit of the training.

The **specificity** of an investment is the percentage that will be lost if the asset is switched to another use. For instance, suppose that the cost of the training is \$400 in labor and \$100 in materials. If Maggie quits, Luna can reuse the materials. So, the specificity of the investment training is $400/(400 + 100) = 80\%$.

Investments in both physical and human assets can be specific. The potential for holdup will deter all forms of specific investments. If holdup could be prevented, the relevant parties would increase specific investments, and so add value and increase profit.

Incomplete contracts

Suppose that Maggie's employment contract had specified conditions under which she had to work overtime and the corresponding fee. Then Maggie would not have been able to hold up Luna. The scope for a holdup depends on the extent to which the contract between the parties is *incomplete*.

Complete contract: Specifies the actions of all parties under every possible contingency.

A **complete contract** specifies the actions of all parties under every possible contingency. By contrast, a contract is incomplete if it does not specify the actions of the parties in some contingency. The actions specified by the contract may include payments.

It is costly to prepare and agree a complete contract. A huge number of contingencies must be covered. Practically, rather than consider every detail, parties will agree on an incomplete contract, and deliberately so. The issue is then how incomplete the contract should be.

Generally, the appropriate degree of incompleteness depends on the potential benefits and costs of completeness. One factor is the stakes. The larger the stakes, the more the parties should invest in preparing the contract. Luna should write a more detailed contract with Maggie for delivery of time-sensitive legal documents than stationery.

The other factor is possible contingencies. Legal negotiations extending late into the night are not uncommon. By contrast, the demand for stationery is fairly stable. So, again, Luna should write a more detailed contract for delivery of time-sensitive legal documents than stationery.

Progress check 12C. What factors should the parties consider in deciding how detailed a contract to prepare?

Electricity without specificity: floating power plants

In 2007, the Turkish energy group, Karadeniz Holding AŞ, launched the "Power of Friendship" project to supply electricity in the Middle East, Africa,

and Asia. Karadeniz's concept was to build floating plants by installing generating sets on ships.

The first floating plant, the *Doğan Bey*, with a capacity of 126.4 MW, was repurposed from a freighter. The investment in the floating plant is very specific to the provision of electric power. However, by contrast with a conventional terrestrial electric plant, the investment in the floating plant is not specific to any particular location.

In May 2010, the *Doğan Bey* sailed to Iraq, where moored in Umm Qasr Port, she supplied electricity to Basra. At the time of writing, she was moored off Freetown and supplying electricity to Sierra Leone.

Covid-19 vaccines: contracts matter

Both the European Commission (EC) and United Kingdom signed contracts to buy Covid-19 vaccines from AstraZeneca. AstraZeneca met the UK's order, but not the EC's. Between January and March 2021, AstraZeneca delivered just 30 million of 90 million doses promised to the EC. In April 2021, the EC sued AstraZeneca for breach of contract, seeking 120 million doses by June 2021, but lost.

Differences in the contracts explain the different outcomes. The UK contract with AstraZeneca was more detailed and favorable to the purchaser. If AstraZeneca or its subcontractors were induced to delay the supply, the UK government could terminate the contract and impose penalties. By contrast, the EC contract only allowed withholding of payments and waived damages in the event of delays.

Moreover, the UK contract was governed by English law, which follows the exact wording of the contract. By contrast, the EC contract was governed by Belgian law, which considers whether the parties tried their best and acted in good faith.

12.5 Ownership

Holdup may be resolved by changing the *ownership* of the relevant assets. **Ownership** means the rights to *residual control*, which are those rights that have not been contracted away.

To explain the meaning of residual control, suppose that Luna bought a delivery truck with a bank loan. The bank has a security against the truck, which means that, if Luna does not pay on time, the bank can legally repossess the vehicle. This is a right that Luna contracted away to get the loan.

Ownership: Rights to residual control, which are those rights that have not been contracted away.

As owner of the truck, Luna has residual control. This means that it has all rights except those contracted away. For instance, it may rent the truck to another delivery service.

A transfer of ownership means shifting the rights of residual control to another party. If Luna sells the truck, then the new owner would have all the rights that previously belonged to Luna.

Residual income

Residual income:

Income remaining after payment of all other claims.

One aspect of residual control is worth emphasizing. The owner of an asset has the right to receive the **residual income** from the asset, which is the income remaining after payment of all other claims.

To illustrate, suppose that Luna rents the truck to Solis for \$2,000 per month. Luna's expenses include \$1,000 in interest and principal to the bank and \$100 in taxes and other expenses. As owner of the truck, Luna receives the residual income of \$2,000 – \$1,000 – \$100 = \$900.

Importantly, as the recipient of the residual income, the owner gets the full benefit of changes in revenues and expenses. For instance, if Luna can increase the rent by \$100, then its profit would increase by \$100. Similarly, if Luna can reduce expenses by \$50, then its profit would increase by \$50.

So the owner has the full incentive to maximize the value of the asset. By contrast, other users of the asset would have less incentive. If the owner is less informed about their actions, they would be subject to moral hazard. Even in the absence of asymmetric information, they may hold up the owner.

Vertical integration

Vertical integration:

The combination of assets for two successive stages of production under common ownership.

Vertical integration is the combination of the assets for two successive stages of production under a common ownership. With common ownership, the owner would have full incentive to maximize the value of the combined assets. By contrast, if the assets are separately owned, each owner would maximize the value of its own asset, disregarding the effect on the other owner.

Vertical integration is downstream or upstream, depending on whether it involves the acquisition of assets for a stage of production nearer to or further from the end user. Suppose, for instance, that a supermarket acquires a delivery service. Since the delivery service is closer to the consumer, this vertical integration is downstream. By contrast, if the supermarket were to acquire a farm, the vertical integration would be upstream.

The decision to vertically integrate upstream is often characterized as the choice of whether to “make or buy.” The supermarket can either *buy* vegetables from farmers or set up its own farm to *make* the input.

Similarly, the decision to vertically integrate downstream may be characterized as the choice of whether to “sell or use.” The farmer can either *sell* her products to supermarkets or establish her own grocery store and *use* her vegetables as input.

Vertical integration or disintegration changes the ownership of assets, and hence alters the distribution of the rights to residual control and residual income. As we explain in the next section, these in turn affect the degree of moral hazard and the potential for holdup.

Progress check 12D. Explain the difference between upstream and downstream vertical integration.

NIO: making the car

Chinese manufacturer NIO specializes in premium electric cars. NIO outsourced the production of its ES8, ES6, and EC6 models to Jianghuai Automobile Group of Hefei, Anhui Province. Government-owned Jianghuai also produced electric cars for Volkswagen.

Jianghuai built a plant with capacity to produce 100,000 units per year. NIO agreed to pay Jianghuai a fee for each unit produced and also compensation for operating losses within the first three years. Between 2018 and 2020, NIO paid 778.4 million yuan in fees and 455.5 million yuan in compensation. In May 2020, NIO extended the agreement for three years, and Jianghuai increased capacity to 240,000 units.

Meanwhile, the Hefei municipal government invested 7 billion yuan in cash into NIO China. NIO agreed to contribute its China businesses and assets, valued at 17.77 billion yuan and 4.26 billion yuan in cash into NIO China.

12.6 Organizational architecture

In Chapter 1, we discussed the vertical and horizontal boundaries of an organization. A car manufacturer that produces batteries is more vertically integrated than one that buys batteries from others. A car manufacturer that also manufactures trucks has wider horizontal boundaries than one that specializes in cars.

Vertical and horizontal boundaries are just two aspects of the organizational architecture, which comprises the distribution of ownership, monitoring systems, and incentive schemes. From the viewpoint of managerial economics, the design of organizational architecture depends on a balance among resolving four issues:

- holdup,
- moral hazard,
- internal market power, and
- economies of scale and scope.

Above, we discussed specific ways of resolving moral hazard and holdup. Here, we consider how ownership will affect holdup, moral hazard, internal market power, and economies of scale and scope.

Holdup

How would changing the ownership of the relevant assets resolve holdup? Recall that when Luna asked Maggie to work overtime, she demanded a higher commission. Luna could have asked another worker to make the delivery.

But what if Maggie had been an independent contractor with her own truck? If Luna refused to concede, Luna would have to find another vehicle as well as another worker. This would be more costly than just finding another worker. Moreover, as owner of the truck, Maggie could more easily find other work, and so would be more likely to engage in holdup.

Hence, by owning the truck, Luna can reduce the likelihood of holdup as well as the costs in the event of holdup. Generally, vertical integration can mitigate the potential for holdup.

Moral hazard

Changes in ownership also affect the degree of moral hazard. To illustrate, suppose that Luna contracts with a warehouse to store goods that it delivers. The owner of the warehouse receives the residual income. Hence, if she exerts additional effort, she would receive all of the additional profit contribution. Thus, when balancing her marginal benefit and marginal cost, the owner would choose the economically efficient effort.

Now, suppose that Luna buys the warehouse and employs the former owner as manager of the facility. Like any worker who does not own the business, managers are subject to moral hazard.

Vertical integration changes ownership. Since an employee is subject to relatively greater moral hazard than an owner, vertical integration increases the degree of moral hazard.

Internal market power

Changes in ownership will affect the monopoly power of internal sources of inputs and monopsony power of internal users of outputs. If Luna sets up its own warehouse, it might prefer using its own warehouse to other warehouses.

The preference in favor of an internal provider, however, means creating an internal monopoly. Chapter 7 showed that a seller with market power would restrict production and raise price. An internal provider may also use its market power to raise its price above the price charged by external providers. This higher cost must be borne by the organization.

One way of resolving an internal monopoly is a policy to outsource whenever the internal provider's cost exceeds that of external sources. Outsourcing is the purchase

of services or supplies from external sources. It subjects internal providers to market competition, and so limits the extent to which internal costs exceed the competitive level.

Similarly, if a business produces an input that it uses internally for downstream production, the downstream user may acquire monopsony power. Chapter 7 showed that a buyer with market power would restrict purchases to depress the price. A policy to sell externally whenever the external price is higher than the internal transfer price can resolve the internal monopsony power.

Economies of scale and scope

Finally, changes in ownership affect the extent of economies of scale and scope. Recall from Chapter 6 that, if there are economies of scale, then the average cost of provision will be lower with a larger scale. An internal provider might operate at a smaller scale than an external contractor. It then is necessary to consider how the average cost varies with the scale of production.

For instance, Luna's need for storage may be quite limited. If Luna were to set up its own warehouse, its utilization would be relatively low. By contrast, an external warehouse would have better capacity utilization and hence a lower average cost. To this extent, it would be less costly to purchase storage from an external contractor.

Also from Chapter 6, if there are economies of scope across two products, then the total cost of production will be lower when the two products are produced together than when they are produced separately. Economies of scope may explain the growth of logistics services. Providing both storage and delivery may be less costly than specializing in storage and delivery.

Economies of scope are the major factor in favor of wide horizontal organizational boundaries. However, for an individual organization, economies of scope have countervailing effects. If it already produces one item, then it can reduce total cost by producing the other one as well. However, if it does not already produce either item, then economies of scope imply that it should outsource both.

Balance

The appropriate organizational architecture depends on a balance among the four issues – the scope for holdup, the degree of moral hazard, internal market power, and the extent of economies of scale and scope – and on other ways to resolve these issues.

Specifically, holdup can be resolved through more detailed contracts and avoiding specific investments, moral hazard can be resolved through incentives and monitoring, and internal market power can be resolved through outsourcing and external sales. Generally, the economically efficient solution will involve a mix of all policies.

Let us illustrate the application of this framework with two examples. One concerns the vertical boundaries of the organization, while the other concerns its horizontal boundaries. The two examples show that the same framework can be applied to address both vertical and horizontal dimensions of organizational architecture.

Vertically integrate

- Holdup
- Economies of scope

Outsource

- Moral hazard
- Internal market power
- Economies of scale and scope

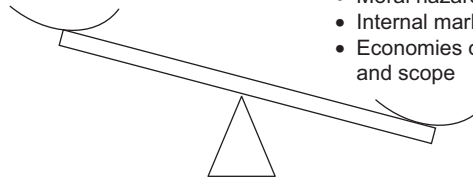


Figure 12.3 Vertical integration

A function that many organizations consider whether to “make or buy” is information technology services. As Figure 12.3 shows, this decision resolves into a balance among four issues. Two factors favor the decision to “make.” One is the extent to which the potential for holdup cannot be cost-effectively reduced through more detailed contracts or avoiding specific investments. The other is the extent to which the internal provider enjoys economies of scope in information technology services.

There are three factors in favor of deciding to “buy.” One is the extent to which the moral hazard of the internal information technology group cannot be cost-effectively resolved through monitoring and incentives. Another is the extent to which internal monopoly power cannot be cost-effectively redressed through outsourcing. A third is the extent to which the internal unit will lack economies of scale and scope in providing information technology services.

Decisions whether to “make or buy” concern the vertical boundaries of the organization. An organization must also consider its horizontal boundaries.

For instance, should a car manufacturer also produce trucks? As the businesses are not vertically related, holdup and internal market power are not relevant. The key factor in favor of producing both is economies of scope. The factor against is the extent to which moral hazard in the trucking unit cannot be cost-effectively resolved through monitoring and incentives.

Progress check 12E. What are the four issues to consider in the decision whether to “make or buy”?

Contract and ownership: Gigafactory Nevada

At Gigafactory Nevada, Panasonic manufactures lithium-ion cells, which Tesla assembles into batteries for its Models 3 and Y. In June 2020, Tesla and Panasonic renewed their manufacturing agreement for ten years after

specified milestones. Tesla also agreed to buy the Panasonic production at specified prices for two years.

Three months later, Panasonic announced that it would upgrade its existing lines at Gigafactory Nevada to implement a more cost-efficient battery technology. Panasonic also would add a 14th production line.

With Panasonic manufacturing lithium-ion cells at Gigafactory Nevada, Tesla could more easily monitor Panasonic and coordinate production. However, by co-locating with Tesla, Panasonic exposed itself to holdup. The advance purchase agreement at specified prices partly resolved the holdup.

Still, Tesla preferred vertical integration. It declared a long-term plan to itself manufacture the cells, which would be "more efficient, manufacturable at greater volumes and cost-effective." Setting up internal manufacturing would be a strategic move to discourage Panasonic from overpricing.

Boeing: unintended vertical integration

In the late 2000s, Boeing's Chairman and CEO, Harry Stonecipher, and head of Commercial Airplanes, Alan Mulally, decided to radically out-source design and construction of the 787. Outsourcing would reduce the required capital and boost financial returns.

Boeing contracted with Vought Aircraft Industries to design and build two rear fuselage sections at Charleston, South Carolina. It also contracted with a joint venture of Vought and Alenia of Italy to assemble the fuselages and send them to Boeing for final assembly.

However, Vought encountered technical and financial difficulties. Its owner, the private-equity investor Carlyle Group, refused to invest more and instead sought to sell out. Vought's CEO, Elmer Doty, explained that "the financial demands of this program are clearly growing beyond what a company our size can support."

In 2008, Boeing bought Vought's share of the joint venture with Alenia. Finally, in July 2009, to resolve the holdup, Boeing again resorted to vertical integration and bought Vought's Charleston factory for US\$1 billion.

Key takeaways

- Moral hazard arises if one party's actions affect but are not observed by another party.
- Resolve moral hazard through monitoring and incentives.

- Holdup is action to exploit another party's dependence.
- Resolve holdup through detailed contracts, avoiding specific investments, and by vertical integration.
- Ownership is the rights to residual control, which are those rights that have not been contracted away.
- Vertical integration is the combination of the assets for two successive stages of production under a common ownership.
- Apply organizational architecture to balance holdup, moral hazard, internal market power, and economies of scale and scope.

Review questions

1. In the context of your business or organization, explain the meaning of organizational architecture.
2. Explain the moral hazard in the following situation. Angela has just bought insurance on her car to covers loss and damage. Her insurer is concerned that she may take fewer precautions against theft.
3. By considering benefits and costs to the various parties, explain why resolving moral hazard can be profitable.
4. Why is it better to pay a real estate broker by commission, as a percentage of the selling price of the property, rather than an hourly rate?
5. Explain the relation between monitoring and incentives.
6. Your compensation package includes shares of the company, which vest after three years. Explain the risk that you bear.
7. Give an example of holdup. Explain what precautions to take.
8. How does the potential for holdup reduce the value of transactions and relationships?
9. Which of the following investments by a pilot is relatively more specific? (a) An MBA program. (b) Training on an airline's flight management system.
10. Why do businesses enter into contracts that are deliberately incomplete?
11. In the context of an incorporated business, explain the meaning of: (a) residual control; (b) residual income.
12. How does vertical integration affect moral hazard?
13. A car manufacturer has experienced holdup by its supplier of electronics. Should the car manufacturer produce the electronics internally?
14. How can outsourcing resolve the monopoly power of an internal supplier?
15. Explain the role of economies of scope in decisions about horizontal integration.

Discussion questions

1. The National University of Singapore provides outpatient medical insurance to faculty and staff. The plan covers the entire bill for treatment and medicine at an approved general practitioner subject to a copayment of S\$5.
 - (a) Construct a diagram with quantity of healthcare (including treatment and medicines) on the horizontal axis and marginal benefit and marginal cost of healthcare on the vertical axis. Draw the patient's marginal benefit and marginal cost, and the insurer's marginal cost.
 - (b) Compare the level of healthcare that the patient would choose with the level that maximizes the patient's benefit less the insurer's cost.
 - (c) How does the S\$5 copayment affect the patient's choice between (i) a generic drug that costs S\$5 and (ii) a branded drug that costs S\$50?
 - (d) Suppose that the University replaces the S\$5 copayment with a 10% copayment. Use your diagram to illustrate how that would affect the patient's choice of healthcare.
2. U.S. motorcar insurer Progressive Corporation offers Snapshot, a mobile application which records driving behavior. New clients who installed Snapshot received an average discount of US\$47. Among Snapshot clients, 80% earned an additional discount, averaging US\$146, while the remainder paid higher premiums.
 - (a) Why would Progressive give a discount for installing Snapshot?
 - (b) Use Snapshot to illustrate monitoring and incentives.
 - (c) Adapt Figure 12.2 to explain the effect of Snapshot on moral hazard.
 - (d) Snapshot is optional. Should the 20% who paid higher premiums opt out? If so, how should Progressive adjust the premium?
3. Singapore's largest mall, VivoCity, contracted with Mapletree Investments to manage the mall. The manager is responsible for the carpark, as well as cleaning, security, and other common services. The mall's retail tenants pay rental which is partly fixed and partly based on the retailer's sales revenue.
 - (a) How is the manager of VivoCity subject to moral hazard relative to its tenants?
 - (b) How does the revenue-based rental align the interests of landlord and tenant?
 - (c) Ideally, should the variable payment be based on the tenant's gross revenue or net revenue (gross revenue less cost of goods sold)?
4. Pension funds and trusts may be limited to investing in securities of particular credit rating, e.g., AAA. To appeal to such investors, investment banks that issue structured products need to meet the required credit rating. Credit rating agencies rate securities, and, after issuance, continue

to update the rating. The agency charges the issuer a fee for rating as well as a fee for updating.

- (a) Consider the managers of an investment bank which plans to issue a structured product. Would they be more concerned about the initial rating or updating?
 - (b) How does your answer to (a) depend on the turnover of investment bank managers?
 - (c) What is the incentive for the rating agency to rate a structured product as AAA?
 - (d) Who would be more affected by inaccuracy in updating: the issuer or the rating agency?
5. Turkish energy group, Karadeniz Holding AŞ, supplies electricity from generators mounted on ships. In May 2010, the first floating plant, the *Doğan Bey*, sailed to Iraq and supplied electricity to Basra. In 2018, she moved to West Africa and supplied electricity to Sierra Leone.
 - (a) How is the specificity of an investment related to sunk costs?
 - (b) Explain the concept of specific investments in relation to building an electric power generation facility.
 - (c) Is the problem of holdup more or less serious for investments with a longer payback period?
 - (d) Do you expect the demand among investors for floating power plants to be greater or less in countries with high political risk? Explain why.
 6. Built at a cost of 4.6 billion euros, the Nord Stream 1 pipeline transports natural gas extracted by Gazprom in Russia to Germany. In January 2006, Gazprom signed a contract with BASF for 8 billion cubic meters of gas a year from 2010 to 2020. Then, in August 2006, Gazprom signed a contract with E.ON for 4 billion cubic meters a year from 2020 to 2035.
 - (a) Why was it important for Gazprom to sign these contracts before commencing construction of the pipeline?
 - (b) Would it be just as good for Gazprom to sign an initial five-year contract with the German customers and then renew the contract later on?
 - (c) Should the contracts specify the price of the gas or leave it for later negotiation?
 - (d) The German companies also bought shares in the pipeline. How would this help to resolve the potential for holdup?
 7. Both the European Commission and United Kingdom contracted to buy Covid-19 vaccines from AstraZeneca. The UK contract provided that if AstraZeneca or its subcontractors were induced to delay the supply, the UK government could terminate the contract and impose penalties. By contrast, the EC contract only allowed withholding of payments and waived damages in the event of delays.

- (a) If you were AstraZeneca and faced production constraints, explain whether you would give priority to the EC or UK.
 - (b) Compare the prices that you would expect for the EC vis-à-vis UK contracts.
 - (c) The EC also contracted to buy vaccines from Pfizer and BioNTech, and other manufacturers. How would that mitigate the potential for holdup?
 - (d) AstraZeneca outsourced some production of Covid-19 vaccines to contract manufacturers. Discuss how the contractors might be subject to moral hazard with respect to production quality.
8. Boeing contracted with Vought Aircraft Industries to design and build two 787 rear fuselage sections at Charleston, South Carolina. Facing technical and financial difficulties, Vought's owner, the Carlyle Group, refused to invest more and instead sought to sell out. In July 2009, Boeing bought the Charleston factory from Vought for US\$1 billion.
- (a) Explain how Boeing and Vought were dependent on each other.
 - (b) Explain Carlyle Group's refusal to invest more in terms of holdup.
 - (c) The Carlyle Group approached various potential buyers. Why would Boeing pay more than other potential buyers?
 - (d) The potential for holdup may lead a manufacturer to contract with two contractors, a practice called "second-sourcing." How does second-sourcing affect economies of scale?
9. At Gigafactory Nevada, Panasonic manufactures lithium-ion cells, which Tesla assembles into batteries for its Models 3 and Y. In June 2020, Tesla and Panasonic renewed their manufacturing agreement for ten years after specified milestones. Tesla also agreed to buy the Panasonic production at specified prices for two years.
- (a) What holdup problem did Tesla face?
 - (b) How did Panasonic co-locating at Gigafactory Nevada resolve the holdup?
 - (c) What holdup problem did Panasonic face?
 - (d) How did Tesla's advance purchase of Panasonic's output resolve the holdup?
 - (e) Why was it important to specify the prices in advance?

You are the consultant!

Consider the architecture of your organization. How can your organization add value by: (a) outsourcing/insourcing, (b) revising incentive schemes, (c) adjusting ownership?

Progress check answers

- 12A. (a) The economically efficient effort will be lower. (b) The effort that the worker actually chooses will be lower.
- 12B. Draw any marginal compensation curve that crosses the worker's marginal cost curve at 250 units of effort a month.
- 12C. Potential benefits and costs – stakes and possible contingencies.
- 12D. Upstream vertical integration is the acquisition of assets for a stage of production further from the end user. Downstream vertical integration is the acquisition of assets for a stage of production closer to the end user.
- 12E. The potential to reduce holdup through detailed contracting and avoiding specific investments; the potential to resolve moral hazard through monitoring and incentives; the potential for outsourcing to reduce internal monopoly power; and the extent of economies of scale and scope.

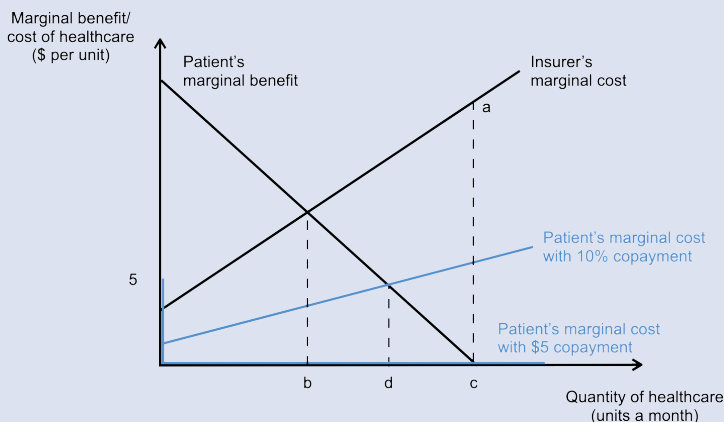
Review answers

- 1. [Omitted.]
- 2. It is costly for the insurer to monitor Angela's precautions, so information is asymmetric. Angela bears the cost of precautions but receives only part of the benefit.
- 3. The party subject to moral hazard will choose the activity at the level where their own marginal benefit equals own marginal cost. At that level, the sum of marginal benefits to all parties differs from the sum of marginal costs to all parties. So a profit can be made by adjusting the activity to the level where the sum of marginal benefits equals the sum of marginal costs.
- 4. It can help to resolve moral hazard by linking compensation to some measure of performance.
- 5. Incentive schemes depend on a link between unobservable action and some observable measure of performance. Monitoring produces the observable measures.
- 6. Your compensation will be affected by factors other than your performance, such as the general state of the economy and competition.
- 7. [Omitted.]
- 8. The potential for holdup would lead the dependent party to take precautions such as writing more detailed contracts and avoiding specific investments. The precautions would increase its costs and reduce its revenues.

9. (b) Training on the airline's flight management system is more specific.
10. Because the additional cost of preparing a complete contract outweighs the potential benefit in avoidance of holdup.
11. (a) Shareholders have residual control (rights that have not been contracted away). For instance, they may dismiss the current board of directors and management. (b) Shareholders also have the rights to residual income (income remaining after the payment of all other claims). They receive dividends only after all other claims, such as interest and debts, have been paid.
12. By changing ownership, vertical integration may change owners into employees. Employees are subject to moral hazard.
13. It should consider the disadvantages of internal production – moral hazard, internal monopoly, and inefficient scale and scope.
14. Outsourcing constrains the monopoly power of the internal supplier.
15. Economies of scope are one reason for horizontal integration: the organization can produce a variety of products at lower cost than if each item were produced separately. However, if the organization produces none of the items for which there are economies of scope, then it should outsource all of them rather than producing a subset.

Discussion answers

1. (a) See figure below.



- (b) For the patient, the \$5 copayment is a fixed cost. So, her marginal cost is vertical at zero quantity of healthcare from \$5 to \$0, and then follows the horizontal axis. She would choose the level

- of healthcare where her marginal benefit equals marginal cost, at level c. The economically efficient level of treatment (that maximizes the patient's benefit less the insurer's cost) is at level b.
- (c) She would choose the branded drug since her cost is the same \$5 for either choice.
 - (d) The quantity of medical healthcare would decrease to level d.

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CHAPTER 13

Regulation

LEARNING OBJECTIVES

- Appreciate the conditions for a natural monopoly and how to regulate a monopoly.
- Appreciate the conditions for a potentially competitive market and how to foster competition.
- Appreciate how to regulate markets with asymmetric information.
- Appreciate how governments should regulate externalities.
- Recognize that global externalities require multilateral cooperation.
- Appreciate how to regulate externalities that are contingent on demand or supply.

13.1 Introduction

In 2019, Jeff Bezos and Christiana Figueres launched the Climate Pledge, by which businesses commit to net zero carbon emissions by 2040. Amazon.com itself pledged to use only renewable energy by 2025, reduce emissions on half of all shipments to net zero carbon by 2030, buy 100,000 electric delivery vehicles, and invest US\$2 billion to reduce carbon emissions and preserve nature.

By April 2021, over 100 businesses had signed the Climate Pledge. The most recent signatories included Alaska Airlines, Colgate-Palmolive, Heineken, PepsiCo, Telefónica, and Visa.

This chapter addresses the role of the government in situations where buyers and sellers, acting independently and selfishly, do not equalize marginal benefit and marginal cost. So, the invisible hand fails – the allocation of resources is not economically efficient.

If private action fails to resolve the economic inefficiency, then there may be a role for government regulation. If the government can resolve the divergence between marginal benefit and marginal cost, then it will increase net benefit for society.

To understand the role of government regulation, we consider the various possible sources of economic inefficiency: market power, asymmetric information, and externalities. For each source of economic inefficiency, we analyze the conditions under which the government should intervene and the appropriate form of regulation.

Greenhouse gases trap heat in the atmosphere and warm the planet. The largest humanly caused source of greenhouse gases is the burning of fossil fuels which releases carbon dioxide. These emissions impose a negative externality on all people (present and future).

Amazon and other major businesses recognize the externality. The Climate Pledge helps to prepare them for regulation of carbon emissions. At the time of writing, major economies including the European Union, China, Japan, Korea, Canada, and the U.S. states of California, Massachusetts, and Washington had begun to regulate carbon emissions.

Over time, the trend is for broader and tougher regulation of emissions. As businesses make investments, especially those with long lives, it makes sense to anticipate future regulation and plan accordingly.

13.2 Natural monopoly

Natural monopoly:

A market where the average cost of production is minimized with a single supplier.

A market is a **natural monopoly** if the average cost of production is minimized with a single supplier. Essentially, economies of scale or scope are large relative to the market demand.

For instance, electricity is distributed through a network of cables. Consider a town with two competing electricity distributors with separate infrastructure. Then two sets of cables would run into every home, office, and factory. In the electricity distribution industry, allowing competition would result in wasteful duplication.

Other examples of natural monopolies include broadband service, distribution of gas and water, and sewage collection. In all of these markets, the economies of scale may be large relative to the market demand. So, the average cost of production is lowest when there is only one supplier.

If a market is a natural monopoly, the government should prohibit competition and allow only a single supplier. This would establish the conditions for production at the lowest average cost.

The monopoly, however, might exploit its exclusive right to raise its price at the expense of its customers. The increase in the price would force the marginal benefit above the marginal cost. Accordingly, to ensure economic efficiency, the government must control the monopoly. The government can do this in two ways:

- The government itself can own the business, and operate at the economically efficient level.
- Award a monopoly franchise to a commercial enterprise and subject the monopoly to regulation.

Government ownership

In principle, government ownership and operation is the simplest and most direct way to ensure economic efficiency. However, in practice, government-owned enterprises tend to be relatively inefficient, and so government ownership and operation fails to achieve economic efficiency.

One source of inefficiency is that government-owned enterprises are prone to being coopted by employees, so that the enterprise serves its employees rather than its customers. Some symptoms of employee control are high wages and overstaffing, both of which inflate costs.

Another source of inefficiency is that government-owned enterprises depend on the government for investment funds. The government budget must finance everything from social welfare to national defense. A government-owned enterprise must compete with other priorities for an allocation from the budget and may not be able to secure the economically efficient level of investment.

Owing to the limitations of government ownership and operation, a worldwide trend has been to *privatize* government-owned enterprises. **Privatization** means transferring ownership from the government to the private sector. It does not necessarily mean allowing competition. Indeed, many privatized enterprises are monopolies in their markets.

Privatization:

Transfer of ownership from government to private sector.

Price regulation

Recall from Chapter 5 that the quantity of a good or service will be economically efficient where marginal benefit equals marginal cost. Suppose that the government awards an exclusive franchise for electricity distribution to Luna Power. Luna's costs include a fixed cost and a constant marginal cost of \$40 per megawatt-hour (MWh). Figure 13.1 shows the cost of distribution and the demand for electricity.

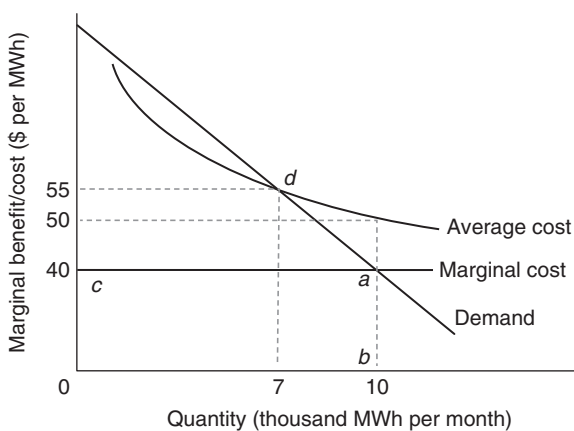


Figure 13.1 Price regulation

Marginal cost pricing:

The provider must set the price equal to the marginal cost and supply the quantity demanded.

Suppose that the government requires the provider to set its price equal to its marginal cost and to meet the quantity demanded. Then, referring to Figure 13.1, at every possible quantity, the price will be the marginal cost. In effect, the government's policy forces the provider to behave like a perfectly competitive supplier. This policy is called **marginal cost pricing**.

The demand curve crosses the marginal cost curve at point *a*. If Luna sets a price of \$40 per megawatt-hour, the market would demand a quantity of 10,000 MWh. Under marginal cost pricing regulation, Luna must supply the quantity demanded; hence, it must produce 10,000 MWh. Now, each customer buys the quantity that balances its marginal benefit with the price. Hence, marginal benefit equals marginal cost, which is the condition for economic efficiency.

Price regulation presents two challenges. One is that, under marginal cost pricing, the provider may incur a loss. Luna's revenue is represented by the area *Obac*, which is $\$40 \times 10,000 = \$400,000$ a month. The average cost at 10,000 MWh is \$50 per MWh, which means that the total cost is $\$50 \times 10,000 = \$500,000$. With marginal cost pricing, the provider would incur a loss of $\$500,000 - \$400,000 = \$100,000$ a month.

Accordingly, the government must provide a subsidy of \$100,000 a month to ensure that the provider is financially viable. The subsidy is necessary to achieve economic efficiency. However, the regulator must then raise funds to provide the subsidy.

How should the government regulate Luna if it does not wish to provide a subsidy? The policy that most closely approaches economic efficiency while allowing the provider to break even is **average cost pricing**. Under **average cost pricing**, the provider must set the price equal to average cost and supply the quantity demanded. With average cost pricing, the provider would exactly cover its costs. Applying average cost pricing to Luna, the price would be \$55 per megawatt-hour and the quantity demanded would be 7,000 MWh a month.

Average cost pricing:

The provider must set the price equal to the average cost and supply the quantity demanded.

The other challenge in price regulation is to acquire information about the provider's costs. The franchise holder has a strong incentive to over-report its costs. Then the regulator will allow a higher price, which would enable the provider to increase its profit. Recalling Chapter 11, if the information asymmetry between regulator and franchise holder is not resolved, the allocation of resources would be economically inefficient.

Progress check 13A. Referring to Figure 13.1, suppose that the demand is higher. How would that affect the optimal price?

Rate-of-return regulation

Under price regulation, the franchise holder may exaggerate its reported costs and so inflate the regulated price. The alternative to price regulation is rate-of-return regulation. This avoids the issue of costs by focusing on the franchise holder's profit. The

regulator allows the franchise holder to set prices freely, provided that it does not exceed the maximum allowed profit.

Under rate-of-return regulation, the regulator limits the franchise holder's profit by stipulating a maximum rate of return on the value of the **rate base**. The rate base may be specified by assets or equity. Whenever the franchise holder's rate of return exceeds the specified maximum, it will be required to reduce its prices.

Suppose, for instance, that Luna Power is regulated to a maximum 12% rate of return on allowed assets of \$50 million. Then the maximum allowed profit would be $0.12 \times \$50 = \6 million a year.

Rate-of-return regulation presents three challenges. One challenge is to set the allowed rate of return. Typically, the rate base is large, so a small difference in the allowed rate of return will translate into a large sum of money. The franchise holder would seek to inflate the required rate of return.

Another challenge is to determine what assets are needed to provide the regulated service and, hence, should be counted in the rate base. The franchise holder will seek the widest possible definition to increase its profit.

Further, within the definition of the rate base, the franchise holder will incentive to invest beyond the economically efficient level. By enlarging the rate base, the allowed rate of return will be applied to a larger base, and so the franchise holder can increase its profit.

Rate base: Assets or equity on which the franchise holder may earn the allowed rate of return.

Progress check 13B. Explain rate-of-return regulation.

Electricity regulation in India: price and return

The Delhi Electricity Regulatory Commission regulates the electricity industry in India's capital. Tata Power Delhi Distribution Limited, a joint venture between Tata Power and the government of Delhi, is the exclusive distributor of electricity in north and northwest Delhi.

The Commission regulates both the prices that Tata Power Delhi can charge and its rate of return. In financial year 2020/21, Tata Power Delhi applied for a regulated rate base of 41.47 billion rupees and weighted average cost of capital of 15.82%, which would allow return on capital employed of $41.47 \times 0.1582 = 6.56$ billion rupees.

However, the Commission only approved a rate base of 35.34 billion rupees and cost of capital of 11.61%, and so, the allowed return on capital employed was $35.34 \times 0.1161 = 4.10$ billion rupees. Further, the Commission did not allow any change in prices.

Potentially competitive market:

Economies of scale and scope are small relative to market demand.

13.3 Potentially competitive market

By contrast with a natural monopoly, a **potentially competitive market** is one where economies of scale and scope are small relative to market demand. So having two or more competing suppliers would not raise average costs. In a potentially competitive market, the invisible hand will ensure economic efficiency and hence society should promote competition.

Competition law

The basic way in which governments promote competition is through competition law (also called “antimonopoly” or “antitrust” law). However, industries that are subject to specific regulation may also be required to comply with competition law specific to the industry.

Generally, competition laws prohibit competitors from colluding on price or other aspects of purchases or sales, prohibit businesses with market power from abusing their market power, and regulate mergers or acquisitions that would create market power. In addition, competition laws may regulate specific business practices such as control over resale prices and exclusive agreements.

The mission of the competition agency is to enforce competition laws. One role is to prosecute collusion and abuse of market power. The other role is to review mergers and acquisitions. The agency may approve the proposed combination subject to specific conditions to mitigate the effects on competition.

Besides government enforcement, the competition laws may also provide for persons harmed by anticompetitive behavior to take legal action in civil law. Under U.S. federal antitrust laws, for instance, plaintiffs in civil actions can recover damages of three times the harm that they suffered. Further, civil plaintiffs can petition courts for an injunction against anticompetitive conduct.

Conduct regulation

The fact that one market is a natural monopoly does not necessarily mean that related upstream or downstream markets are also natural monopolies. In electricity, for instance, production may be potentially competitive even while transmission and distribution are natural monopolies.

In such circumstances, the government must consider how to preserve the benefits of monopoly in one market while fostering competition in others. A special challenge to the regulator arises when the monopoly franchise holder also participates in the potentially competitive market.

To illustrate, suppose that Luna Power has a monopoly franchise over electricity distribution but the government allows competition in generation. So, Luna is a monopsony in the purchase of electricity from generators. Hence, the government must regulate Luna's monopoly over distribution of electricity as well as its monopsony over purchases of electricity.

Now suppose that Luna has vertically integrated upstream into the generation of electricity. Then Luna may then prefer to buy electricity from its internal generator even if more costly than competing generators. This would be economically inefficient.

One way to prevent such inefficiency is for the regulator to stipulate Luna's conduct, and specifically, to prohibit discrimination between internal and external suppliers of electricity. Under **conduct regulation**, the regulator stipulates how a business produces goods and services.

Conduct regulation:
Stipulating how a business produces goods and services.

Structural regulation

An even stricter way of resolving possible discrimination by a vertically integrated entity against external parties is *structural regulation*. This would be to separate the natural monopoly from the potentially competitive market. Under **structural regulation**, the regulator separates the businesses that produce related goods and services.

The regulator could require Luna to separate its electricity distribution and generation businesses. In the extreme, it could simply disallow Luna from generating electricity. With Luna purely distributing electricity, it would have no incentive to discriminate among generators of electricity.

Structural regulation:
Separating businesses that produce related goods and services.

Progress check 13C. Explain conduct and structural regulation.

Competition in data

In July 2019, Thomson Reuters and private equity owners disclosed a possible sale of Refinitiv to the London Stock Exchange Group (LSEG) for US\$27 billion. Refinitiv provided financial markets data and infrastructure to over 40,000 institutions in 190 countries. The LSEG provided financial markets infrastructure.

The merger required approvals in multiple jurisdictions. In July and August 2020, the US Department of Justice and Australian Competition & Consumer Commission allowed the merger.

In January 2021, the European Commission (EC) approved the merger subject to conditions on structure and conduct. The LSEG agreed to divest the Borsa Italiana group, and to provide data to downstream competitors for ten years. In May 2021, the Competition and Consumer Commission of Singapore approved the merger with similar conditions on data.

13.4 Asymmetric information

The invisible hand may also fail where information about some characteristic or future action is asymmetric. Recall from Chapters 11 and 12 that, if the information asymmetry is not resolved, the marginal benefit will diverge from marginal cost, and the allocation of resources will not be economically efficient.

Consider, for instance, the market for healthcare. Patients rely on physicians for advice as well as treatment. Owing to the asymmetry of information between physician and patient, the physicians are subject to moral hazard. Physicians may overprescribe treatment to increase their incomes.

Figure 13.2 illustrates the market equilibrium. The true demand is the patients' marginal benefit if they had the same information as their physicians. The inflated demand results from asymmetry of information and exceeds the true demand to the extent that physicians advise excessive treatment.

The inflated demand crosses the supply of treatment at point *a*. In the market equilibrium, the price is \$140 per hour and the quantity of treatment is 210,000 hours a month. At that quantity, the true marginal benefit of treatment is \$50, which is the height of the true demand curve. At that quantity, the marginal cost of treatment is \$140.

In equilibrium, the marginal cost exceeds the true marginal benefit by \$90. This economic inefficiency results from the asymmetry of information between physicians and patients. In Figure 13.2, to the extent that the asymmetry can be resolved, the inflated demand would shift toward the true demand. Then the equilibrium would be closer to point *b*, where the true marginal benefit equals the marginal cost.

Disclosure

The most direct way to resolve asymmetric information is to require the better-informed party to disclose its information truthfully. However, disclosure will resolve the asymmetry only if the information can be objectively verified.

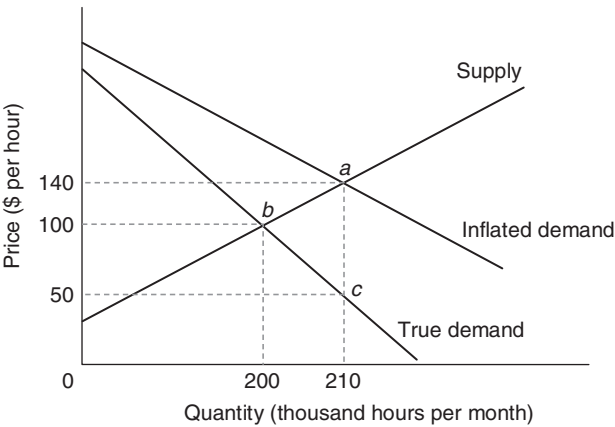


Figure 13.2 Regulating moral hazard

In healthcare, the patient's condition and needs are a matter of professional judgment. To the extent of subjectivity in judgment, disclosure may not resolve the information asymmetry.

Conduct regulation

Instead of directly resolving the information asymmetry, an alternative is to regulate the conduct of the better-informed party and so limit the extent to which it can exploit informational advantage. If parties with better information cannot exploit their advantage, then the outcome would be closer to the economically efficient level.

One way to regulate excessive healthcare would be to pay physicians a fixed salary rather than according to their treatment of patients. This would reduce the incentive to overtreat patients. However, it might also reduce the incentive for effort.

Structural regulation

Another way to limit the extent to which a better-informed party can exploit an informational advantage is to regulate the *structure* of the industry. By enforcing separation of different businesses, a regulator may reduce the opportunities for exploiting superior information.

Some jurisdictions limit physicians to providing advice and treatment, and prohibit them from selling medicines. This structural regulation effectively dissuades doctors from excessive prescription of medicines.

Progress check 13D. How can the government regulate asymmetries of information?

More risk, more return, or just more risk?

The Monetary Authority of Singapore (MAS) regulates the sale of investment products. Financial advisors must consider their client's investment objectives and finances, and only recommend suitable products. They must disclose all material information, including risks and returns, fees and charges, as well as restrictions on withdrawal.

Before the sale of an investment product, a separate person – the supervisor of the advisor – must check and approve the sale. The law also stipulates a minimum “cooling-off period” during which a customer may cancel the purchase without penalty.

Further, the MAS regulates the compensation of financial advisors and their supervisors. Compensation must be based on compliance with regulations as well as sales. In June 2021, the MAS publicly reprimanded insurers Aviva and Prudential for breaching the regulations on compensation.

Mayo Clinic: no financial incentives

At the time of writing, Mayo Clinic, headquartered in Rochester, Minnesota, was ranked highest for quality more than other healthcare providers. Six of 13 Mayo Clinic hospitals earned the highest five-star rating from the U.S. Centers for Medicare & Medicaid Services.

One possible factor might be how Mayo pays its over 2,800 physicians. The compensation scheme prescribes standardized pay steps and increments based on national benchmarks, and does not offer incentives or bonuses. Mayo believes that financial incentives divert physicians from treating patients optimally.

13.5 Externalities

The invisible hand may fail in situations of externalities, that is, when some benefit or cost passes directly from source to recipient and not through a market. Without a market, the invisible hand cannot work.

To illustrate, consider the demand for water from a river or lake. The water that each consumer uses reduces the quantity available to others, and imposes a negative externality.

Chapter 10 showed that, for economic efficiency, an externality should be at the level where the sum of the marginal benefits equals the sum of the marginal costs. Referring to Figure 13.3, the economically efficient consumption is 800,000 cubic meters a year, where the social marginal benefit equals the social marginal cost.

How can economic efficiency be achieved? Generally, there are two ways of regulating externalities. One is user fees or taxes, while the other is standards or quotas.

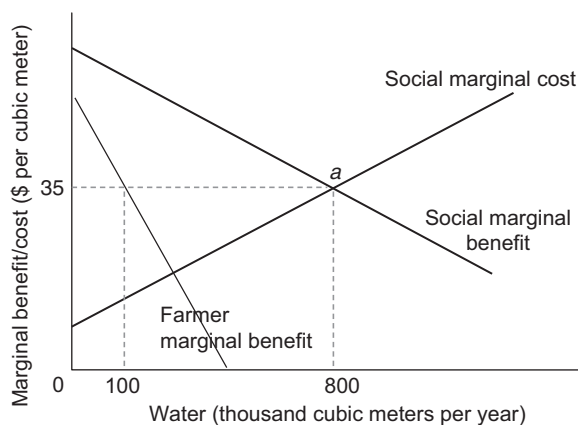


Figure 13.3 Regulating externality

User fee/tax

This method of regulation aims to mimic Adam Smith's invisible hand: allow all consumers to use as much as they like provided that they pay the appropriate user fee or tax.

Referring to Figure 13.3, at the economically efficient consumption, the social marginal cost is \$35 per cubic meter. Suppose that the regulator sets a fee of \$35 per cubic meter.

Consider a farmer who uses the water to irrigate her crops. To maximize profits, she should use water up to where her marginal benefit equals the \$35 fee. Referring to Figure 13.3, that rate is 100,000 cubic meters per year.

To see why that rate maximizes profit, suppose that she uses less than 100,000 cubic meters per year. Then her marginal benefit would exceed \$35. So she should use more water and raise profit. If it uses more than 100,000 cubic meters per year, then her marginal benefit would be less than \$35, and so she should use less water.

All consumers would use water up to the level that their marginal benefit equals the fee. Since the regulator charges the same fee to every consumer, the marginal benefits of all consumers would be equal.

Furthermore, the regulator sets the fee according to the social marginal cost of water. Thus, the marginal benefits equal the fee which equals the social marginal cost of water. So, the fee implements the economically efficient consumption.

Quota/standard

The other method of regulation is directly through quotas or standards. Referring to Figure 13.3, the economically efficient consumption is 800,000 cubic meters per year. So the regulator could simply stipulate a maximum quota of 800,000 cubic meters per year. However, there are many consumers of water. How should the regulator allocate the quota among the various consumers?

One way is to issue licenses for 800,000 cubic meters of water per year and sell the licenses through public auction. Each consumer would demand licenses according to its marginal benefit from water. The market demand would be the social marginal benefit curve in Figure 13.3.

The supply of licenses would be perfectly inelastic at 800,000 cubic meters a year. By Figure 13.3, the marginal benefit of the 800,000th cubic meter of water is \$35. Thus, the equilibrium price of a license – where quantity demanded equals quantity supplied – would be \$35.

Each consumer would buy licenses up to the level that its marginal benefit equals the price of \$35 per cubic meter. Hence, the consumption of water would be economically efficient. By selling water licenses, the regulator is effectively charging a fee that is determined by a competitive market.

In some cases, it may be more cost-effective to regulate through standards rather than quotas or user fees. For instance, it may be less costly to stipulate low-flush toilets than to install water meters and let consumers choose how much water to use in flushing.

Progress check 13E. Referring to Figure 13.3, compare the social marginal benefit and cost if the fee is \$25 per cubic meter.

Colorado River water: who gets it?

The Imperial Irrigation District manages the distribution of water from the Colorado River in California's Imperial Valley. In 2018, the District delivered more than 2.6 million acre feet of water, the majority of it to roughly 520,000 acres of farmland.

Yet, the District must cope with general economic growth and particularly the geothermal industry. In 2013, the District published a plan for the equitable distribution of water.

Farmer Michael Abatti sued the District to rescind the plan, arguing that farmers had a guaranteed right to water. His lawyer, Cheryl Orr, objected that the plan "even provided a priority for future industrial users above agricultural users."

However, Wally Leimgruber of a citizens group which supported the District's plan, countered that "[t]he Abatti claims of historic ownership, current ownership, or special status as trust beneficiaries with respect to the District's water rights are simply wrong."

13.6 Global externalities

Externalities such as water contamination and aircraft noise affect many people within the vicinity. Given the difficulties of resolving such externalities through private action, there may be a role for government regulation.

What about externalities, such as emissions of greenhouse gases and the spread of infectious diseases, which transcend national boundaries? The benefit from resolving global externalities is a public good. All people on earth receive equal, non-rival benefit.

To illustrate, consider emissions of greenhouse gases. Suppose that Figure 13.4 depicts the global marginal benefit and global marginal cost. Since reducing emissions yields non-rival benefit, the global marginal benefit is the vertical sum of the national marginal benefits.

At 35 billion tons per year, the marginal benefit to one particular country is \$8 per ton. The marginal benefits to the other countries add up to \$42 per ton, and so, the global marginal benefit is \$50 per ton.

The economically efficient rate of emissions is that where the global marginal benefit equals the global marginal cost, which is 35 billion tons per year. At that rate, the global marginal benefit and global marginal cost are \$50 per ton.

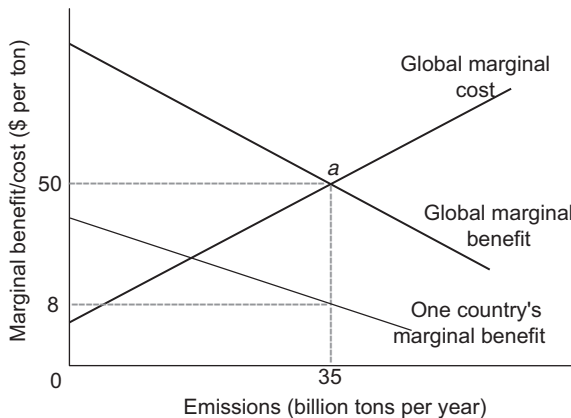


Figure 13.4 Regulating global externality

Multilateral regulation

The challenge to achieving economic efficiency is that regulation by a single government would not resolve the externality. For instance, if some countries regulate fossil fuels while others continue to burn, the carbon would escape into the atmosphere. The atmospheric carbon would harm people in the countries that do not burn.

Moreover, it is difficult to exclude anyone from the benefit of reducing emissions. Individual countries would like to free-ride on reduction of emissions by other countries. Resolving global externalities requires multilateral regulation.

Information and biases

Individual adaptation to government policies may be hindered by information asymmetries and behavioral biases. Such challenges are larger in resolving global externalities, as these involve more diverse people.

Information about the benefits and costs of resolving global externalities may be asymmetric. Those who perceive the benefits to be larger and the costs to be smaller would more strongly support resolving the externalities.

Behavioral biases may affect adaptation to government policies. One bias is hyperbolic discounting, which is the tendency to over-weight the present relative to the future. This would hinder policies that impose costs in the present for benefits in the future.

The status quo bias tends to impede any change in policy. Finally, resolving global externalities may require new technologies and render obsolete existing equipment and facilities. The sunk-cost fallacy would cause vested interests to resist change.

Progress check 13F. Referring to Figure 13.4, if the marginal benefit of one country is lower, how would that affect the economically efficient emissions?

Paris Agreement

Greenhouse gases trap heat in the atmosphere and warm the planet. In December 2015, the 21st Conference of the United Nations Framework Convention on Climate Change in Le Bourget, France, adopted the Paris Agreement. The Agreement aims to limit the increase in the global average temperature to less than 2 degrees Celsius above pre-industrial levels.

As of February 2021, 190 states and the European Union (EU), accounting for about 97% of global emissions, had ratified or acceded to the Agreement. Among others, the EU, China, Japan, Korea, Canada, and the U.S. states of California, Massachusetts, and Washington have begun to regulate carbon emissions.

One mechanism is “cap and trade.” The government stipulates a quota on emissions and allows sources to buy and sell emissions licenses. In 2021, the price of carbon in the EU Emissions Trading System increased to 50 euros per ton. California, Massachusetts, and Washington regulate emissions through cap and trade systems, and China will do so soon.

Another mechanism is a tax on emissions. The Canadian government imposed a carbon tax at the rate of C\$20 per metric ton in 2019, which will increase to C\$50 in 2022.

Climate pledge

At the time of writing, Amazon and over 100 other businesses including Alaska Airlines, Colgate-Palmolive, Heineken, PepsiCo, Telefónica, and Visa had signed the Climate Pledge. This commits them to net zero carbon emissions by 2040.

The Climate Pledge is not just a charitable act. It helps businesses to prepare for increasingly stricter regulation of carbon emissions. Between 2020 and 2021, the price of carbon in the EU Emissions Trading System rose from 30 to 50 euros per ton. The price of carbon in the Californian emissions auction rose from US\$14.53 per metric ton in February 2018 to US\$19.04 in May 2021. The Canadian carbon tax will increase to C\$50 in 2022. The trend is clear.

13.7 Contingent externalities

Externalities may be contingent on demand or supply conditions. To illustrate an externality contingent on demand, consider a tunnel that can smoothly convey traffic up to 50 vehicles per hour. Figure 13.5 depicts the social marginal benefit and social marginal cost.

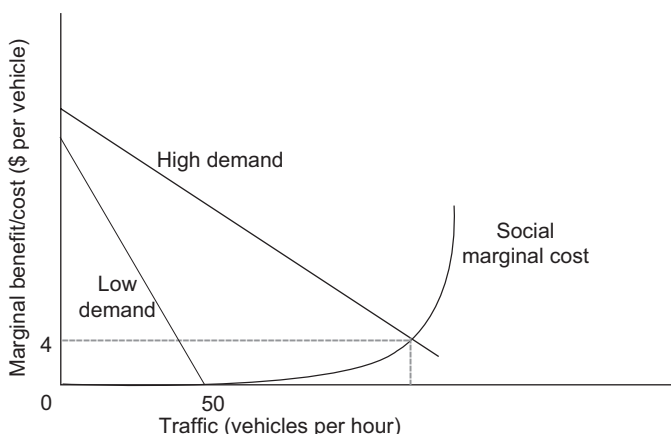


Figure 13.5 Regulating contingent externality

When there are fewer than 50 vehicles per hour, the social marginal cost is zero. When, however, the traffic reaches 50 vehicles per hour, each additional user imposes a cost in congestion, which is a negative externality.

What if the tunnel does not regulate entry? The marginal driver (the 51st) would decide whether to enter the tunnel by comparing her private benefit with her private cost. She would ignore the additional costs on other drivers. Owing to this negative externality, too many drivers enter the tunnel.

For economic efficiency, the tunnel should regulate usage so that the marginal benefit equals the social marginal cost, where the cost includes the negative externalities imposed on other users.

If the tunnel regulates usage through a fee, that fee should vary with demand. Referring to Figure 13.5, when demand is low, the fee should be zero, and when demand is high, the fee should be \$4 per vehicle.

Progress check 13G. Explain why highway tolls should vary with traffic usage.

Mekong: seasonal flows

The Mekong river illustrates an externality that is contingent on supply. From its source in the Tibetan plateau, the Mekong river flows through China as the Lancang, then through Myanmar, Laos, Thailand, Cambodia, and Vietnam to the South China Sea.

In 1995, the four downstream countries signed the Mekong River Agreement to regulate the river flow. The Agreement stipulates a minimum

flow during the dry season, a reverse flow into the Tonle Sap during the wet season, and a maximum peak flow during the flood season.

However, China and Myanmar are not parties to the Agreement. So far, China has built 11 dams on the Lancang. Upstream dams affect the flow to the downstream countries. The intrusion of sea water into the Mekong Delta in southern Vietnam has forced rice farmers to switch to farm shrimp or grow reeds.

Key takeaways

- A market is a natural monopoly if the average cost of production is minimized with a single supplier.
- Governments can regulate monopolies by either price or rate of return.
- Governments can foster competition through competition law, and by regulating conduct and structure.
- Governments can regulate markets with asymmetric information through disclosure, conduct, and structure.
- Governments can regulate externalities through user fees/taxes or quotas/standards.
- Global externalities require multilateral cooperation.
- Regulation of externalities should adjust to demand and supply conditions.

Review questions

1. Explain the concept of a natural monopoly.
2. Does privatization necessarily increase competition? Explain why or why not.
3. Explain marginal cost pricing.
4. What are the problems with price regulation?
5. Discuss the problems with rate-of-return regulation.
6. Explain how to resolve monopolistic behavior by regulating conduct and business structure.
7. The best way to resolve asymmetric information is mandatory disclosure. True or false?

8. Explain how to resolve asymmetric information by regulating conduct and business structure.
 9. Explain how to regulate construction site noise with a user fee.
 10. Compare regulation of automobile emissions through a standard vis-à-vis user fee.
 11. Explain how auctioning a quota of negative externalities would be economically efficient.
 12. Explain the free-rider problem in resolving global externalities.
 13. Discuss how hyperbolic discounting affects public support for reducing greenhouse gas emissions.
 14. Explain how the use of a tunnel can generate negative externalities.
 15. Why should the toll for using a bridge vary by the time of day?
-

Discussion questions

1. The electricity industry in India's National Capital Territory is vertically separated into generation, transmission, and distribution. Tata Power Delhi Distribution Limited (TPDDL) is the exclusive distributor in north and northwest Delhi. In financial year 2020/21, TPDDL applied for a rate base of 41.47 billion rupees and cost of capital of 15.82%. However, the Delhi Electricity Regulatory Commission approved a 35.34 billion rupees rate base and 11.61% cost of capital. Also, the Commission did not allow any change in prices.
 - (a) Explain natural monopoly in the context of electricity distribution.
 - (b) Using a relevant diagram, explain average cost pricing of electricity distribution.
 - (c) Explain why the electricity industry should be vertically separated with monopoly franchises for transmission and distribution.
 - (d) What challenges would the Commission face in administering rate-of-return regulation?
 - (e) Under rate-of-return regulation, discuss the incentives to generate electricity from renewable sources.
2. In January 2021, the London Stock Exchange Group (LSEG) acquired Refinitiv for US\$27 billion. Refinitiv's businesses included trading of European government bonds. The European Commission had approved the merger under several conditions. One was that the LSEG divest the Borsa Italiana group, which also traded European government bonds. Another was to provide data to downstream competitors for ten years.
 - (a) Discuss the effect on market power if the LSEG did not divest the Borsa Italiana group.
 - (b) Explain how structural regulation would resolve the issue in (a).

- (c) Discuss the effect on downstream competitors if the LSEG did not commit to providing data.
 - (d) Consider whether collection and compilation of financial data is a natural monopoly.
3. Most U.S. securities brokers are required to join the Securities Investor Protection Corporation (SIPC). The SIPC covers customers for losses of up to \$500,000 on cash, stocks, and bonds due to default by the broker. The SIPC does not cover losses on other investments such as commodity futures.
 - (a) How does asymmetric information between brokers and investors explain the requirement of SIPC insurance?
 - (b) How does SIPC insurance affect any incentive of brokers to promote risky investments to clients?
 - (c) Some brokers purchase private insurance to cover losses beyond the SIPC coverage. How does this signal their financial reliability?
 - (d) Commodity futures are more complex than stocks and bonds. Why is it reasonable for SIPC not to insure losses on futures?
 4. Mayo Clinic, headquartered in Rochester, Minnesota, is a leading healthcare provider and employs over 2,800 physicians. The Clinic's compensation scheme stipulates standardized pay steps and increments based on national benchmarks, and does not offer incentives or bonuses.
 - (a) Explain the asymmetry of information between physicians and patients.
 - (b) Adapt Figure 13.2 to explain why physicians paid according to treatment might overtreat patients.
 - (c) Referring to your figure in (a), discuss the effect of the Mayo Clinic's compensation scheme.
 - (d) Discuss the effect of the scheme on each physician's unobservable efforts and moral hazard relative to the Mayo Clinic.
 5. In India, many poor parents prefer their children to work than attend school. To encourage attendance, Akshaya Patra provides free lunches at government and government-aided schools. At the time of writing, it served over 1.8 million children at over 19,000 schools. Some parents, even illiterate, pay for their children to attend private schools. Yet, private schools are poorly regulated and some fail to educate their pupils.
 - (a) Consider parents who are subject to hyperbolic discounting. How would that affect their decision whether to educate their children?
 - (b) Does education of children generate an externality? Does that justify a subsidy to education?
 - (c) Explain the asymmetry of information between illiterate parents and private schools, and discuss how it should be resolved.
 - (d) Some reason that giving cash is more efficient than gifts in kind. Discuss whether Akshaya Patra should give cash instead of the free lunch.

6. The European Union has committed to reduce net greenhouse gas emissions by at least 55% by 2030, and climate neutrality by 2050. To reduce emissions, it set up the Emissions Trading System (ETS). The EU stipulates a quota on total emissions, which declines over time. Within the quota, sources of emissions are given or buy emissions allowances, which can be traded.
 - (a) Construct a figure with emissions (million tons per year) on the horizontal axis and marginal benefit/cost (\$ per ton) on the vertical axis. Let the target emissions be 800 million tons per year. Represent this by a marginal social cost curve which is zero up to 800 million and then vertical.
 - (b) Draw two downward sloping social marginal benefit curves, one lower than the other. Compare the economically efficient fee and quota with the two social marginal benefit curves.
 - (c) Suppose that the government is uncertain about the social marginal benefit. Discuss whether the fee or quota is the better policy.
 - (d) Why is it important that the ETS allowances be tradeable?
7. To reduce greenhouse gas emissions, individual businesses must invest in new technologies and possibly retire older equipment and facilities. By April 2020, Amazon and over 100 other businesses had signed the Climate Pledge, which commits them to net zero carbon emissions by 2040.
 - (a) What are the worldwide trends in emissions quotas and taxes?
 - (b) Explain how hyperbolic discounting and the sunk-cost fallacy among managers might delay investments to reduce emissions.
 - (c) How might signing the Climate Pledge help businesses overcome behavioral biases?
 - (d) Discuss possible network effects in the Climate Pledge.
8. Commercial rentals in Causeway Bay, Hong Kong, are among the world's highest. In 2011, the Town Planning Board limited the height of future buildings in the area to less than 200 meters. Real estate developer Hysan Group, which owned nine properties in the area, applied to relax the limits, but the Board denied the application.
 - (a) Explain what externality the height restrictions resolve.
 - (b) Why would the Hysan Group seek to relax the height restrictions?
 - (c) Using a relevant diagram, explain how the Town Planning Board should determine the restrictions on height.
 - (d) Should the restrictions on height be the same throughout Hong Kong?
9. The U.S. Federal Aviation Administration (FAA) classifies all civil transport aircraft in decreasing order of noise, from Stage 1 (noisiest) to Stage 4 (quietest). From 2016, the FAA prohibited the operation of Stage 2 aircraft weighing less than 75,000 pounds within the contiguous United States. Some noisier planes can be retrofitted to Stage 3 standards.

- (a) Discuss whether federal or local governments should regulate aircraft noise.
- (b) Using a relevant diagram, explain how the airport should determine the level of noise to allow. Should the level vary with the time of day?
- (c) Consider an airport that has specified standards for aircraft noise. Should the airport create permits for aircraft noise and allow airlines to trade these permits?
- (d) The FAA regulation does not cover regional jets such as the Embraer 190 and larger aircraft which exceed 75,000 pounds. Discuss this exemption.

You are the consultant!

How does government regulation affect your organization? Write a memorandum to the government explaining how to improve the administration of regulation.

Progress check answers

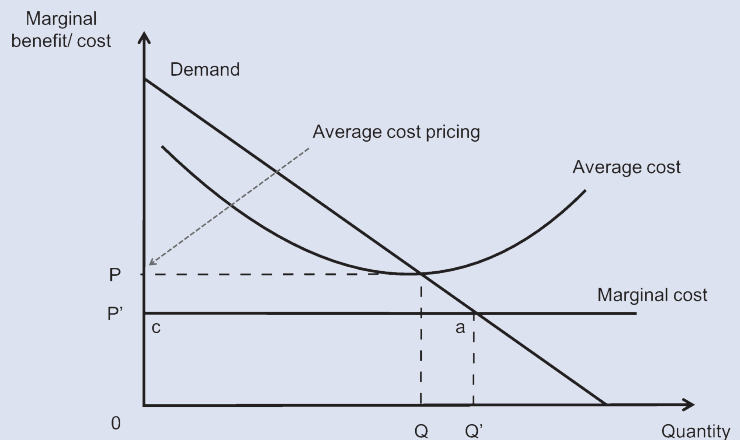
- 13A. The optimal price would be the same (equal to the marginal cost). However, the consumption would be larger.
- 13B. The regulator limits the franchise holder's profit by stipulating a maximum rate of return on the value of the rate base. Whenever the franchise holder's rate of return exceeds the maximum, it will be required to reduce its prices.
- 13C. Conduct regulation stipulates how a business produces goods and services. Structural regulation separates businesses that produce related goods and services.
- 13D. In situations of asymmetric information, the regulator may be able to resolve the asymmetry by regulating the disclosure of information, conduct, and business structure of the better-informed party.
- 13E. If the user fee is \$25 per cubic meter, farmers would consume water to a level where the marginal benefit is less than the social marginal cost. This would be economically inefficient.
- 13F. The global marginal benefit would be lower, and the economically efficient emissions would be lower.
- 13G. The marginal cost of congestion is increasing in traffic usage.

Review answers

1. A market is a natural monopoly if the average cost of production is minimized with a single supplier.
2. Privatization means transferring ownership from the public to the private sector. Allowing competition means removing an exclusive (monopoly) right. A government-owned monopoly may be privatized without allowing competition.
3. Marginal cost pricing means that provider must set price equal to marginal cost and supply the quantity demanded.
4. Price regulation gives the regulated entity an incentive to exaggerate its reported costs and so increase its actual profit.
5. Under rate-of-return regulation, the regulated entity has little incentive to minimize costs and has an incentive to inflate the required rate of return and rate base.
6. Regulation of conduct seeks to prevent a business from exploiting monopoly power, and structural regulation seeks to remove the incentive to exploit monopoly power.
7. False. If the information cannot be objectively verified, disclosure will not resolve the asymmetry.
8. Regulation of conduct seeks to prevent a business from exploiting superior information, and structural regulation seeks to remove the incentive to exploit superior information.
9. The regulator could charge a user fee for noise generated by the construction equipment.
10. Set a standard for engines in terms of emissions (quantity per hour). This would be more practical than charging for emissions.
11. Suppose that the quota is set where social marginal benefit equals social marginal cost. Each source of the negative externality would buy the number of licenses where its marginal benefit equals the auction price. This would be equal to the social marginal cost.
12. It may be difficult to exclude particular countries from enjoying the benefiting of reducing the externality. A country that does not join the agreement to reduce the externality would still benefit.
13. Hyperbolic discounting is the tendency to over-weight the present relative to the future. This would hinder policies that impose costs in the present for benefits in the future.
14. When demand is high, additional users cause congestion which is harmful to other users.
15. Because the marginal cost of congestion varies by the time of day.

Discussion answer

1. (a) The average cost of electricity distribution is minimized with a single supplier. So, electricity distribution is a natural monopoly.
- (b) With average cost pricing, the price equals average cost and the provider must supply the demand. Referring to the figure, the regulated price would be P and the quantity would be Q .



- (c) If the electricity industry were not vertically separated, the electricity distributor would have an incentive to buy electricity from its internal generator even if doing so was more costly than buying from competing generators. Such discrimination between internal and external suppliers of electricity is eliminated through vertical separation, which is a form of structural regulation.
- (d) It would be difficult to determine the appropriate rate of return and the rate base.
- (e) Under rate-of-return regulation, the incentive to generate electricity from renewable sources is stronger as the capital investments for renewable energy increase the firm's capital stock, which in turn increases its total profit.

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