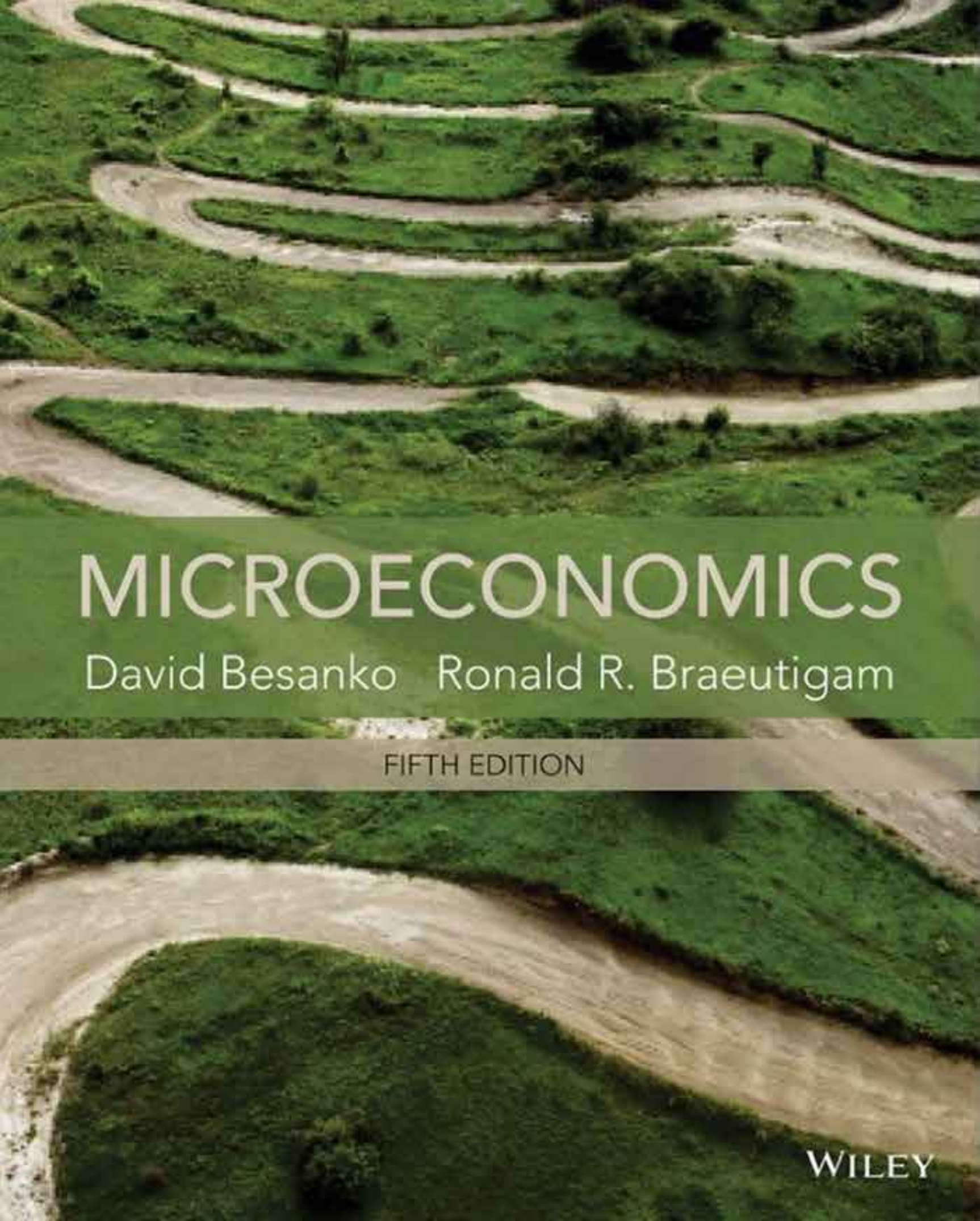
MICROECONOMICS
David Besanko Ronald R. Braeutigam
FIFTH EDITION
WILEY

MICROECONOMICS

FIFTH EDITION

DAVID A. BESANKO
Northwestern University,
Kellogg School of Management

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Northwestern University,
Department of Economics

with Contributions from

Michael J. Gibbs
The University of Chicago,
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WILEY

To our wives . . .
Maureen and Jan
. . . and to our children
Suvarna and Eric, Justin, and Julie

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ABOUT THE AUTHORS

DAVID BESANKO is the Alvin J. Huss Distinguished Professor of Management and Strategy at the Kellogg School of Management at Northwestern University. From 2007 to 2009 he served as Senior Associate Dean for Academic Affairs: Strategy and Planning and from 2001 to 2003 served as Senior Associate Dean for Academic Affairs: Curriculum and Teaching. Professor Besanko received his AB in Political Science from Ohio University in 1977, his MS in Managerial Economics and Decision Sciences from Northwestern University in 1980, and his PhD in Managerial Economics and Decision Sciences from Northwestern University in 1982. Before joining the Kellogg faculty in 1991, Professor Besanko was a member of the faculty of the School of Business at Indiana University from 1982 to 1991. In addition, in 1985, he held a postdoctorate position on the Economics Staff at Bell Communications Research. Professor Besanko teaches courses in the fields of Management and Strategy, Competitive Strategy, and Managerial Economics. In 1995 and 2010, the graduating classes at Kellogg named Professor Besanko the L.G. Lavengood Professor of the Year, the highest teaching honor a faculty member at Kellogg can receive. He is only one of two faculty members of Kellogg to have received this award twice. At the Kellogg School, he has also received the Alumni Choice Teaching Award in 2006, the Sidney J. Levy Teaching Award (1998, 2000, 2009, 2011) the Chair's Core Teaching Award (1999, 2001, 2003, 2005), and Certificate of Impact awards from students (2009, 2010, 2011, 2012, 2013).

Professor Besanko does research on topics relating to competitive strategy, industrial organization, the theory of the firm, and economics of regulation. He has published two books and over 40 articles in leading professional journals in economics and business, including the *American Economic Review*, *Econometrica*, the *Quarterly Journal of Economics*, the *RAND Journal of Economics*, the *Review of Economic Studies*, and *Management Science*. Professor Besanko is a co-author of *Economics of Strategy* with David Dranove, Mark Shanley, and Scott Schaefer.

RONALD R. BRAEUTIGAM is the Harvey Kapnick Professor of Business Institutions in the Department of Economics at Northwestern University. He is currently Associate Provost for Undergraduate Education, and he has served as Associate Dean for Undergraduate Studies in the Weinberg College of Arts and Sciences. He received a BS in Petroleum Engineering from the University of Tulsa in 1970 and then attended Stanford University, where he received an MS in engineering and a PhD in Economics in 1976. He has taught at Stanford University and the California Institute of Technology, and he has also held an appointment as a Senior Research Fellow at the Wissenschaftszentrum Berlin (Science Center Berlin). He also has worked in both government and industry, beginning his career as a petroleum engineer with Standard Oil of Indiana. He served as research economist in The White House Office of Telecommunications Policy and as an economic consultant to Congress, many government agencies, and private firms on matters of pricing, costing, managerial strategy, antitrust, and regulation.

Professor Braeutigam has received many teaching awards, including the Northwestern University Alumni Association Excellence in Teaching Award (1991), and recognition as a Charles Deering McCormick Professor of Teaching Excellence at Northwestern (1997–2000), the highest teaching award that can be received by a faculty member at Northwestern.

Professor Braeutigam's research interests are in the field of microeconomics and industrial organization. Much of his work has focused on the economics of regulation and regulatory reform, particularly in the telephone, transportation, and energy sectors. He has published many articles in leading professional journals in economics, including the *American Economic Review*, the *RAND Journal of Economics*, the *Review of Economics and Statistics*, and the *International Economic Review*. Professor Braeutigam is a co-author of *The Regulation Game* with Bruce Owen, and *Price Level Regulation for Diversified Public Utilities* with Jordan J. Hillman. He also has served as President of the European Association for Research in Industrial Economics.

ABOUT THE AUTHORS

MICHAEL GIBBS is Clinical Professor of Economics, and Faculty Director of the Executive MBA Program, at the University of Chicago Booth School of Business. He also is a Research Fellow of the Institute for the Study of Labor, and the Institute for Compensation Studies. Professor Gibbs earned his AB, AM, and PhD in Economics from the University of Chicago. He also has taught at Harvard, the University of Michigan, USC, Sciences Po (Paris), and the Aarhus School of Business (Denmark). Professor Gibbs has won several teaching and research awards. He is a leading scholar in personnel economics, publishing in journals such as the *Quarterly Journal of Economics*, *Accounting Review*, and *Industrial & Labor Relations Review*. His research focuses on organizational design, incentives, and the economics of personnel policies. He is co-author of the textbook *Personnel Economics in Practice*, with Edward Lazear. Professor Gibbs is a Director at Cummins Western Canada and Huy Vietnam, and advisor to several startups.

After many years of experience teaching microeconomics at the undergraduate and MBA levels, we have concluded that the most effective way to teach it is to present the content with a variety of engaging applications, coupled with an ample number of practice problems and exercises. The applications ground the theory in the real world, and the exercises and problems sets enable students to master the tools of economic analysis and make them their own. The applications and the problems are combined with verbal intuition and graphs, so that they are reinforced and amplified. This approach enables students to see clearly the interplay of key concepts, to thoroughly grasp these concepts through abundant practice, and to see how they apply in actual markets and business firms.

Our reviewers and adopters of the first edition told us that this approach worked for them and their students. In the second edition, we built on this approach, adding even more applications and problems and revisiting every explanation, every graph, and every Learning-By-Doing exercise to make sure the text was as clear as possible. In the third edition, we continued in the spirit of the second edition, adding more current applications and problems. In fact, we added at least five problems to each chapter (nearly 90 new problems in all). In the fourth edition, we added still more new problems, and we introduced over 30 new applications. In addition, we added a new Appendix to Chapter 4 that introduces the basic concepts of time value of money, such as present and future value. Finally, every chapter now begins with a set of concrete, actionable learning goals based on Bloom's Taxonomy of Educational Objectives. In the fifth edition, we updated applications and chapter openers, and added new applications throughout the book, many with a focus on current events. Each major section of every chapter now has at least one application. We also added new material to Chapter 15 on pay for performance and to Chapter 17 on contrasting emissions fees, emissions standards, and tradable permits.

• **The Solution Is in the Problems.** Our emphasis on practice exercises and numerous, varied problems sets this book apart from others. Based on our experience, students need drills in order to internalize microeconomic theory. They need to work through many problems that are tangible, problems that have specific equations and numbers in them. Anyone who has mastered a skill or a sport, whether it be piano, ballet, or golf, understands that a fundamental part of the learning process involves repetitive drills that seemingly bear no relation to how one would actually execute the skill under "real" conditions. We feel that drill problems in microeconomics serve the same purpose. A student may never have to do a numerical comparative statics analysis after completing the microeconomics course. However, having seen concretely, through the use of numbers and equations, how a shift in demand or supply affects the equilibrium, a student will have a deeper

LEARNING-BY-DOING EXERCISE 2.6

Elasticities along Special Demand Curves

Problem

(a) Suppose a constant elasticity demand curve is given by the formula $Q = 200P^{-\frac{1}{2}}$. What is the price elasticity of demand?

(b) Suppose a linear demand curve is given by the formula $Q = 400 - 10P$. What is the price elasticity of demand at $P = 30$? At $P = 10$?

Solution

(a) Since this is a constant elasticity demand curve, the price elasticity of demand is equal to $-1/2$ everywhere along the demand curve.

(b) For this linear demand curve, we can find the price elasticity of demand by using equation (2.4): $\epsilon_{Q,P} = (-b)(P/Q)$. Since $b = -10$ and $Q = 400 - 10P$, when $P = 30$,

$$\epsilon_{Q,P} = -10\left(\frac{30}{400 - 10(30)}\right) = -3$$

and when $P = 10$,

$$\epsilon_{Q,P} = -10\left(\frac{10}{400 - 10(10)}\right) = -0.33$$

Note that demand is elastic at $P = 30$, but it is inelastic at $P = 10$ (in other words, $P = 30$ is in the elastic region of the demand curve, while $P = 10$ is in the inelastic region).

Similar Problems: 2.5, 2.6, 2.12

appreciation for comparative statics analysis and will be better prepared to interpret events in real markets.

Learning-By-Doing exercises, embedded in the text of each chapter, guide the student through specific numerical problems. We use three to ten Learning-By-Doing exercises in each chapter and have designed them to illustrate the core ideas of the chapter. They are integrated with the graphical and verbal exposition, so that students can clearly see, through the use of numbers and tangible algebraic relationships, what the graphs and words are striving to teach. These exercises set the student up to do similar practice problems as well as more difficult analytical problems at the end of each chapter.

As noted above, we have added to the already complete end-of-chapter problem sets to give students and instructors more opportunity to assess student understanding. Chapters have between 20 and 35 end-of-chapter exercises. There is at least one exercise for each of the topics covered in the chapter, and the topics covered by the exercises generally follow the order of topics in the chapter. At the end of the book, there are fully worked-out solutions to selected exercises.

• **It Works in Theory, but Does It Work in the Real World?** Numerous "real-world" examples illustrate how microeconomics applies to business decision making and public policy issues. We begin each chapter with an extended example that introduces the key themes of the chapter and uses real markets and companies to reinforce particular concepts and tools. Each chapter contains, on average, seven examples, called Applications, woven into the narrative or highlighted in sidebars. In this fifth edition, we have taken care to update our applications and to add to them, so that we now have over 120 Applications. A full list may be found on the front endpapers of this text. New applications include health care reform in the U.S., federal income tax reform, parking meter privatization in Chicago, and the bailout of the Parmesan cheese industry in Italy.

APPLICATION 2.8

What Hurricane Katrina Tells Us About the Price Elasticity of Demand for Gasoline

Gasoline prices tend to be highly volatile. Figure 2.24 illustrates this by plotting the average retail gasoline price in the United States in 2005.[23] Large swings in price in short periods of time are common, as are seasonal fluctuations. The seasonal changes are largely attributable to shifts in demand. Gasoline prices usually rise in the spring through late summer, due to warmer weather, closed schools, and summer vacations. They are usually lower in winter. Gasoline prices can also fluctuate due to changes in crude oil prices, since gasoline is refined from crude oil.

In addition to these factors, gasoline prices are highly responsive to changes in supply. Prices may change dramatically if there are disruptions to the supply chain. Typical inventory levels of commercial gasoline usually amount to only a few days of

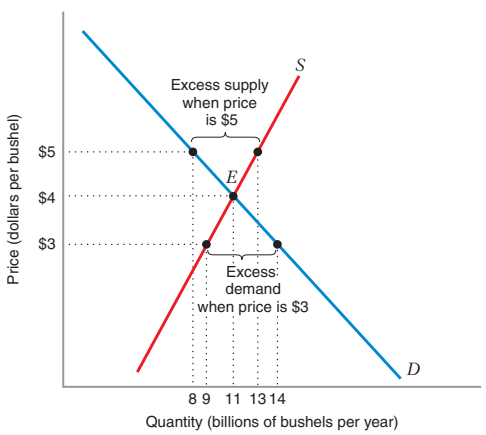

FIGURE 2.5 **Excess Demand and Excess Supply in Market for Corn**
If the price of corn were $3, per bushel, excess demand would result because 14 billion bushels would be demanded, but only 9 billion bushels would be supplied. If the price of corn were $5 per bushel, excess supply would result because 13 billion bushels would be supplied but only 8 billion bushels would be demanded.

• **Graphs Tell the Story.** We use graphs and tables more abundantly than most texts, because they are central to economic analysis, enabling us to depict complex interactions simply.

In economics, a picture truly *is* worth a thousand words. In each new edition we have worked to make the graphs even clearer and more useful for students.

• **Get to the Point.** All too often, verbal explanations of economic ideas and concepts seem convoluted and unintuitive. Tables and graphs are powerful economic tools, but many students cannot interpret them readily at first. We believe our exposition of the economic intuition underlying the graphs is clear and easy to follow. We have worked through every line to streamline the exposition. Patient step-by-step explanations with examples enable even nonvisual learners to understand how graphs are constructed and what they mean.

ORGANIZATION AND COVERAGE

This book is traditional in its coverage and organization. To the extent that we have made a trade-off, it is to cover traditional topics more thoroughly, as opposed to adding a broad range of additional topics that might not easily fit into a one-quarter or one-semester microeconomics course. Thus an instructor teaching a one-semester microeconomics course could use all or nearly all of the chapters in the book, and an instructor teaching a one-quarter microeconomics or managerial economics course could use more than two-thirds of the chapters. The following chart shows how the book is organized.

Introduction to Microeconomics	Consumer Theory	Production and Cost Theory	Perfectly Competitive Markets	Monopoly and Monopsony	Imperfectly Competitive Markets and Strategic Behavior	Special Topics
1 Overview and introduction to constrained optimization, equilibrium analysis, and comparative statics analysis	3 Introduction to consumer choice	6 Production function, marginal and average product, and returns to scale	9 Profit-maximizing output choice by a price-taking firm and prices in short-run and long-run equilibrium	11 Theories of monopoly and monopsony price setting	13 Price determination in imperfectly competitive markets	15 Risk, uncertainty, and information, including a utility-theoretic approach to uncertainty and decision tree analysis, Insurance markets and asymmatric information, and auctions
2 Introduction to demand curves, supply curves, market equilibrium, and elasticity	4 Budget lines, utility maximization, and analysis of revealed preference	7 Concept of cost, input choice and cost minimization	10 Using the competitive market model to analyze public policy interventions	12 Price discrimination	14 Simultaneous-move games and sequential-move games	16 Overview of general equilibrium theory and economic efficiency
	5 Comparative statics of consumer choice and consumer surplus	8 Construction of total, average, and marginal cost curves				17 Externalities and public goods

ALTERNATIVE COURSE DESIGNS

In writing this book, we have tried to serve the needs of instructors teaching microeconomics in a variety of different formats and time frames.

- **One-quarter course (10 weeks):** An instructor teaching a one-quarter undergraduate microeconomics course that fully covers all of the traditional topics (including consumer theory and production and cost theory) would probably assign Chapters 1–11. If the instructor prefers to deemphasize consumer theory or production theory, he or she might also be able to cover Chapters 13 and 14.
- **One-semester course (15 weeks):** In a one-semester undergraduate course, an instructor should be able to cover Chapters 1–15. If the course must include general equilibrium theory, public goods, and externalities, then Chapter 15 could be dropped and the instructor could assign Chapters 1–14, 16, and 17.
- **Two-quarter course (20 weeks):** For a two-quarter sequence (the structure we have at Northwestern), the first quarter could cover Chapters 1–11, and the second quarter could pick up where the first quarter left off and cover Chapters 12–17.
- **MBA-level managerial economics course (10 weeks or 15 weeks):** For a one-quarter course, the instructor would probably want to skip the chapters on consumer theory, production functions, and cost minimization (Chapters 3–6 and the second half of Chapter 7) and cover Chapters 1–2, the first half of Chapter 7—economic concepts of cost—Chapter 8, and Chapters 9–14. Extending such a course to a full semester would allow the instructor to include the material on production and cost minimization as well as Chapter 15.

TEACHING AND LEARNING RESOURCES

COMPANION WEBSITE (www.wiley.com/college/besanko) includes resources for both students and instructors. Provides many of the resources listed here as well as Lecture Outline PowerPoint presentations, and Excel-based problems that provide graphical illustrations related to key concepts within the text.

INSTRUCTOR'S MANUAL includes additional examples related to the chapter topics, references to relevant written works, website addresses, and so on, which enhance the material within each chapter of the text, additional problem sets, and sample exams.

SOLUTIONS MANUAL provides answers to end-of-chapter material and worked out solutions to any additional material not already provided within the text.

TEST BANK contains nearly 1,000 multiple-choice and short answer questions as well as a set of problems varying in level of difficulty and correlated to all learning objectives.

COMPUTERIZED TEST BANK consists of content from the Test Bank provided within a test-generating program that allows instructors to customize their exams.

STUDENT PRACTICE QUIZZES contain at least 10–15 practice questions per chapter. Multiple choice and short answer questions, of varying difficulty, help students evaluate individual progress through a chapter.

STUDY GUIDE includes a Chapter Summary, Exercises with Answers, Chapter Review Questions with Answers, Problems with Answers, and Practice Exam Questions with Answers for each chapter.

Wiley E-Text
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The Wiley **E-Text: Powered by VitalSource** gives students anytime, anywhere, access to the best economics content when and where they study: on their desktop, laptop, tablet, or smartphone. Students can search across content, highlight, and take notes that they can share with teachers and classmates.

Wiley's E-Text for *Microeconomics*, *Fifth Edition* takes learning from traditional to cutting edge by integrating inline interactive multimedia with market-leading content. This exciting new learning model brings textbook pages to life—no longer just a static e-book, the E-Text enriches the study experience with dynamic features:

- **Clickable Images** enlarge so students can view details up close
- **Interactive Tables and Graphs** allow students to access additional rich layers of explanation by manipulating slider controls or clicking on embedded "hotspots" incorporated into select tables and graphs
- **Embedded Practice Quizzes** appear inline and are contextual within the E-Text experience—students practice as they read and receive instant feedback on their progress
- **Audio-Enhanced Graphics** provide further explanation for key graphs in the form of short audio clips

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The clarity of the presentation and organization in this book owes a great deal to the efforts of Leonard Neufeld, who provided a close and insightful line and art edit. Len carefully worked through every line of the manuscript and made numerous thoughtful suggestions for sharpening and streamlining the exposition. Melissa Hayes, at the time a Northwestern undergraduate, made extensive suggestions for making the first edition of the book readable from a student's point of view. We owe a special debt to Nick Kreisle. Nick has worked with us as a colleague, as a teaching assistant in our courses, and as an instructor using our text in his own course in intermediate microeconomics. He carefully reviewed drafts of the manuscripts of the first and second editions, and provided many valuable suggestions. We are pleased that he is now Dr. Kreisle.

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BRIEF CONTENTS

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PART 4 PERFECT COMPETITION

PART 5 MARKET POWER

1 Analyzing Economic Problems

Microeconomics and Climate Change

By the late 2000s, the scientific consensus had formed: climate change is for real, and it cannot be explained entirely by natural forces:

- There is compelling scientific evidence that concentrations of greenhouse gasses—compounds such as carbon dioxide and methane whose properties work to warm surface temperatures on the Earth—have accumulated to levels substantially higher than those that prevailed at any time during the last 500,000 years.
- There is strong evidence that the climate is warming. According to the Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC) issued in 2007—the best representation of the scientific consensus on climate change—"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."[1]

[1]"Summary for Policymakers" in *Climate Change 2007: The Physical Science Basis. Contributions of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Soloman, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Avery, M. Tignor, and H. L. Mikllers (eds.) (Cambridge: Cambridge University Press 2007), p. 5. http://www.ipcc.ch/ipccreports/ar4-wg1.htm (accessed April 3, 2009).

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- There is persuasive evidence that climate change has been induced, in part, by humans. According to the IPCC: "The common conclusion of a wide range of fingerprint studies conducted over the last 15 years is that observed climate changes cannot be explained by natural factors alone."[2]

But if the diagnosis of climate change is unequivocal, what to do about it is less obvious. Greenhouse gas emissions come from power plants, factories, and automobiles all over the world. The number of pollution sources that potentially need to be controlled is mind-boggling. And large countries such as China and the United States, the two countries accounting for the largest share of greenhouse gas emissions, might balk at the enormous price tag associated with curtailing their emissions. In light of these issues, the challenge of combating global climate change would appear to be insurmountable.

Microeconomics offers powerful insights into why climate change is such a difficult problem and what to do about it. Climate change is a tough problem to deal with because the parties that cause greenhouse gas emissions are unlikely to take into account the environmental harm that their decisions cause for others. For example, economists estimate that in the mid-2000s, the typical American household caused about $150 annually in environmental damage by consuming products or services that caused greenhouse gas emissions.[3] Did you or your family take this into account when you made decisions about how much electricity to use or how much to drive? Probably not. After all, you did not have to pay this cost, either directly (because no one directly charged you for this cost) or indirectly (because it was not reflected in the price of the products you consumed because the producers of those products were not charged for this cost). *New York Times* columnist Tom Friedman puts it this way:

> [I]f I had my wish, the leaders of the world's 20 top economies would commit themselves to a new standard of accounting—call it "Market to Mother Nature" accounting. Why? Becouse it's now obvious that the reason we're experiencing a simultaneous meltdown in the financial system and the climate system is because we have been mispricing risk in both arenas—producing a huge excess of both toxic assets and toxic air that now threatens the stability of the whole planet.
>
> Just as A.I.G. sold insurance derivatives at prices that did not reflect the real costs and the real risks of massive defaults (for which we the taxpayers ended up paying the difference), oil companies, coal companies and electric utilities today are selling energy products at prices that do not reflect the real costs to the environment and real risks of disruptive climate change (so future taxpayers will end up paying the difference).[4]

[2]H. R. Le Treut, R. Somerville, U. Cubasch, Y. Ding, C. Mauritzen, A. Mokssit, T. Peterson, and M. Prather, "Historical Overview of Climate Change," in *Climate Change 2007: The Physical Science Basis*, p. 103.

[3]The estimate of the social cost of electricity usage comes from W. Nordhaus, *A Question of Balance: Weighing the Options on Global Warming Policies* (New Haven, CT: Yale University Press, 2008), p. 11.

[4]"The Price Is Not Right," *New York Times* (March 31, 2009).

But Friedman's diagnosis of the problem is also suggestive of a solution: to induce parties to make decisions that reflect the real costs of climate change, find a way to put a price on the harm that greenhouse gas emissions cause to the climate and the economy. Basic ideas from microeconomics are being applied today to help do this. Consider, for example, the European Union (EU) Emissions Trading System. Under the provisions of the Kyoto Treaty, the countries of the EU must reduce their emissions of greenhouse gases 8 percent below their emissions in 1990. To do so, the EU has adopted what is called a cap-and-trade system.[5]

A cap-and-trade system applies microeconomics to achieve a given amount of pollution reduction at a cost as low as possible. Here's how it works. Caps are placed on how much of a greenhouse gas, say carbon dioxide (CO_2), can be emitted from specific sources (e.g., power plants or factories). At the same time, CO_2 permits are granted to the firms that own those sources of CO_2 pollution, allowing them to emit a given amount of CO_2 within a given period of time. Firms are then free to trade these permits in an open market. The idea behind this scheme is that a firm that can cheaply reduce its CO_2 emissions below its cap (e.g., by installing pollution control equipment), and can sell its allowances to other firms for whom pollution control would be more expensive. The beauty of this system—which follows directly from the fact that it is market-based—is that reductions in emissions of a given amount are achieved as cheaply as possible. Moreover, a government (or group of governments as in the case of the EU) does not need to know which firms can reduce pollution more cheaply. The free market identifies those firms through the purchase and sale of permits: firms with low costs of compliance sell permits; firms with high costs of compliance buy them. By reducing the supply of allowances over time, the government can reduce pollution, all the while being assured that the reduction is done at as low a cost as is possible.

Microeconomics is a field of study that has broad applicability. It can help public policy makers deal with difficult issues such as climate change, and it can help those same public officials anticipate the unintended consequences of the policies they adopt. For example, microeconomic analyses of cap-and-trade systems reveal that while a cap-and-trade system offers the potential to correctly price greenhouse gas emissions, there are circumstances under which this system can result in significant underpricing or overpricing of those emissions if policy makers make even small mistakes in setting the cap.[6] Microeconomics can also help business firms better understand their competitive environments, and it can give them concrete tools that can be used to unlock additional profitability through pricing strategies. It can help us understand how households' consumption decisions are shaped by the fundamentals (e.g., tastes and price levels) they face, and it can shed light on why prices in competitive markets fluctuate as they do. Microeconomics can even help us understand social phenomena such as crime and marriage (yes, economists have even studied these). What's remarkable is that nearly all phenomena studied by

[5]The Kyoto Treaty was adopted in the late 1990s, and it called for industrialized countries to scale back the amount of greenhouse gases. The treaty was ratified by EU counties, but not by the United States.

[6]See, for example, W. J. McKibbin and P. J. Wilcoxen, "The Role of Economics in Climate Change Policy," *Journal of Economic Perspectives*, 16, no. 2 (Spring 2002): 107–129.

economists rely on three powerful analytical tools: constrained optimization, equilibrium analysis, and comparative statics.

CHAPTER PREVIEW After reading and studying this chapter, you will be able to:

- Contrast the two main branches of economics—microeconomics and macroeconomics.
- Describe the three main analytical tools of microeconomics—constrained optimization, equilibrium analysis, and comparative statics—and recognize examples of each of these tools.
- Explain the difference between positive and normative analysis.

1.1 WHY STUDY MICRO-ECONOMICS?

Economics is the science that deals with the allocation of limited resources to satisfy unlimited human wants. Think of human wants as being all the goods and services that individuals desire, including food, clothing, shelter, and anything else that enhances the quality of life. Since we can always think of ways to improve our well-being with more or better goods and services, our wants are unlimited. However, to produce goods and services, we need resources, including labor, managerial talent, capital, and raw materials. Resources are said to be *scarce* because their supply is limited. The scarcity of resources means that we are constrained in the choices we can make about the goods and services we produce, and thus also about which human wants we will ultimately satisfy. That is why economics is often described as *the science of constrained choice*.

Broadly speaking, economics is composed of two branches, microeconomics and macroeconomics. The prefix *micro* is derived from the Greek word *mikros*, which means "small." Microeconomics therefore studies the economic behavior of individual economic decision makers, such as a consumer, a worker, a firm, or a manager. It also analyzes the behavior of individual households, industries, markets, labor unions, or trade associations. By contrast, the prefix *macro* comes from the Greek word *makros*, which means "large." Macroeconomics thus analyzes how an entire national economy performs. A course in macroeconomics would examine aggregate levels of income and employment, the levels of interest rates and prices, the rate of inflation, and the nature of business cycles in a national economy.

Constrained choice is important in both macroeconomics and microeconomics. For example, in macroeconomics we would see that a society with full employment could produce more goods for national defense, but it would then have to produce fewer civilian goods. It might use more of its depletable natural resources, such as natural gas, coal, and oil, to manufacture goods today, in which case it would conserve less of these resources for the future. In a microeconomic setting, a consumer might decide to allocate more time to work, but would then have less time available for leisure activities. The consumer could spend more income on consumption today, but would then save less for tomorrow. A manager might decide to spend more of a firm's resources on advertising, but this might leave less available for research and development.

Every society has its own way of deciding how to allocate its scarce resources. Some resort to a highly centralized organization. For example, during the Cold War, governmental bureaucracies heavily controlled the allocation of resources in the

economies of Eastern Europe and the Soviet Union. Other countries, such as those in North America or Western Europe, have historically relied on a mostly decentralized market system to allocate resources. Regardless of its market system, every society must answer these questions:

- What goods and services will be produced, and in what quantities?
- Who will produce the goods and services, and how?
- Who will receive the goods and services?

Microeconomic analysis attempts to answer these questions by studying the behavior of individual economic units. By answering questions about how consumers and producers behave, microeconomics helps us understand the pieces that collectively make up a model of an entire economy. Microeconomic analysis also provides the foundation for examining the role of the government in the economy and the effects of government actions. Microeconomic tools are commonly used to address some of the most important issues in contemporary society. These include (but are not limited to) pollution, rent controls, minimum wage laws, import tariffs and quotas, taxes and subsidies, food stamps, government housing and educational assistance programs, government health care programs, workplace safety, and the regulation of private firms.

1.2 THREE KEY ANALYTICAL TOOLS

To study real phenomena in a world that is exceedingly complex, economists construct and analyze economic models, or formal descriptions, of the problems they are addressing. An economic model is like a roadmap. A roadmap takes a complex physical reality (terrain, roads, houses, stores, parking lots, alleyways, and other features) and strips it down to bare essentials: major streets and highways. The roadmap is an abstract model that serves a particular purpose—it shows us where we are and how we can get where we want to go. To provide a clear representation of reality, it "ignores" or "abstracts from" much of the rich detail (the location of beautiful elm trees or stately homes, for example) that makes an individual town unique and charming.

Economic models operate in much the same way. For example, to understand how a drought in Colombia might affect the price of coffee in the United States, an economist might employ a model that ignores much of the rich detail of the industry, including some aspects of its history or the personalities of the people who work in the fields. These details might make an interesting article in *Business Week*, but they do not help us understand the fundamental forces that determine the price of coffee.

Any model, whether it is used to study chemistry, physics, or economics, must specify what variables will be taken as given in the analysis and what variables are to be determined by the model. This brings us to the important distinction between *exogenous* and *endogenous* variables. An **exogenous variable** is one whose value is taken as given in a model. In other words the value of an exogenous variable is determined by some process outside the model being examined. An **endogenous variable** is a variable whose value is determined within the model being studied.

exogenous variable
A variable whose value is taken as given in the analysis of an economic system.

endogenous variable
A variable whose value is determined within the economic system being studied.

To understand the distinction, suppose you want to build a model to predict how far a ball will fall after it is released from the top of a tall building. You might assume that certain variables, such as the force of gravity and the density of the air through which the ball must pass, are taken as given (exogenous) in your analysis. *Given* the exogenous variables, your model will describe the relationship between the distance the ball will drop and the time elapsed after it is released. The distance and time predicted by your model are endogenous variables.

Nearly all microeconomic models rely on just three key analytical tools. We believe this makes microeconomics unique as a field of study. No matter what the specific issue is—coffee prices in the United States, or decision making by firms on the Internet—microeconomics uses the same three analytical tools:

- Constrained optimization
- Equilibrium analysis
- Comparative statics

Throughout this book, we will apply these tools to microeconomic problems. This section introduces these three tools and provides examples of how they can be employed. Do not expect to master these tools just by reading this chapter. Rather, you should learn to recognize them when we apply them in later chapters.

CONSTRAINED OPTIMIZATION

constrained optimization An analytical tool for making the best (optimal) choice, taking into account any possible limitations or restrictions on the choice.

objective function The relationship that a decision maker seeks to maximize or minimize.

As we noted earlier, economics is the science of constrained choice. The tool of **constrained optimization** is used when a decision maker seeks to make the best (optimal) choice, taking into account any possible limitations or restrictions on the choices. We can therefore think about constrained optimization problems as having two parts, an objective function and a set of constraints. An **objective function** is the relationship that the decision maker seeks to "optimize," that is, either maximize or minimize. For example, a consumer may want to purchase goods to maximize her satisfaction. In this case, the objective function would be the relationship that describes how satisfied she will be when she purchases any particular set of goods. Similarly, a producer may want to plan production activities to minimize the costs of manufacturing its product. Here the objective function would show how the total costs of production depend on the various production plans available to the firm.

constraints The restrictions or limits imposed on a decision maker in a constrained optimization problem.

Decision makers must also recognize that there are often restrictions on the choices they may actually select. These restrictions reflect the fact that resources are scarce, or that for some other reason only certain choices can be made. The **constraints** in a constrained optimization problem represent restrictions or limits that are imposed on the decision maker.

Examples of Constrained Optimization

To make sure that the difference between an objective function and a constraint is clear, let's consider two examples. See if you can identify the objective function and the constraint in each example. (Do not attempt to solve the problems. We will present techniques for solving them in later chapters. At this stage the important point is simply to understand examples of constrained optimization problems.)

LEARNING-BY-DOING EXERCISE 1.1

Constrained Optimization: The Farmer's Fence

Suppose a farmer plans to build a rectangular fence as a pen for his sheep. He has F feet of fence and cannot afford to purchase more. However, he can choose the dimensions of the pen, which will have a length of L feet and a width of W feet. He wants to choose the dimensions L and W that will maximize the area of the pen. He must also make sure that the total amount of fencing he uses (the perimeter of the pen) does not exceed F feet.

Problem

(a) What is the objective function for this problem?

(b) What is the constraint?

(c) Which of the variables in this model (L, W, and F) are exogenous? Which are endogenous? Explain.

Solution

(a) The objective function is the relationship that the farmer is trying to maximize—in this case, the area LW. In other words, the farmer will choose L and W to maximize the objective function LW.

(b) The constraint will describe the restriction imposed on the farmer. We are told that the farmer has only F feet of fence available for the rectangular pen. The constraint will describe the restriction that the perimeter of the pen $2L + 2W$ must not exceed the amount of fence available, F. Therefore, the constraint can be written as $2L + 2W \leq F$.

(c) The farmer is given only F feet of fence to work with. Thus, the perimeter F is an exogenous variable, since it is taken as given in the analysis. The endogenous variables are L and W, since their values can be chosen by the farmer (determined within the model).

Similar Problems: 1.4, 1.16, 1.17

By convention, economists usually state a constrained optimization problem like the one facing the farmer in Learning-By-Doing Exercise 1.1 in the following way:

$$\max_{(L,W)} LW$$

$$\text{subject to: } 2L + 2W \leq F$$

The first line identifies the objective function, the area LW, and tells whether it is to be maximized or minimized. (If the objective function were to be minimized, "max" would be "min.") Underneath the "max" is a list of the endogenous variables that the decision maker (the farmer) controls; in this example, "(L, W)" indicates that the farmer can choose the length and the width of the pen.

The second line represents the constraint on the perimeter. It tells us that the farmer can choose L and W as long as ("subject to" the constraint that) the perimeter does not exceed F. Taken together, the two lines of the problem tell us that the farmer will choose L and W to maximize the area, but those choices are subject to the constraint on the amount of fence available.

We now illustrate the concept of constrained optimization with a famous problem in microeconomics, consumer choice. (Consumer choice will be analyzed in depth in Chapters 3, 4, and 5.)

Marginal Reasoning and Constrained Optimization

Constrained optimization analysis can reveal that the "obvious" answers to economic questions may not always be correct. We will illustrate this point by showing how constrained optimization problems can be solved using marginal reasoning.

LEARNING-BY-DOING EXERCISE 1.2

Constrained Optimization: Consumer Choice

Suppose a consumer purchases only two types of goods, food and clothing. The consumer has to decide how many units of each good to purchase each month. Let F be the number of units of food that she purchases each month, and C the number of units of clothing. She wants to maximize her satisfaction with the two goods. Suppose the consumer's level of satisfaction when she purchases F units of food and C units of clothing is measured by the product FC, but she can purchase only limited amounts of goods per month because she must live within her budget. Goods cost money, and the consumer has a limited income. To keep the example simple, suppose the consumer has a fixed monthly income I, and she must not spend more than I during the month. Each unit of food costs P_F and each unit of clothing costs P_C.

Problem

(a) What is the objective function for this problem?

(b) What is the constraint?

(c) Which variables (P_F, F, P_C, C, and I) are exogenous? Which are endogenous? Explain.

(d) Write a statement of the constrained optimization problem.

Solution

(a) The objective function is the relationship that the consumer seeks to maximize. In this example she will choose the amount of food and clothing to maximize her satisfaction, measured by FC. Thus, the objective function is FC.

(b) The constraint represents the amounts of food and clothing that she may choose while living within her income. If she buys F units of food at a price of P_F per unit, her total expenditure on food will be $(P_F)(F)$. If she buys C units of clothing at a price of P_C per unit, her total expenditure on clothing will be $(P_C)(C)$. Therefore, her total expenditure will be $(P_F)(F) + (P_C)(C)$. Since her total expenditure must not exceed her total income I, the constraint is $(P_F)(F) + (P_C)(C) \leq I$.

(c) The exogenous variables are the ones the consumer takes as given when she makes her purchasing decisions. Since her monthly income is fixed, I is exogenous. The prices of food P_F and clothing P_C are also exogenous, since she cannot control these prices. The consumer's only choices are the amounts of food and clothing to buy; hence, F and C are the endogenous variables.

(d) The statement of the constrained optimization problem is

$$\max_{(F,C)} FC$$

$$\text{subject to: } (P_F)(F) + (P_C)(C) \leq I$$

The first line shows that the consumer wants to maximize FC and that she can choose F and C. The second line describes the constraint: total expenditure cannot exceed total income.

Similar Problems: 1.4, 1.16, 1.17

APPLICATION 1.1

Generating Electricity: 8,760 Decisions per Year

Examples of constrained optimization are all around us. Electric power companies typically own and operate plants that produce electricity. A company must decide how much electricity to produce at each plant to meet the needs of its customers.

The constrained optimization problem for a power company can be complex:

- The company needs to generate enough power to ensure that its customers receive service during each hour of the day.
- To make good production decisions, the company must forecast the demand for electricity.

The demand for electricity varies from one hour to another during the day, as well as across seasons of the year. For example, in the summer the highest demand may occur in the afternoon when customers use air conditioners to cool offices and homes. The demand for power may decline considerably in the evening as the temperature falls.

- Some of the company's plants are relatively expensive to operate. For example, it is more expensive to produce electricity by burning oil than by burning natural gas. Plants using nuclear fuel are even less costly to run. If the company wants to produce power at the lowest possible cost, its objective function must take these cost differences into account.
- If the company expects the demand for electricity to be low for a long period of time, it may want to shut down production at some of its plants. But there are substantial costs to starting up and shutting down plants. Thus, if the company expects the demand for electricity to be low for only a short time (e.g., a few hours), it might not want to shut down a plant that will be needed again when the demand goes up.
- The company must also take into account the costs of transmitting power from the generators to its customers.
- There is a spot market for electricity during each hour of the day. A company may buy or sell power from other electric power companies. If the company can purchase electricity at a low enough price, it may be able to lower the costs of service by buying some electricity from other producers, instead of generating all of the required electricity itself. If it can sell electricity at a high enough price, the company may find it profitable to generate more electricity than its customers need. It can then sell the extra electricity to other power companies.

Electric power companies typically make production decisions on an hourly basis—that's 8,760 (365 days times 24 hours per day) production decisions a year![7]

Imagine that you are the product manager for a small beer company that produces a high-quality microbrewed ale. You have a $1 million media advertising budget for the next year, and you have to allocate it between local television and radio spots. Although radio spots are cheaper, television spots reach a far wider audience. Television spots are also more persuasive and thus on average stimulate more new sales.

To understand the impact of a given amount of money spent on radio and TV advertisements, you have studied the market. Your research findings, presented in Table 1.1, estimate the new sales of your beer when a given amount of money is spent on TV advertising and on radio advertising. For example, if you spent $1 million on TV advertising, you would generate 25,000 barrels of new beer sales per year. By contrast, if you spent $1 million on radio advertising, you would generate 5,000 barrels of new sales per year. Of course, you could also split your advertising budget between the two media, and Table 1.1 tells you the impact of that decision, too. For example, if you spent $400,000 on TV and $600,000 on radio, you would generate 16,000 barrels of new sales from the TV ads and 4,200 barrels in new sales from the radio ads, for a total of 16,000 + 4,200 = 20,200 barrels of beer overall.

In light of the information in Table 1.1, how would you allocate your advertising budget if your objective is to maximize the new sales of beer?

[7]For a good discussion of the structure of electricity markets, see P. Joskow and R. Schmalensee, *Markets for Power: An Analysis of Electric Utility Deregulation* (Cambridge, MA: MIT Press, 1983).